BUCHANAN'S MANUAL OF ANATOMY

BUCHANAN'S
MANUAL OF ANATOMY

INCLUDING EMBRYOLOGY

SIXTH EDITION

EDITED BY

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PREFACE TO SIXTH EDITION

THE necessity for a new edition of this Manual has afforded the opportunity of bringing its terminology into line with other English textbooks. The old English nomenclature, which has been used in the book from the first, is therefore replaced by the new Birmingham Revision throughout—except to some extent in the Embryological Section.

For many years the student will come across the terms of yesterday in his clinical and other textbooks and papers. For this reason, and because he should not be cut off from the advantage of study of the great teachers of past times, it has been considered necessary to introduce as subsidiaries the more common and popular terms used up to the present; having been once mentioned, they are not as a rule employed again. Other terms of such sort, particularly those connected with proper names, can be found in the Glossary. Otherwise there have been general revision of the text, some rearrangement, a small amount of new matter inserted, and a number of new illustrations added.

I am indebted to Mr. T. K. Elliott for the greater part of the change of terminology and for the Index, and to the Publishers for their unfailing readiness and help in all the questions concerned in the production of this edition.

J. E. FRAZER.

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A MANUAL OF ANATOMY

CHAPTER I

TERMINOLOGY AND RELATIVE POSITIONS

THE word **anatomy,** used in the strict sense, implies the knowledge of what can be studied by the process of dissection. **Morphology** is the name given to the more scientific aspect of anatomical research—the reason why, and the method by which, the various anatomical structures have reached their present conditions. In modern times the term ' anatomy ' is frequently used in a wide general sense, covering both descriptive and morphological anatomy. **Comparative anatomy,** the structure of animals other than man, is an essential foundation for human morphology. **Human embryology,** the study of the development of the body, is an extension of direct anatomical investigation on the one hand, and on the other hand, particularly when the study of human and other types is carried on together, it is a second fundamental support for the superstructure of morphology. **Histology,** the examination and study by the microscope of the minute structure of tissues and organs, is microscopical anatomy, anatomical research pushed to the farthest visual limits of practical value.

Anatomy, the plain descriptive structure of the body, is a subject of primary importance to the medical man. If he wishes to understand what has happened—either from injury or disease—to produce some abnormal physical condition, he must first know the normal state; this knowledge is necessary for scientific diagnosis, and frequently for scientific treatment. Hence it comes that the well-equipped physician or surgeon possesses a good working knowledge of the anatomy of the body as well as of the functions of its parts, some information on morphology to give him a deeper understanding of the matter, and a sufficient acquaintance with histology and embryonic development to enable him to grasp more fully some of the pathological problems which he has to consider. It may be said here, for the benefit of those who are as yet students, with little or no clinical experience, that there are practically no items of anatomical information which may not be of value—to-morrow, if not to-day—if they are known; their value cannot be apparent if they are not known. The more detailed the knowledge possessed by the practitioner, the more useful, and the more frequently useful, he will find it, and the firmer

will be the standpoint from which he views the clinical problems before him.

The anatomy of the body must be studied on the actual human frame itself. It may be pointed out in this connection that dissection and investigation of the dead body ought to be amplified by study of the living body where this is practicable. Textbooks on anatomy must be looked on as mere explanatory guides to actual anatomy, as summaries and co-ordinations of what is observed during this actual study, and as convenient references when occasion arises; they must not be considered to be anatomy itself.

The descriptions of anatomical findings, whether in a book or as

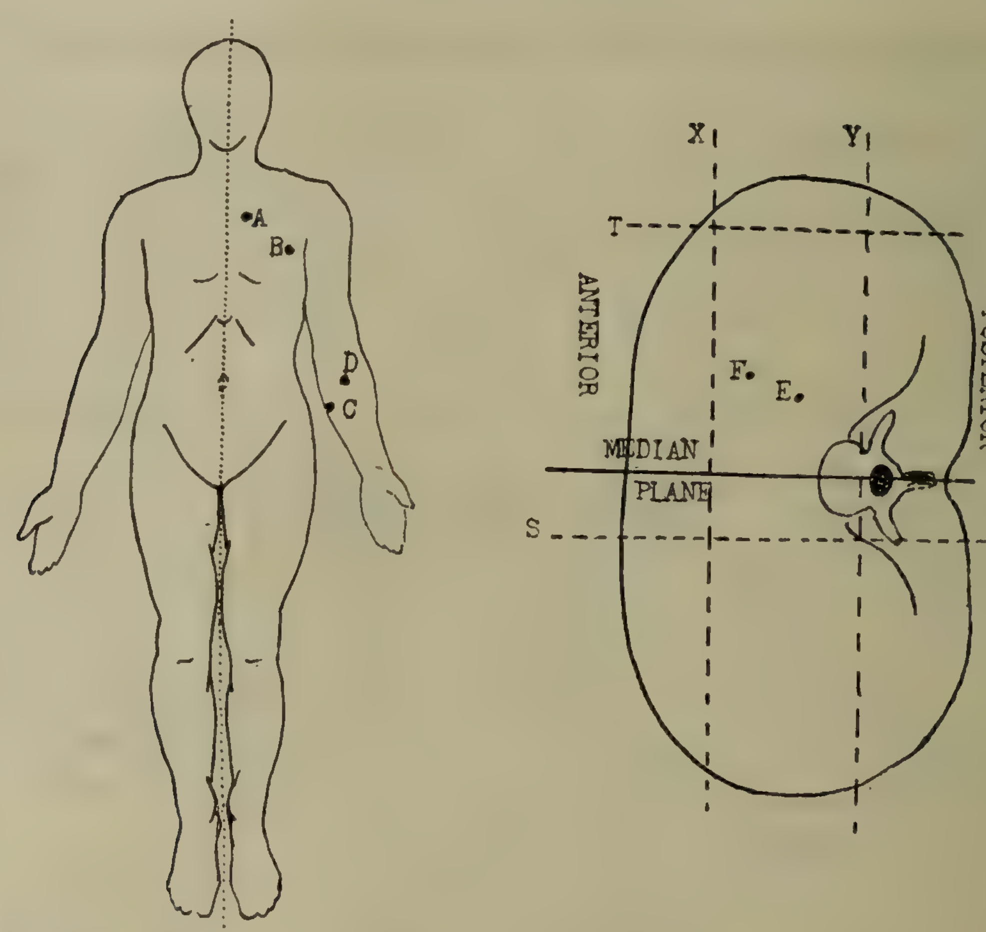


FIG. 1.—HUMAN FIGURE TO ILLUSTRATE THE 'FORMAL POSITION' OF ANATOMY.

The diagram on the right is a section through the trunk to show planes, etc. For description refer to text.

the record of some investigation, must rest on certain fixed and recognized foundations. Unless this rule is respected the anatomical description, which ought to be absolutely exact and unmistakable, becomes chaotic and misleading. One of the first things that the student of anatomy must learn and understand is the proper use and meaning of terms of position; these have fixed and definite values, and should never be used in any other sense than those recognized by anatomists as correct.

In the first place, the body, *for purposes of description*, is always supposed to be standing upright (Fig. 1), with the arms by the side, the palms looking forward, and fingers straight, and the legs and feet

close together and fully extended. This is the 'formal position' of anatomy, and the description of any part or organ is always put into language applicable to this formal position, whatever may be the actual position of the body during dissection, or during the progress of the description. The body is not lying on its back, or in any other dissection position, when it is being spoken about, but is supposed to be standing up. This mental adoption of the formal position must be understood thoroughly by the student if the statements he hears and reads are to be intelligible to him.

The position of the body for descriptive purposes being fixed, it is now possible to employ fixed terms of relative position which will always have the same meaning, whatever may be the actual position of the body at the moment. These fixed terms deal with the three dimensions in space, and are therefore six in number; variants exist for many of the terms, but this does not, of course, increase the number of meanings implied. The terms are: Superior and inferior, anterior and posterior, medial and lateral. Their use and meaning can be illustrated and understood in this way. In Fig. 1 are shown two points, A and B; one of them is higher than the other when the body is in the formal position, so it is said to be above or superior to the other, which is inferior to it or below it. Again, it can be seen that A is not directly above B, but is nearer the middle line of the body, so that it is not only above, but is medial to B, which is lateral to it. It is very important to recognize that these terms refer to nearness or distance from the *median plane of the body*, and have nothing to do with the middle line of any of its parts, such as a limb; for example, of the two points C, D on the arm of the figure, C is medial to D because it is nearer the middle line of the body when in the formal position, whereas it is farther away than D from the middle of the limb. The transverse section of the trunk in Fig. 1 shows two points, E and F; of these, E is nearer the posterior surface of the body than F, so is said to be behind or posterior to it, and F is in front of or anterior to E. This is, of course, in addition to the medial and lateral relations they evidently possess also.

The fixed terms of relative position, then, refer to the formal position of the body, and their meanings can be shortly stated as follows:

Above : nearer to the top of the head.
Below : nearer to the soles of the feet.
Medial : nearer to the median plane of the body.
Lateral : farther from the median plane of the body.
Anterior : nearer to the front surface of the body.
Posterior : nearer to the posterior surface of the body.

Many synonymous terms are used in place of these, giving a variety of choice, but no difference in meaning; those in commonest use for medial and lateral are internal and external, and dorsal and ventral for posterior and anterior. Other descriptions have more limited applications; thus, cephalic and caudal are sometimes used to express

nearness (on the trunk) to its upper or lower end, as the case may be; proximal and distal are employed in the limbs to signify a position nearer to, or farther from, the attachment to the trunk; volar or palmar is often used in place of anterior when dealing with the hand, and sometimes (though improperly) when speaking of the forearm; and plantar and dorsal, in the foot, imply nearer to the sole or the upper surface of the foot respectively.

It must be pointed out here that these fixed terms of position have a different signification when used in strict *early embryological* description. In this case the embryo is described in terms of comparative anatomy—*i.e.*, it is considered as lying on its ventral surface on the ovum; its dorsal surface is now above, its head end is in front, with corresponding changes in the meanings of below and behind. Medial and lateral remain as before, referring to relation to the median longitudinal plane. This strict embryological usage is only adopted as a rule, so far as human description is concerned, during the earlier embryonic period of development; after the third month, when the embryo is known as a fœtus, it is usual to find the terms used in the adult sense.

In addition to the fixed terms there are two descriptive words, superficial and deep, which are not fixed in their meaning with regard to the whole body, but vary according to the way in which any part is dissected, looked at, or described. When used with proper care, to avoid doubt or confusion as to the meaning implied, they are terms of great descriptive value, and can frequently replace with advantage a more cumbrous employment of fixed terms. We can, for example, speak with much more convenience and brevity of the subcutaneous tissue as being deep to the skin than we would experience if we were to attempt to describe its relation to the skin all over the body by fixed terms. Speaking generally, the words superficial and deep apply to the order in which things would be met with in the ordinary course of dissection from the nearest surface, but if there is any possibility of doubt as to what might be inferred from their use, the meaning should be defined clearly before proceeding further. It must be clearly understood that these terms, although in every case necessarily corresponding with some terms of fixed descriptive value, do not in each case necessarily correspond with the same terms, and they must never be used as if they possessed a fixed value of the same sort.

There can be no hesitation in repeating the assertion that the student must understand and become accustomed to the proper use of all these expressions of relative situation, and their application to the body in the formal position; otherwise he will find written description apparently confused or even untrue, and he himself will not be able to give a clear and comprehensive account of any part he may wish to describe. He must get rid of the tendency to looseness in expression and meaning which is so commonly found in ordinary conversation, and he must beware especially of thinking that any of the terms of fixed relation are synonymous with expressions of superficiality or depth.

There are many words and expressions commonly used in anatomical science, but otherwise unfamiliar. A large number of these have a definite topographical application, and will be considered in the appropriate places; but others have more general reference, and may be dealt with conveniently in this chapter.

Among the terms used to describe position or relation there are several which have not been noticed so far, and call for explanation.

Coronal and **sagittal** are terms referring to vertical planes in the body, transverse or antero-posterior respectively in disposition. In Fig. 1 two *sagittal planes* are indicated at S and T, and two *coronal planes* at X and Y. But a sagittal plane may be in any place so long as it passes directly from before backwards, and a coronal plane may be anywhere between the front and back walls so long as it is at right angles to the sagittal direction, and the planes illustrated are only some out of an innumerable number. It is evident that the *median plane* is only one of the series of sagittal planes.

Prone and **supine** are words occasionally used. The former, applied to the body as a whole, is practically the same as 'lying on its face,' and the latter term implies its position 'on its back.' The terms are most frequently used in speaking of the upper limb; the hand and forearm, when in the 'formal position,' as in Fig. 1, is said to be *supinated*, and it is *pronated* when turned over on to its front surface.

Preaxial and **postaxial** only apply to the limbs. The axis referred to is the axis of the limb. The lateral border of the arm is its preaxial border, the postaxial being its medial border. But in the lower limb the preaxial border begins at the lateral side of the upper end, crosses the thigh obliquely, and passes down the medial side of the leg and foot; the postaxial border passes down and out to the lateral side of the foot. These borders are only descriptively true in early development, when the limbs are plate-like, and project from the body with definite cranial and caudal borders. They come in to the side later, but in the case of the lower limb the plate is twisted inwards and ventrally, so that the original dorsal surface comes to look ventrally, and the cranial (preaxial) border is turned towards the middle line. The twist is completed when the legs are brought straight down.

Terms of General Application.

Normal is a word which, when applied to some condition, implies that it is the condition found in the majority of cases; it is frequently extended to cover common, though not most frequent, occurrences.

Abnormal, strictly speaking, means that the condition to which the word is applied is not that usually found. The term is often used as if it were synonymous with 'pathological' or 'monstrous.' Such a mental limitation of the meaning of the word must be avoided; all monstrous conditions are abnormal, but all abnormalities are not to be classed as monstrous. Nevertheless, it must be admitted that it

is very hard to draw a line of distinction when dealing with the more extreme degrees of departure from the normal.

Typical is a word which signifies that the thing to which it refers is one possessing all the characteristics of the ' type ' to which it belongs. In practical use it implies almost the same thing as the use of the word ' normal,' but it is not quite the same; for a ' typical ' example of some region, for instance, may not actually correspond with any particular or individual region known to the observer, but may be more like an average summing up of several known regions. Normality, on the other hand, is a word essentially applied to individual instances.

Atypical, then, merely implies some definite departure from the state recognized as typical.

In dealing with the relations of structures with one another, and with similar or related structures in other animals, etc., certain terms are in frequent use, and call for some explanation.

Structures are often said to be **homologous. Homology** expresses the relation between parts which own for their origin similar embryonic or evolutionary structures, as in the case of a man's arm and the wing of a bird or the foreleg of a dog. **Homogeny** is a word with practically the same meaning and use as *homology*, but has reference more to the evolutionary side of development; thus it can apparently be used to throw back the resemblances between structures further than actual embryonic observation would seem to justify. *Homogeny* must not be confounded with *homogenesis*, which is simply the name of the production of like from like, as in the case of one animal producing a similar animal; nor with *homogeneity*, the quality of being *homogeneous*, which is a word used to imply that the thing described has a uniform structure or substance. It may be pointed out here that probably nothing is absolutely uniform in its composition provided that sufficiently searching methods of examination are employed, and that ' homogeneousness ' is therefore a term of only relative value.

Serial homology is the name given to the relation between parts which are developed from structures that may be described as units in a series of things essentially similar. Thus, each vertebra is ' serially homologous ' with other vertebræ, and each hypothetical segment of the body is the serial homologue of any of the others.

Homodynamy expresses the relation between structures which owe their existence, or their form, to the influence of similar forces or the serving of similar functions. Thus the arm and leg are homodynamic or homodynamous, though they cannot be said to be homologous.

Terms used in dealing with the formation or evolution of the body include:

Atavistic.—This implies the reversion, in some structure, to some peculiarity of a more or less remote ancestor. It is used in various ways in description. Certain structures, as, for example, some epiphyses on bones, appear to be degenerated representatives of better formed and functional parts in other animal types, and are classed as *atavistic*, although they are parts of the normal skeleton. On the

other hand, the ' reappearance ' of a structure normally absent in the human body, though existing in other types, is referred rather vaguely to ' atavism '; the implications of such use of the term must not, however, be taken too strictly.

Phylogeny is the development of the body considered from an evolutionary standpoint, and has to do with the connection between human formation and that of types in or near the line of descent.

Ontogeny is the formation of the individual apart from his evolution. The ontogenetic development of an individual is, in a very general way, a recapitulation of his phylogenetic development, but any phylogenetic suggestions gained from ontogenetic study must be submitted to the tests of extended comparative embryological search before they can stand.

Other terms of more particular application will be explained as occasion arises.

CHAPTER II

GENERAL EMBRYOLOGY

Embryology treats of the embryo and the development of its tissues and organs from the stage of the fertilized ovum to their mature condition.

Two factors are concerned in the formation of the embryo—namely, (1) the **male pronucleus,** formed by the *head* and a portion of the *middle piece* of a spermatozoon or male germ-cell, and (2) the **female pronucleus** and the cell-body of the *mature* ovum or female germ-cell. The two factors together lead to the **fertilized ovum.** The embryo is composed of cells derived from the fertilized ovum. Every cell comes from a pre-existing cell by cell-division. It will be well to consider first the general structure and mode of division of an animal cell before describing those of the specialized germ-cells.

The Animal Cell.

The animal cell is a mass of a living substance called **protoplasm.** The essential component parts of the cell are (1) a cell-body, and (2) a nucleus. The nucleus may contain one or more nucleoli, but these are not essential elements. The protoplasm of the cell-body is called the **cytoplasm,** or **cell-protoplasm,** and it may be enclosed (as in the ovum) within an envelope, called the **cell-membrane,** which is simply a condensation of the peripheral cytoplasm. The protoplasm of the nucleus is called the **karyoplasm,** or **nucleoplasm,** and it is enclosed within an envelope called the **nuclear membrane.** The animal cell is therefore 'a mass of protoplasm containing a nucleus.'

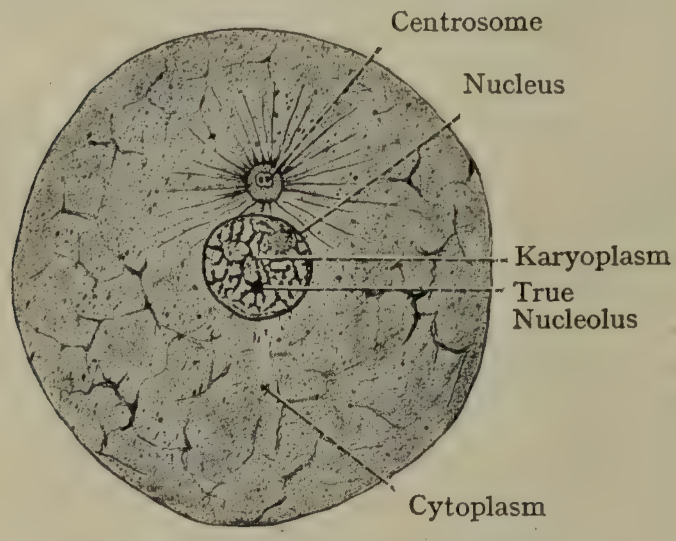


Fig. 2.—The Animal Cell.

Cytoplasm.—The cytoplasm is the protoplasm of the cell-body, as distinguished from the karyoplasm, which is the protoplasm of the nucleus. It is viscid, translucent, and more or less granular. At the periphery it may be condensed to form a cell-membrane. The basis of the cytoplasm consists of a network of slender filaments, which is known as the *spongioplasm* or *cyto-reticulum.* The meshes of this reticulum are occupied by a semifluid substance called the *hyaloplasm.*

The cytoplasm contains granules, which are called *cyto-microsomes*. The hyaloplasm, in addition to the cyto-microsomes, contains several non-protoplasmic bodies—*e.g.*, food-particles and pigment-granules—which are known as the *deutoplasm*.

In most cells, usually close to the nuclear membrane, but external to it, there is a small spherical area of cytoplasm, from which lines radiate outwards into the cell-protoplasm. This area is called the **centrosome** or **attraction-sphere,** and the protoplasm around the area is known as the **archoplasm.** At the centre of the centrosome there are usually two small nodules of protein matter, called the *central* or *attraction-particles*, from which lines radiate outwards into the archoplasm and cytoplasm. The centrosome thus constitutes the *aster*, and it plays an important part in nuclear division by mitosis.

The **cell-membrane,** when present, is a condensation of the peripheral cytoplasm. In many cells, however, it is absent.

The Nucleus.—The nucleus is usually situated eccentrically in the cytoplasm. Its protoplasm is called karyoplasm, and the nuclear elements are as follows:

1. Nuclear membrane.
2. Nuclear reticulum.
3. Karyoplasm.
4. Nucleoli.

The **nuclear membrane** is a well-defined envelope which surrounds the nuclear contents and separates them from the cytoplasm. It consists of the elements of the nuclear reticulum—namely, nuclein containing chromatin, and linin.

The **nuclear reticulum,** which corresponds to the spongioplasm of the cell-protoplasm, consists of **nuclein,** containing a stainable material called *chromatin*, arranged in granules. These granules are connected by threads of *linin*.

The **karyoplasm,** which corresponds to the hyaloplasm of the cell-protoplasm, occupies the meshes of the nuclear reticulum, and contains granules, known as *karyosomes*.

The **nucleolus** (sometimes absent) may be one or more in number. There are two kinds of nucleoli—true and false. The *true nucleoli* lie in the nuclear reticulum, or, it may be, in the karyoplasm. The *false nucleoli* are nodes which are connected with the filaments of the nuclear reticulum, where they intersect.

Cell-Division.

Cells increase in number by division: this is therefore a physical necessity for growth and, more indirectly, for differentiation.

There are two kinds of cell-division—namely, *karyokinetic* or *mitotic*, which is indirect division, and *akinetic* or *amitotic*, which is direct division.

Karyokinesis or Mitosis.—This kind of cell-division is of a very complicated nature, and the changes involved affect both the nucleus and the centrosome. It is convenient to consider it under four phases

—namely, (1) the anaphase, (2) the metaphase, (3) the kataphase, and (4) the telophase.

Anaphase.—The anaphase constitutes the preparatory stage, and it includes three phenomena, all of which lead ' up ' to the metaphase, as follows:

1. Formation of spireme. 2. Formation of chromosomes.
3. Formation of spindle.

Spireme.—The chromatin and linin of the nuclear reticulum and nuclear membrane become transformed into a coiled thread, called the *spireme* or *skein*.

Chromosomes.—The spireme is broken up transversely into an even number of segments, called **chromosomes,** the number of these being constant and characteristic of the species of animal. These chromosomes usually assume the form of short rods, which resemble a **V**.

Spindle.—Whilst the chromosome-stage is in progress, important changes take place in the stellate centrosome or aster. It divides into two segments, each division taking up a central or attraction-particle, and being furnished with radiating fibres. In this manner two centrosomes or asters are formed. Certain of the radiating fibres extend from one centrosome to the other in a fusiform manner, and these connecting fibres, called the spindle-fibres, constitute the spindle, which has a centrosome or aster at either pole. As the nucleus becomes elongated transversely, the two centrosomes take up positions one at either pole of the somewhat elliptical nucleus, the spindle-fibres becoming gradually elongated. Up to this point the spindle, with an astral centrosome at either pole, is external to the nuclear membrane, but when this membrane disappears the spindle becomes intranuclear, and the spindle-fibres extend from one pole of the nucleus to the other, where they are connected with the two astral centrosomes respectively.

The foregoing phenomena conclude the anaphase or preparatory stage.

Metaphase.—After the disappearance of the nuclear membrane, the chromosomes are brought into direct contact with the spindle, and lie at first scattered between the spindle-fibres. Very soon, however, they congregate at the equatorial plane of the spindle, which corresponds to its widest part. Here they are arranged in a stellate manner, which constitutes the *aster*, according to some authorities. Each chromosome now splits longitudinally into two equal parts, called **daughter-chromosomes,** the original number of parent-chromosomes being thereby doubled. The formation of daughter-chromosomes constitutes the metaphase or chief stage.

Kataphase.—The daughter-chromosomes at first form two rows at the equatorial plane of the spindle, lying close to each other. They soon, however, separate, those of each row travelling along (*metakinesis*) the corresponding spindle-fibres to either pole of the spindle, where they lie close to the centrosome. These phenomena conclude the kataphase, or leading ' down ' stage.

Telophose.—The daughter-chromosomes within each aster now unite end to end, and form a spireme, round which a new nuclear

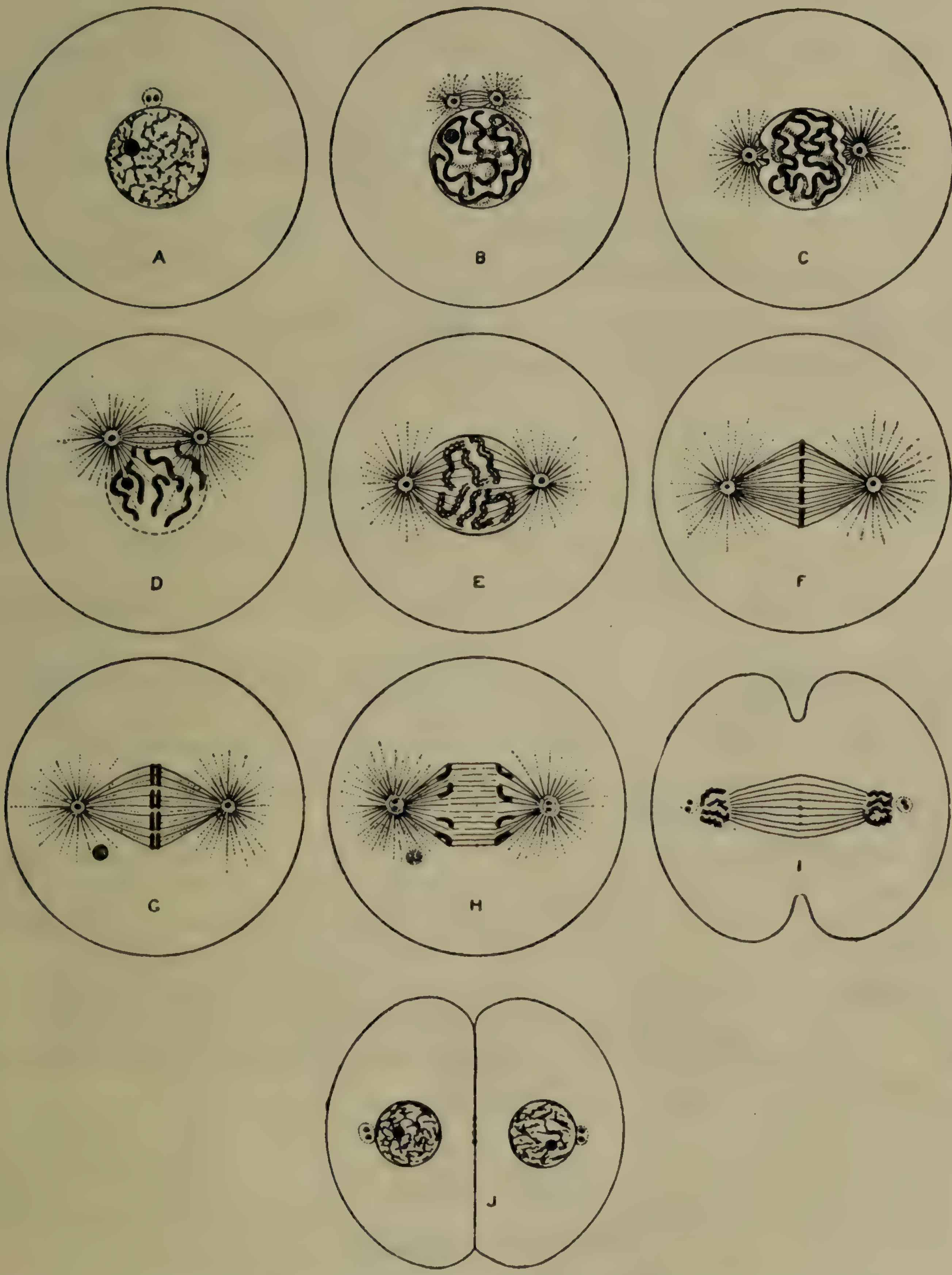


FIG. 3.—STAGES OF KARYOKINESIS (FROM E. B. WILSON'S 'CELL,' BY PERMISSION OF THE MACMILLAN COMPANY, NEW YORK).

A, resting-cell; B, early anaphase; C, later anaphase; D, later anaphase; E, latest anaphase; F, cell ready for karyokinesis; G, metaphase; H, kataphase; I, telophase; J, division complete.

membrane is formed. The spireme gradually assumes the form of a chromatic reticulum, characteristic of a normal nucleus, and karyo-

plasm is formed within the meshes of the reticulum. Two **daughter-nuclei** are thus constructed, one in either centrosome, each of which contains one-half of the parent-chromosomes belonging to the original cell. The cytoplasm of the parent-cell now becomes constricted at the equatorial plane, and by the deepening of this constriction the cytoplasm is divided into two halves, which separate from each other, each half surrounding the nuclear membrane of the corresponding daughter-nucleus. Two complete **daughter-cells** are thus formed, and the telophase or concluding stage is finished.

The complex changes concerned in the mitotic division of the parent-cell are concluded with the formation of two complete daughter-cells.

Summary of Karyokinesis, or Mitosis.—There are four phases—namely, anaphase, metaphase, kataphase, and telophase.

The **anaphase** consists in (1) the conversion of the linin—and chromatin—reticulum of the nucleus into a **spireme,** or **skein ;** (2) the breaking up of this spireme into **chromosomes ;** and (3) the formation of a **spindle** from the spindle-fibres which connect the two centrosomes, these centrosomes gradually separating from each other, and the nuclear membrane disappearing.

The **metaphase** consists in the congregation of the chromosomes at the equatorial plane of the spindle.

The **kataphase** consists in (1) the splitting of each chromosome into two **daughter-chromosomes,** and (2) the migration of these daughter-chromosomes from either side of the equatorial plane of the spindle along the corresponding spindle-fibres to either pole of the spindle where they enter the aster.

The **telophase** consists in (1) the formation of a **daughter-nucleus** within each aster, and (2) the cleavage of the cytoplasm of the parent-cell into two halves, each of which surrounds the corresponding daughter-nucleus, two daughter-cells being thereby formed.

Amitosis.—This is *direct* cell-division. The nucleus is simply cleft into two daughter-nuclei, with accompanying cleavage of the cytoplasm. It is possible that this mode of division occurs more frequently than is usually thought to be the case.

Germ-Cells.

The Spermatozoon.

Spermatozoa are male germ-cells. They are end products of a division series of genital cells; cells termed **spermatids** are the last stages of division, and these are transformed into **spermatozoa.**

A **spermatozoon** is essentially a cell, though it has undergone considerable modifications from the usual cell-type. It is an elongated body, which is endowed with remarkable power of movement, the movement being of a lashing or vibratory nature. It consists of the following parts:

1. A *head*, somewhat pointed, and compressed from side to side. It is provided with a *head-cap*, which forms the *perforaculum*, for penetrating the ovum. The head represents the nucleus of the parent-spermatid, the archoplasm of which forms the head-cap.

2. The *neck*, which is a thick disc behind the head, containing the *anterior centrosomal body*.

3. The *tail*, containing the *posterior centrosomal body*, and consisting, behind this, of an *axial filament* surrounded by certain coverings. The tail has three parts: (*a*) a *middle piece*, in which the axial filament is surrounded by a *spiral filament* and covered by a *mitochondrial sheath*; (*b*) a *flagellum* or *main piece*, in which the axial filament is surrounded by a *cytoplasmic sheath*, which becomes thinner as it is traced backwards; (*c*) the *terminal filament* or *end piece*, in which there is no covering for the axial filament.

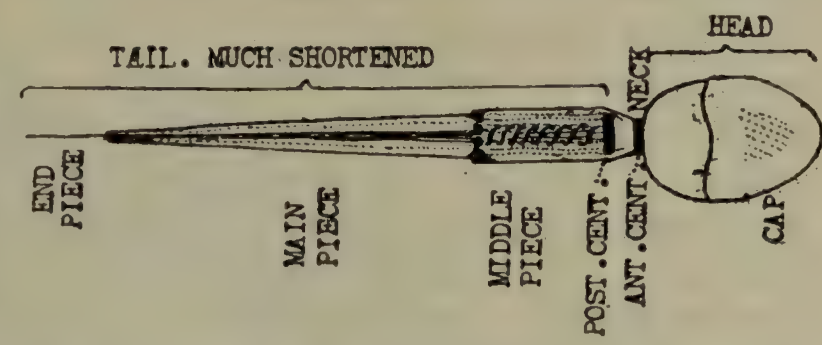


FIG. 4.—HEAD OF SPERMATOZOON ENLARGED, MAIN PIECE CONSIDERABLY SHORTENED.

The average length of the entire spermatozoon is about 0·05 to 0·06 mm., of which the head measures about one-twelfth. It has been calculated that there are about 200 million spermatozoa in an average ejaculation, and that the production of spermatozoa during life may lie between 300 and 400 billions.

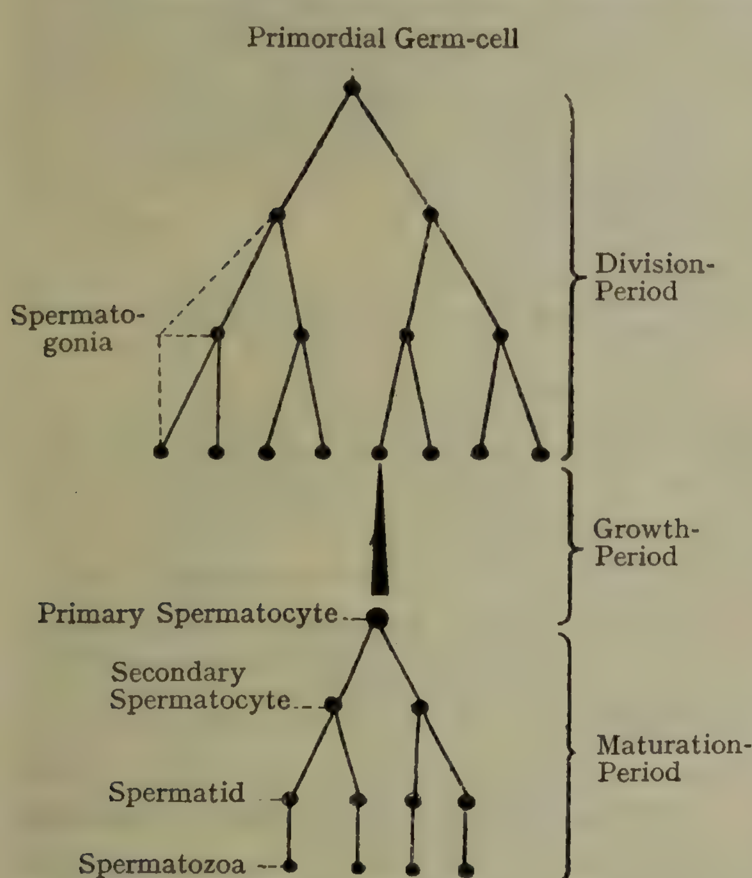


FIG. 5.—DIAGRAM SHOWING SPERMATOGENESIS (AFTER BOVERI).

Spermatogenesis.

Spermatogenesis is the development of spermatozoa, which are formed in immense numbers within the tubuli seminiferi of the testes. Each spermatozoon is developed from the **germinal epithelium,** its original source being known as the **primordial germ-** or **sperm-cell,** which is of large size. These cells undergo several mitotic divisions, and from the last generation **spermatogonia** are developed, which correspond to the **oögonia** of the female. These spermatogonia divide, by mitosis, and give rise to **primary spermatocytes,** two for each spermatogonium, and these correspond to the female **primary oöcytes.** Each

primary spermatocyte divides, by mitosis, into two cells, which are known as the **secondary spermatocytes,** and correspond to the female **secondary oöcytes.** Each secondary spermatocyte, in turn, divides, by mitosis, into two cells, which are called **spermatids,** and each of these corresponds to the **mature ovum** of the female. Each spermatid now undergoes transformation into a **spermatozoon,** the change taking place within a cell or column of Sertoli (sustentacular cell). Prior to its full development a spermatozoon has passed through four stages—namely, (1) a spermatogonium; (2) a primary spermatocyte; (3) a secondary spermatocyte; and (4) a spermatid. When the primary spermatocyte divides to form two secondary spermatocytes, the mitotic change preceding this is of the nature of a *reduction-division*, the resultant daughter-cells possessing only half the specific number of chromosomes. This division is thus heterotypical. The next division, into spermatids, is homotypical, but the number of chromosomes, of course, remains the reduced or haploid number.

From one primary spermatocyte (mother-cell) there thus result four grand-daughter cells of equal size, each of which is a spermatid. These spermatids subsequently undergo transformation, each into an active spermatozoon, capable of fertilizing a mature ovum.

The Ovum.

The ovum or oöcyte, which is the female germ-cell, has all the characters of a typical cell, being specially remarkable for the large size of its nucleus and nucleolus. It is formed within a Graafian follicle of the ovary, and it has a diameter of $\frac{1}{125}$ inch. Its component parts are as follows:

1. Cell-wall.
2. Cell-body.
3. Nucleus.
4. One or more nucleoli.

The **cell-wall** is known as the vitelline membrane.

The **vitelline membrane** surrounds the vitellus, of which it is a peripheral condensation. External to the vitelline membrane is the **zona pellucida,** which is separated from the vitelline membrane by a narrow interval, called the *perivitelline space.* When examined under a high power of the microscope, it presents very delicate striæ, which radiate across its breadth, and from this circumstance it is known as the **zona radiata.** These striæ are regarded as minute pores or passages.

External to the zona radiata there are several layers of cells, which are disposed in a radiating manner and constitute the **corona radiata.** These cells, like the zona radiata, are derived from the discus proligerus within the Graafian follicle, and the innermost cells send processes through the pores of the zona radiata to the cytoplasm of the ovum.

The **cell-body,** as in an ordinary cell, consists of cytoplasm (oöplasm), and this presents the usual reticulum or spongioplasm, the meshes of which are occupied by hyaloplasm. The oöplasm constitutes the **vitellus** or **yolk.** Embedded in it there are several fat-globules and

albuminoid granules. These granules constitute the *deutoplasm* or *nutritive yolk*. According to some authorities, the vitellus contains, in the earlier stages, an attraction-sphere and centrosome, situated close to the nuclear membrane.

The **nucleus** represents the **germinal vesicle**, and constitutes the essential part of the ovum. As will be presently described, it forms the mature ovum or female pronucleus, after extrusion of the two polar bodies. It is a large spherical body, situated at first at the

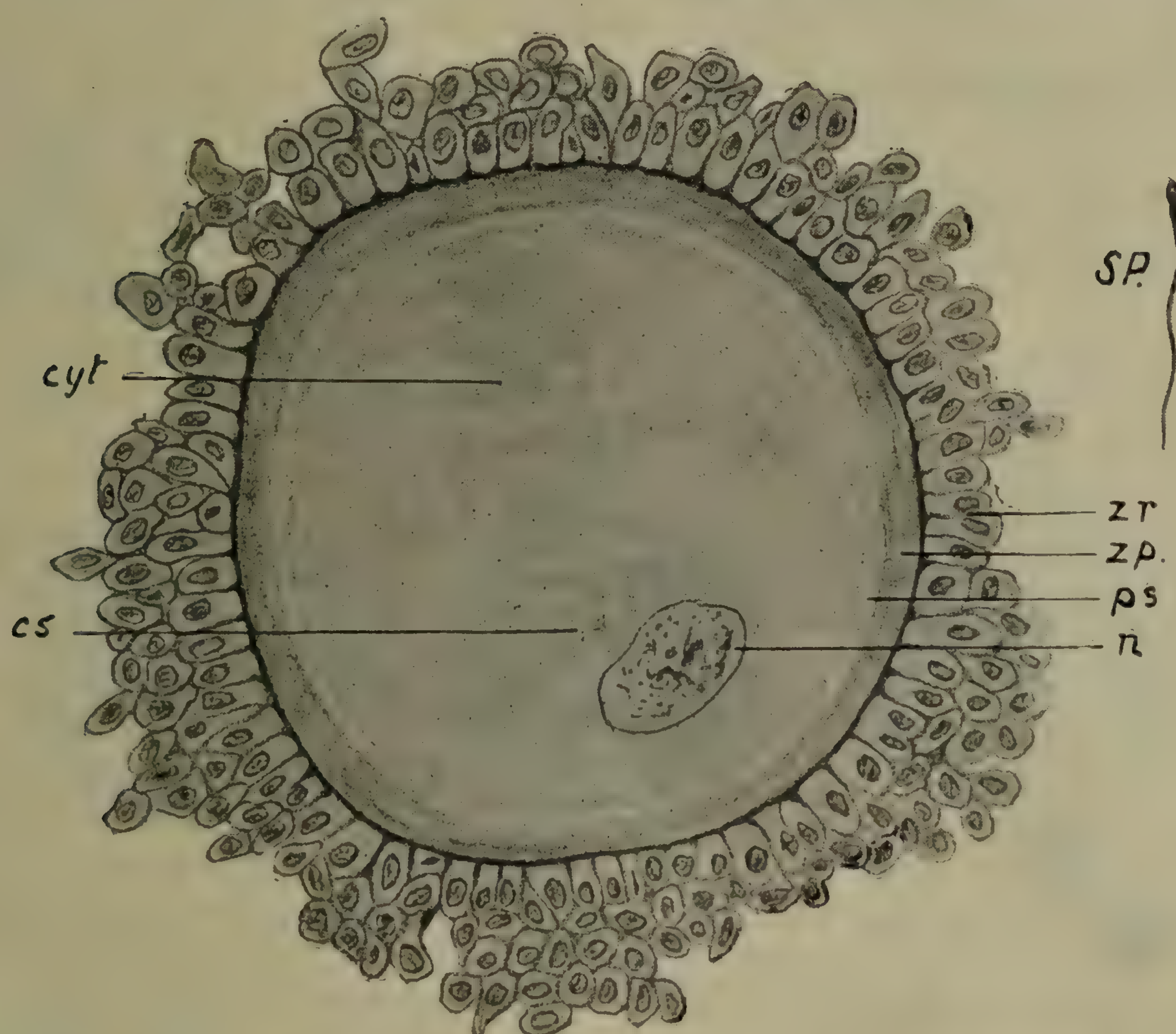


FIG. 6.—MATURE OVUM, SEMIDIAGRAMMATIC, WITH FIGURE OF SPERMATOZOON AT SAME MAGNIFICATION (× 300) TO SHOW RELATIVE SIZES.

cyt, body of ovum; *cs*, centrosome; *n*, nucleus; *ps*, perivitelline space; *zp*, zona pellucida; *zr*, corona radiata.

centre of the ovum, but subsequently becoming eccentric. Its diameter is about $\frac{1}{500}$ inch, and it consists of the following parts:

1. Nuclear membrane.
2. Nuclear reticulum.
3. Karyoplasm.
4. Nucleolus.

The **nuclear membrane** is well marked, and is formed by the chromatin and linin of the nuclear reticulum. The **nuclear reticulum** resembles that of a typical cell.

The **karyoplasm** occupies the meshes of the nuclear reticulum.

The **nucleolus** is often termed the **germinal spot.**

Oögenesis.

Oögenesis is the development of mature ova. Each ovum is developed from the *germinal epithelium*, the remnant of which epithelium covers the adult ovary. The original source of the ovum is known as the **primordial germ-cell.** These cells undergo many mitotic divisions, and, from the last generation, **oögonia** are developed, which correspond to the spermatogonia of the male. These oögonia divide by mitosis, and give rise to **primary oöcytes.** Each primary oöcyte represents the ovum as it leaves the Graafian follicle, and it corresponds to a male **primary spermatocyte.** In the process of development each primary oöcyte undergoes two mitotic divisions, one after the other. In the first division the primary oöcyte (mother-cell) extrudes the *first polar body*, and then it becomes a **secondary oöcyte,** which corresponds to a **secondary spermatocyte** of the male. In other words, the primary oöcyte divides by mitosis into two cells—namely, (1) the first polar body, of small size; and (2) the secondary oöcyte. In the second division the secondary oöcyte (daughter-cell) extrudes the *second polar body*, and then it becomes a **mature ovum (female pronucleus)**. In other words, the secondary oöcyte divides, by mitosis, into two cells—namely, (1) the second polar body, of small size; and (2) the mature ovum (female pronucleus), which latter only undergoes further division if fertilized. *Prior* to its maturation, the ovum has passed through three stages—namely, (1) oögonium, (2) primary oöcyte, and (3) secondary oöcyte. The **mature ovum** corresponds to a male **spermatid,** the difference, in the case of the latter, being that the spermatid undergoes further transformation into a spermatozoon.

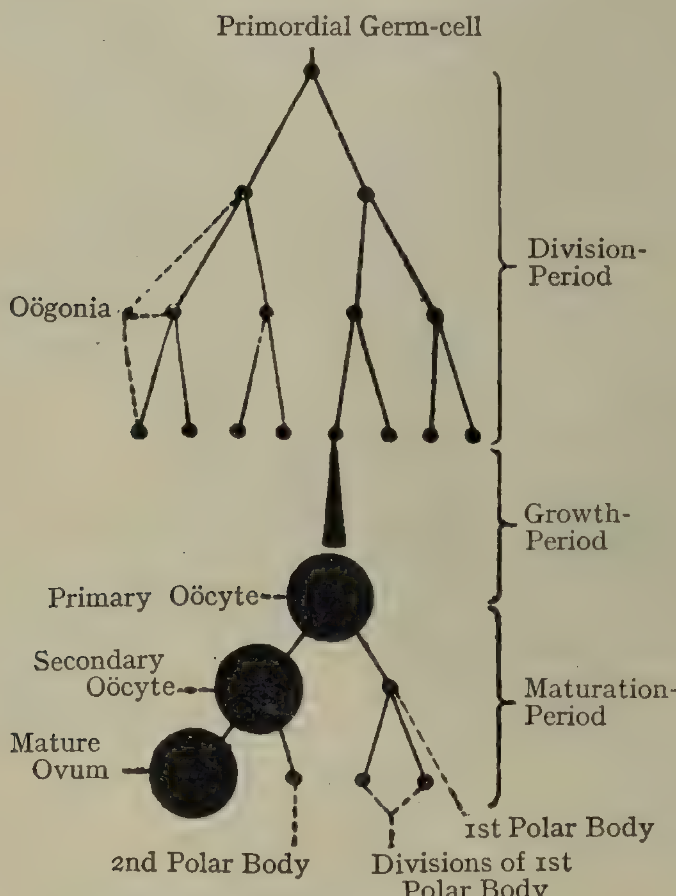


FIG. 7.—DIAGRAM SHOWING OÖGENESIS (AFTER BOVERI).

A reduction-division, as in the male cell, takes place at a corresponding stage. The primary oöcyte divides by the modified mitosis, giving a reduced or haploid number of chromosomes to its two products. One of these, the secondary oöcyte, possessing this haploid number, divides with homotypical mitosis and passes this haploid number on to the mature ovum.

From one primary oöcyte (mother-cell) there thus finally result four grand-daughter cells, one large and three small—namely, the mature ovum (female pronucleus) of large size, and three small polar bodies,

the first polar body, as a rule, having divided into two small cells. The mature ovum is capable of fertilization, but the polar bodies (abortive ova) are inactive and disappear.

Table of Comparison between the Male and Female Germ-cells.

Male.		Female.
Spermatogonium ..	=	Oögonium.
Primary spermatocyte ..	=	Primary oöcyte.
Secondary spermatocyte	=	Secondary oöcyte.
Spermatid	=	Mature ovum.

Though there is a great resemblance between spermatogenesis and oögenesis, two differences are to be noted: (1) The final result in oögenesis is the formation of four cells—namely, (*a*) the mature ovum, of large size, and capable of fertilization; and (*b*) three, as a rule, polar bodies, all small, quite inactive, and subsequently disappearing. In

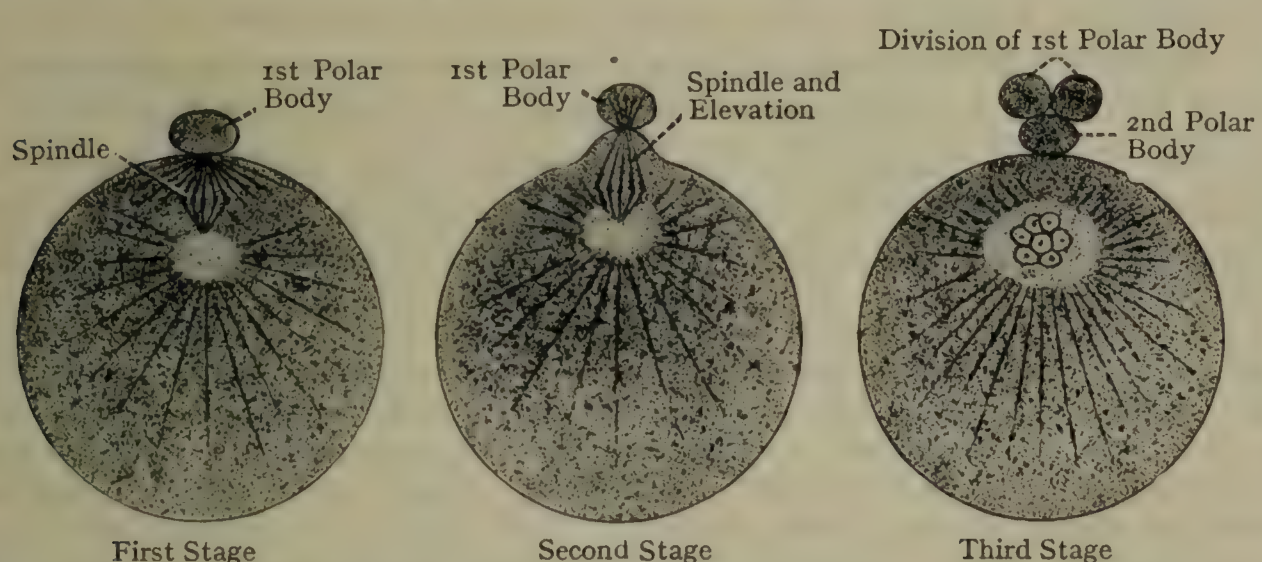


FIG. 8.—EXTRUSION OF POLAR BODIES (MODIFIED AFTER HERTWIG).

spermatogenesis, on the other hand, though four spermatids are formed at the same stage of cell-division as in oögenesis, they are all equal in size. (2) The mature ovum undergoes no further change, unless it becomes fertilized. Each spermatid, on the other hand, becomes transformed into an active spermatozoon, capable of fertilizing a mature ovum. Spermatogenesis may therefore be said to comprise one stage more than oögenesis, but this additional stage is not one of cell-division, but is simply the transformation of a spermatid into a spermatozoon.

Reduction-Division.*—This process is one by which the number of chromosomes or segments of the chromatin spireme within the nucleus is reduced to half that characteristic of the body cells in general. The reduction takes place at the first division, when the primary sper-

* This term is used here in a simple sense, as a convenient label for the process in which the number of chromosomes is reduced. It must not be confounded with the expression ‘ reducing division ’ as originally used by Flemming, which was applied to a process leading to a qualitatively unequal division of chromosomes.

matocyte or oöcyte forms the secondary spermatocyte or oöcyte. In this division, when the chromosomes are differentiated from the spireme, a process of *synapsis* takes place, whereby pairs of chromosomes fuse together; this leads to halving of the actual number of chromosomes. The spindle formation and subsequent stages of cell-division now proceed more or less as usual, the resultant daughter-cells consequently possessing only half the number of chromosomes presented by the original unmodified cell. The division differs, therefore, from the typical one in the occurrence of synapsis and its results, and is spoken of as *atypical* or *heterotypical.*

The secondary spermatocyte and oöcyte pass on to their subsequent divisions, by which the final products are formed. These divisions proceed in the ordinary way with, of course, the already reduced number of chromosomes. They are therefore *homotypical.* The final result is that, from each original spermatogone or oögone, four cells are produced of the same *nuclear* value, although their *functional* value from a reproductive point of view differs in the two sexes, as will be seen later. Each of these nuclei has a chromosome number (*haploid* number) half that of the original (somatic) number (*diploid* number).

It may be noted also that a certain amount of nuclear chromatin is discharged from the nucleus in later stages of the mitotic changes, and lost in the surrounding cytoplasm; this is most marked in the female cell.

The synaptic fusion of chromosomes, which leads to the acquisition of the haploid number in the heterotypical division, is a matter of much interest. When the ovum is fertilized by the conjugation with it of the nuclear material of the spermatozoon, the number of chromosomes is raised to the full by the addition of those of the male nucleus. The male and female chromosomes pair, but do not fuse. Thus the individual formed from this ovum contains in his cells an equal number of chromosomes from each parent, paired, but not fused. In the heterotypical division, however, these male and female parental elements fuse for the first time. Hence the mature sex-cells of the individual have only the haploid chromosome number, and the inter-relations of these elements are different.

It is obvious that such marked and constant changes occurring in the chromatin content and chromosome structure of the nucleus afford physical grounds for both qualitative and quantitative theories of variation and heredity, but these cannot be entered upon here. It may be said, however, that the reduction in chromosome number is a preparation for sexual conjugation, while the occurrence of conjugation is probably less concerned with actual reproduction or rejuvenescence than with the provision of material for the play of the forces of variation and heredity.

Ovulation.

The ovum lies for some time within a Graafian follicle in the ovary. At this period it is embedded within a heap of cells, known as the *discus proligerus.* The innermost cells of this discus, which are in direct contact with the ovum, form the **zona pellucida** or **zona radiata,**

and two or three layers of the succeeding cells give rise to the **corona radiata.** Within the Graafian follicle, besides the discus proligerus and ovum, there is some fluid, called the *liquor folliculi.*

Ovulation is the extrusion of the ovum from the Graafian follicle. As a follicle becomes mature, it approaches the surface of the ovary, being distended with fluid, and, when quite mature, it lies close beneath the surface. This part of the follicle presents a slight projection, on which there is a pale spot, called the *stigma.* The stigma, becoming very much attenuated, ruptures. The liquor folliculi then escapes, carrying with it the ovum, surrounded by the corona radiata and the zona pellucida or radiata, these, as stated, being derived from the discus proligerus. The expelled ovum, as a rule, gains the *ostium abdominale* of the Fallopian tube. Here it enters that tube, and is gradually conveyed into the cavity of the body of the uterus, where, if previously fertilized, it undergoes development into the embryo, and then into the fœtus.

Abnormal Conditions.—(1) The ovum may never leave the Fallopian tube, and, if fertilized, it would give rise to *tubal pregnancy.* (2) When expelled from the Graafian follicle and ovary, the ovum may drop into the abdominal cavity, and, if fertilized under these conditions it would give rise to *abdominal pregnancy.* (3) In extremely rare cases the ovum may not leave the Graafian follicle, even though that follicle and the ovary should rupture in the usual way. If fertilized under these conditions, it would give rise to *ovarian pregnancy.* These three abnormal conditions are spoken of as cases of *extra-uterine pregnancy.*

The periods of **ovulation** or extrusion of the ovum from the Graafian follicle and ovary, which occur at more or less regular successive intervals, are attended by certain changes in the mucous membrane of the cavity of the body of the uterus.

These changes are of the nature of a preparation of this membrane for the reception and embedding of the fertilized ovum, and are apparently brought about by the action of a hormone formed in the ovary under pituitary influence. When fertilization fails, the prepared mucosa breaks down and is partly cast off, constituting the phenomena of menstruation.

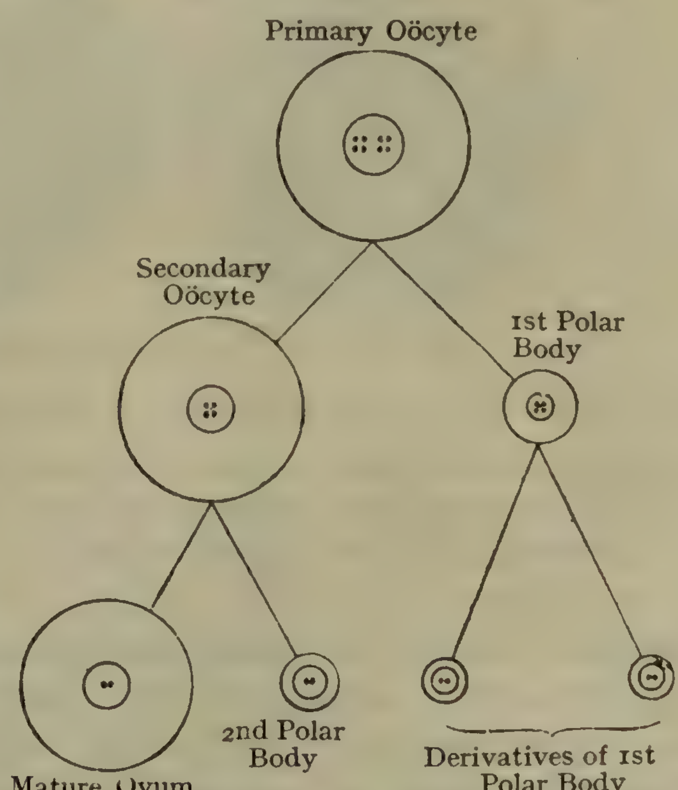


Fig. 9.—Maturation of the Ovum.

Maturation of the Ovum.

The immediate cause of the rupture of the follicle may possibly be the action of the involuntary muscle fibres within the ovary contracting in a period of sexual excitement. It is not known by what mechanism the extruded ovum, whatever the position of the follicle may be on the surface of the ovary, is conducted into the opening of the tube. Having entered the tube, it probably takes about a week or less to traverse this canal

and enter the uterus, from whence, if it has not been fertilized, it is discharged with uterine secretions or during menstruation.

In the majority of animals the maturation of the ovum, although it must, of necessity, precede the actual conjugation of the male and female pronuclei, is not *completed* before the entrance of the spermatozoon. In other words, the entrance of the sperm may take place either before, during, or after the maturation of the ovum. In the human ovum, however, the observations of Professor Arthur Thomson and Professor Dixon seem to make it reasonably certain that maturation, with discharge of the polar bodies, is completed before or as the ovum enters the Fallopian tube, in which, normally, it is fertilized.

When the ovum is discharged from the Graafian follicle it is probably mature and capable of being fertilized. The processes through which it has passed to attain to this state, possessing the reduced number of chromosomes, have been described already (see Oögenesis and Reduction-Division).

Fertilization of the Ovum.

Fertilization is otherwise spoken of as *impregnation*, or *fecundation.* It consists in the conjugation or fusion of the male pronucleus, or head of a spermatozoon, with the female pronucleus, or mature ovum,

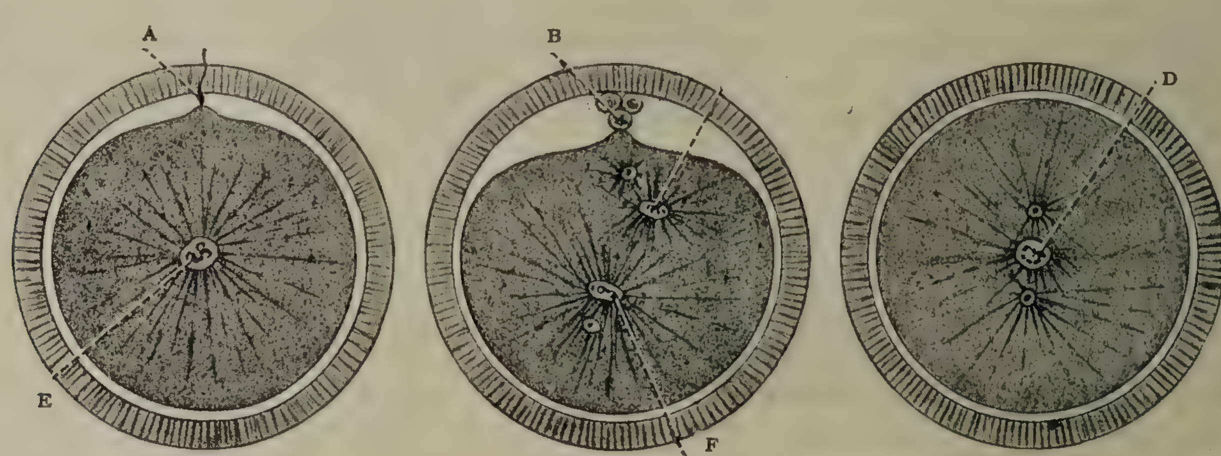


FIG. 10.—FERTILIZATION OF OVUM.

A, entrance of spermatozoon; B, extrusion of polar bodies; C, male pronucleus; D, compound nucleus (male and female pronucleus); E, female pronucleus (ovum); F, female pronucleus.

and it constitutes the commencement of the development of a new individual to propagate the species. As a general rule, conjugation of spermatozoon and ovum takes place in the outer part of the Fallopian tube, or oviduct, into which spermatozoa have made their way through the vagina and uterus by the lashing movement of their tails.

When the spermatozoa come into contact with the mature ovum one of them as a rule passes through the zona pellucida, or radiata, into the yolk. At the point of entrance the yolk forms a conical

protuberance, called the *receptive*, or *entrance cone*. As the spermatozoon passes through this cone it parts with its tail, the surrounding vitellus becoming disposed in a radiating manner. Meanwhile a delicate membrane is formed round the yolk, called the vitelline membrane, which prevents the entrance into the yolk of other spermatozoa as a rule.

The **head,** or *nucleus*, of the spermatozoon now constitutes the **male pronucleus,** or **sperm-nucleus,** and the middle piece contains a centrosome, called the *spermo-centre*. The male pronucleus advances towards the centre of the ovum, near which, up till now, the mature ovum, or **female pronucleus,** is lying quiescent, being destitute of its original centrosome, which has disappeared. As the male pronucleus, along with its centrosome, advances, the centrosome leading the way, the female pronucleus shows receptive signs, and moves slightly to meet the approaching visitor. The two pronuclei then come into very near contact, not far from the centre of the ovum, but they do not as yet fuse. The male centrosome, or spermo-centre, now divides, and two centrosomes are formed, one of which passes to the distal side of the female pronucleus. Conjugation or fusion of the two pronuclei now takes place, and the *mixed* nucleus thus produced is called the **segmentation,** or **cleavage-nucleus.**

This completes the stage of fertilization. A chromatic spireme, or skein, chromosomes, and a spindle are subsequently formed within the segmentation-nucleus, and the *segmentation-stage* is entered upon—that is to say, cell-division with mitosis, or karyokinesis, takes place.

Certain authorities maintain that the ovum, after parting with the second polar body, retains a centrosome, known as the *ovo-centre*. The male pronucleus, as stated, brings with it a centrosome or *spermo-centre*. Each ovo-centre and spermo-centre divides into two, and each division of the ovo-centre joins a division of the spermo-centre. When, therefore, fusion of the two pronuclei has been effected, the resultant segmentation-nucleus has two *mixed* centrosomes (male and female), one on either side, or at each pole.

Segmentation of the Ovum.*

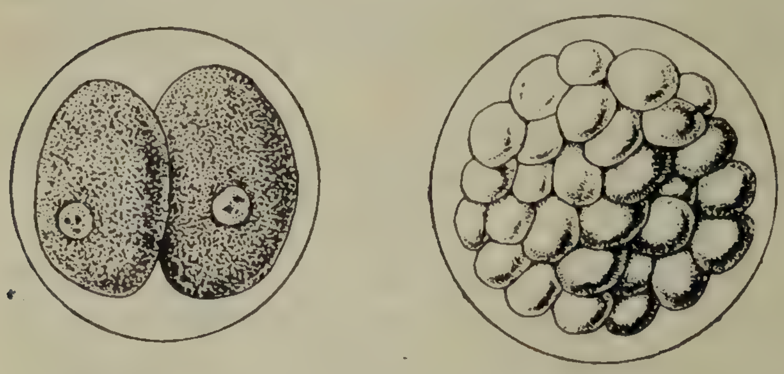
Segmentation consists in the division of the fertilized ovum into a mass of cells.

After the mature ovum, or female pronucleus, has been fertilized by fusion with the male pronucleus, mitotic or karyokinetic cell-division commences, and the ovum is ultimately transformed into a great number of cells, which are called **blastomeres,**† or **segmentation-**

* The word 'ovum,' it will be noticed, is used to denote the egg-cell after fertilization, as well as before this. Such employment of the term has some disadvantages, which can, however, be neutralized with a little care. No suitable word has been coined which does not replace these disadvantages by others, and, as the older method is used in general by writers, it is retained here.

† The prefix *blast*, derived from a Greek word meaning 'germ' or 'beginning,' is used properly in those terms that describe the earliest-known morphological stage of development of some structure. Thus, a blastoderm is the earliest state of cell-layers from which an embryo will be formed, and a

cells. At the first division, which affects primarily the segmentation nucleus, the ovum is cleft into *two* cells, which lie close together, the opposed surfaces being flattened. At the second division each of these cells is cleft into two, so that *four* blastomeres now occupy the interior of the ovum. Each of these, in turn, divides into two, thus giving rise to *eight* blastomeres. This process of cell-division goes on, *sixteen* blastomeres being formed, succeeded by *thirty-two*, and so on. Finally, the ovum, originally simple, becomes transformed into a heap of nucleated blastomeres, or segmentation-cells, the superficial cells being clear, whilst the more deeply placed cells are granular. These constitute a solid, spherical, mulberry-like mass, called the **morula,** and this stage is hence known as the **morula-stage.**



First Division Final Division

FIG. 11.—SEGMENTATION OF OVUM.

Segmentation is not to be looked on as an actual part of specific development, but as a process of changes within the ovum which are necessary to allow it to begin its development. Every organism has a definite quantitative relationship between its nuclear and cytoplasmic masses, which must be attained before development can be carried on: segmentation is the process bringing this about. The rapid subdivision of the excessive cytoplasm of the ovum, with the gradual building up of the nuclei after their first formation by division, bring the mass of cells gradually toward the cyto-nuclear ratio. The additional material for the nuclei is obtained from the cytoplasm, within which a certain amount of nuclear constituents have been situated. The last stage of segmentation thus corresponds with the production of the first potentially developmental cells, and thus with the beginning of true development.

Segmentation has never been seen in the human ovum, but it must be assumed to occur as a preliminary to development.

The stages of development of the fertilized ovum, so far as they have been followed at present, may be said, in a general way, to be common to all the members of the animal kingdom. As development proceeds, the embryonic rudiment begins to take shape and to become definitely vertebrate in character, and subsequently grafts on to this generalized vertebrate form the large and small characteristics which place it in its special subdivisions, genus, and species. The characters of a vertebrate (Fig. 12) are the possession of a *longitudinal axial*

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blastomere is the earliest form of cell in the segmenting ovum. The affix may be at the end of the word, as, for example, in the term 'mesoblast,' met with later. Here the word, properly used, implies the very earliest state of the mass of undifferentiated cells which make the middle layer of the ovum and embryo, but, as soon as development has led in any evident way to an advance on the undifferentiated state, the word 'mesoderm' is used instead of 'mesoblast.'

skeleton, lying *below the central nervous system*, and the presence of a body-cavity or *cœlom* between the body-wall and the alimentary canal.*

The **axial skeleton** may be, as in the simplest forms, a non-jointed cartilaginous rod, or it may be hidden in a complicated system of vertebræ. The **cœlom** may be a common cavity within which the alimentary canal projects, and the heart is placed towards the cephalic end, or these two structures may be more or less shut off from one another by septa forming in the cœlom, and, in air-breathing animals, the pleural sacs, containing the lungs, are also derived from the cœlom. The **alimentary canal** opens in front (mouth) and behind (anus), and the **central nervous system** forms a *brain* at its front end, which may secondarily project forward over the situation of the mouth.

The human embryo, subsequent to the general development of the ovum, which has been already described, evolves from the cells of the ovum as a living vertebrate animal, possessing a central nervous system, a longitudinal axial skeleton, the **notochord**, and a cœlomic cavity separating its body-wall from the simple alimentary or 'visceral' structures. This may be looked on as the first period of development. The subsequent evolution of the details of bodily structure are engrafted on to the general vertebrate stage; they will consist, firstly, of the building up of an air-breathing type, and then of the necessary changes and additions which bring the mammalian human being out of this generalized state.

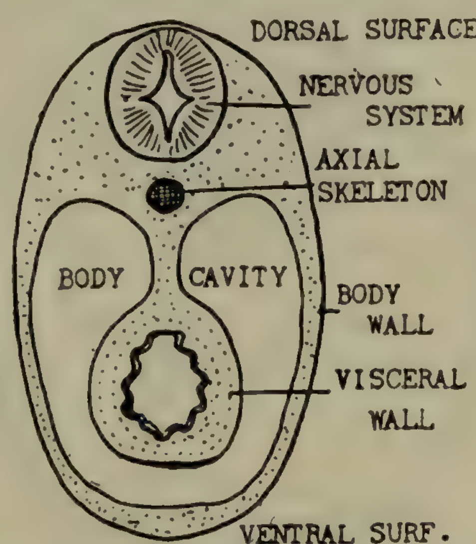


FIG. 12.—SECTIONAL SCHEME TO SHOW VERTEBRATE TYPE OF BODY.

It must not be imagined that these developmental periods are distinctly marked off from one another. They overlap in many ways, and the order of development given above is only true of the development as a whole. Nevertheless, it is convenient from a descriptive point of view to make use of such a conception of the evolution of the embryo, and the developmental changes, to the account of which we are just about to pass, may be looked on as

* The vertebrates are divided into three great classes: *Ichthyopsida*, or fishes; *Sauropsida*, including reptiles and birds; and *Mammalia*. It must not be thought, because the other members of the animal kingdom are termed 'lower' by man, that they are necessarily simpler or more primitive in their structure than man. Most of them are highly specialized for their own particular sphere in life, in some ways more specialized than so-called higher animals. But among these divisions the more primitive fishes and reptiles may be considered to be nearest to the line of human descent. Since the adults have undergone more or less specialization, and since the embryo is a nearer approach to the primitive than the adult can be, the most reliable contributions to morphology can be obtained by comparison of the embryonic forms. Birds lie outside the line of descent, being only highly specialized developments from more primitive reptiles; hence morphological purposes are best served by comparison between mammalian, reptilian, and primitive fish embryos.

leading up to the evolution of the general vertebrate type from that representing a more primitive animal stock.

It may be said, finally, that man is a *placental* mammal; the embryo depends for its nutrition on supplies obtained from maternal sources, and, to do this effectively, develops an absorbent organ, the **placenta,** which comes into intimate relation and connection with the walls of the uterus. The functional mass of the placenta is formed from the wall of the ovum.

Formation of Blastula and Blastoderm.

It must be understood that the early stages of development, such as are now being described, have not yet been seen in the case of the human subject. Segmentation and the formation of a morula are among these unknown stages in man, but, from their universal appearance in other types, their existence among the human stages can be assumed almost certainly. The next stages, however, those of the formation of the blastula and of the earliest embryonic layers (blastodermic layers), being equally unknown, can only be assumed in their details on much less certain grounds, and the following account must be taken as little more than a suggestion of the lines along which these developments take place. The assumptions are based on what is known of the stages in other types resembling man in certain developmental characteristics.

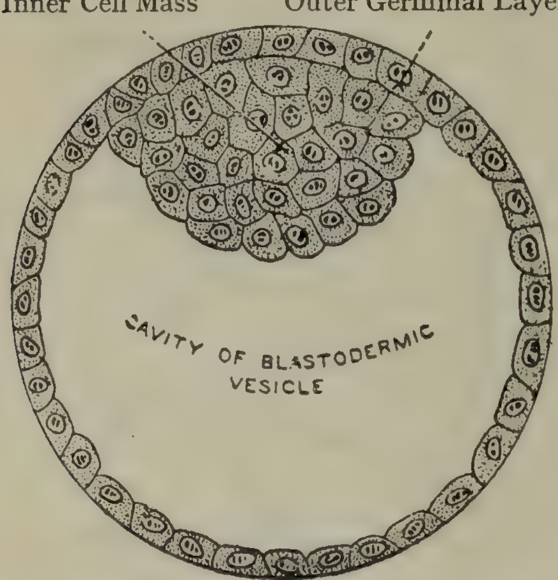


Fig. 13.—The Blastodermic Vesicle, showing the Segmentation Cavity and Inner Cell Mass.

The mass of cells composing the morula is soon converted into a hollow sphere consisting of a wall of cells surrounding a central cavity; the cavity is known as the *segmentation cavity* or *blastocœle,* the whole structure being termed a *blastula* or *blastocyst.*

The formation of a central cavity may be looked on as the natural biophysical result of the necessity of the cells obtaining their nutriment from the surrounding media, and hence occupying as superficial positions as possible in the sphere.

The peripheral disposition of the cells, however, is not equal throughout the sphere, for whereas the layer is thin—possibly only of the thickness of one or two cells—throughout the greater part of the wall of the blastocyst, yet a mass of cells is gathered near one pole, and projects into the segmentation cavity. This is known as the **inner cell mass** or **formative cell mass** (Fig. 13).

As a general statement it may be said that the inner cell mass is particularly concerned in forming the embryonic structures, the extra-embryonic structures of the ovum being associated with the

remaining parts of the blastula. The position of the inner cell mass marks the upper, apical, or animal pole of the ovum, the opposite end being termed the abapical or vegetative pole.

Restriction of the area of actual embryonic formation to one part of the whole ovum is a secondary development found among certain animals possessing a large amount of yolk stored in their egg-cells. Yolk (see p. 14) is a fatty material provided for the nutrition of the developing embryo. In the fertilized ova of different species it is found that the yolk may be more or less evenly distributed, thus making *isolecithal* eggs, or may be gathered towards the lower or abapical pole, these being known as *telolecithal* eggs. On the other hand, the yolk may be practically absent; this is an *alecithal* condition. The concentration of yolk granules leads to a comparative inertia in the cell-division of the region concerned, so that a telolecithal egg, when it segments, shows large and slowly forming cells (macromeres) towards its lower pole, and a large number of smaller cells (micromeres) near its upper pole, where the yolk granules are few or absent. The difference in rapidity and completeness of cell-formation between these two regions is more marked in those eggs that are heavily yolked and markedly telolecithal. In these cases of extreme and heavy telolecithality the actual proliferation of cells is practically confined to the upper pole, at any rate in the earlier stages, and the egg is termed *meroblastic*. In alecithal, isolecithal, or only moderately telolecithal eggs, division of the whole egg takes place, although the lower cells may be considerably larger than the upper ones, and the egg is then said to be *holoblastic*. In the meroblastic egg the area from which the embryo is forming is confined to one part of the ovum, for this is the only part admitting of the rapid cell-division necessary for the formation, but in the holoblastic egg the whole mass of cells is used in the actual formation of the embryo.

Among the placental mammals the eggs are, if not absolutely alecithal, only very moderately yolked, and are consequently holoblastic, yet they form an exception to the general statement made in the last paragraph: the embryo is developed from one polar region only of the ovum. This is explained by the assumption that their moderately yolked condition is a secondary one, that they were derived originally from heavily yolked telolecithal forms, but that, when they acquired the power of deriving nourishment directly from maternal sources, the storage of yolk became unnecessary, and was gradually lost. This change would allow holoblastic division to replace the original meroblastic type, but the limited blastodermic area still persists, being connected later with the acquisition of certain embryonic appendages, which will be dealt with later.

Changes occurring in Association with the Inner Cell Mass.

The first changes in the human blastocyst are not actually known as yet. They lead up to the earliest known stage, and may be assumed to be of a nature such as is schematically shown in Fig. 14. Spaces appear between the cells of the inner cell mass, and run together, making a single rounded cavity; this is the *amniotic cavity*, and is surrounded by a layer of cubical cells, the *epiblast*, or *primitive ectoderm*.

A second enclosed cavity is formed below this, the *archenteric cavity*, surrounded by *hypoblast* or *primitive entoderm*. Nothing can be said definitely about its mode of formation; its cellular wall may spread round the wall of the blastocœle from the inner cell mass, or may be formed by splitting occurring among the lower cells of this mass.

The two-layered plate of ectoderm and entoderm, separating these cavities, is the *embryonic plate*; this is the earliest form of definition of *the region from which the embryo itself will be developed later*.

The most superficial cells of the original blastocyst now form a

FIG. 14.—DIAGRAM TO SHOW SPACES BETWEEN THE CELLS OF THE INNER MASS JOINING TO FORM THE AMNIOTIC CAVITY (A).

E, archenteric cavity; S, segmentation cavity; T, trophoblast.

complete covering layer or *trophoblast*, so called because it is directly concerned, now and subsequently, with the absorption of nutriment for the contents of the ovum. The zona radiata has disappeared completely, but it is not known under what conditions this occurs.

Attainment of Earliest Known Human Stage.

All the stages described so far are passed through, in all probability, during the transit of the fertilized ovum through the tube, and during its short stay in the uterus preceding its fixation there by the process of ' embedding ' to be described later. This preliminary stage of transit probably takes a week or ten days to accomplish.

The next stage of development of the ovum after those described above is shown in Fig. 15. This practically corresponds with the earliest known fertilized human ovum.

This ovum had apparently just embedded itself, but its structural stage may be assumed to have been the same, to all intents and purposes, immediately before the embedding.

The figure shows the small amniotic and archenteric cavities as before, but there are marked differences in other respects. The interior of the ovum is now occupied by *mesoblast*, or *primitive mesoderm*; this does not extend between the ectodermal and entodermal layers of the embryonic plate, whence it is termed *extra-embryonic mesoderm*.

The origin of this extra-embryonic middle layer is exceedingly doubtful, and it is possible that there may be more than one site from which it arises. Reference is made to this matter later from another standpoint.

The external covering of trophoblast has become much thicker, and it can be seen to be composed of two layers; one, deeper and next the mesoderm, is more or less distinctly seen to be cellular, but the more superficial and extensive layer shows no cell-boundaries, and is nothing but a nucleated plasmodial covering. These two

Fig. 15.—Ovum filled with Primitive Mesoderm (M).

Plasmodium (P) and cellular layer (C) compose the trophoblast. A, amnion; E, archenteron.

layers are called *cyto-trophoblast* (cellular trophoblast) and *plasmodi-trophoblast* respectively, and, taken together, they constitute the trophoblast.

It is possible that the plasmodium, which by its digestive powers effects the embedding of the ovum, is a solid and continuous layer before and during this process, but, as soon as the ovum is embedded, the layer grows and pushes itself out towards the surrounding mucous membrane of the uterus; in doing this it develops cavities and lacunæ in its mass, and forms a plasmodial network, as is shown in the figure.

The Embedding in the Uterine Mucosa.

The mucous membrane of the uterus, known as the *decidua* or *decidual membrane*, is a thick and vascular layer when the fertilized ovum comes into contact with it. The ovum proceeds at once to embed itself in this membrane, bringing this about by the necrotic and digestive action of the plasmodi-trophoblast on the decidua.

The uterine decidua contains many glands, and is applied to the muscular wall of the organ without any intervening submucosa. Deeply, nearer the muscular wall, its gland-tubes are much convoluted

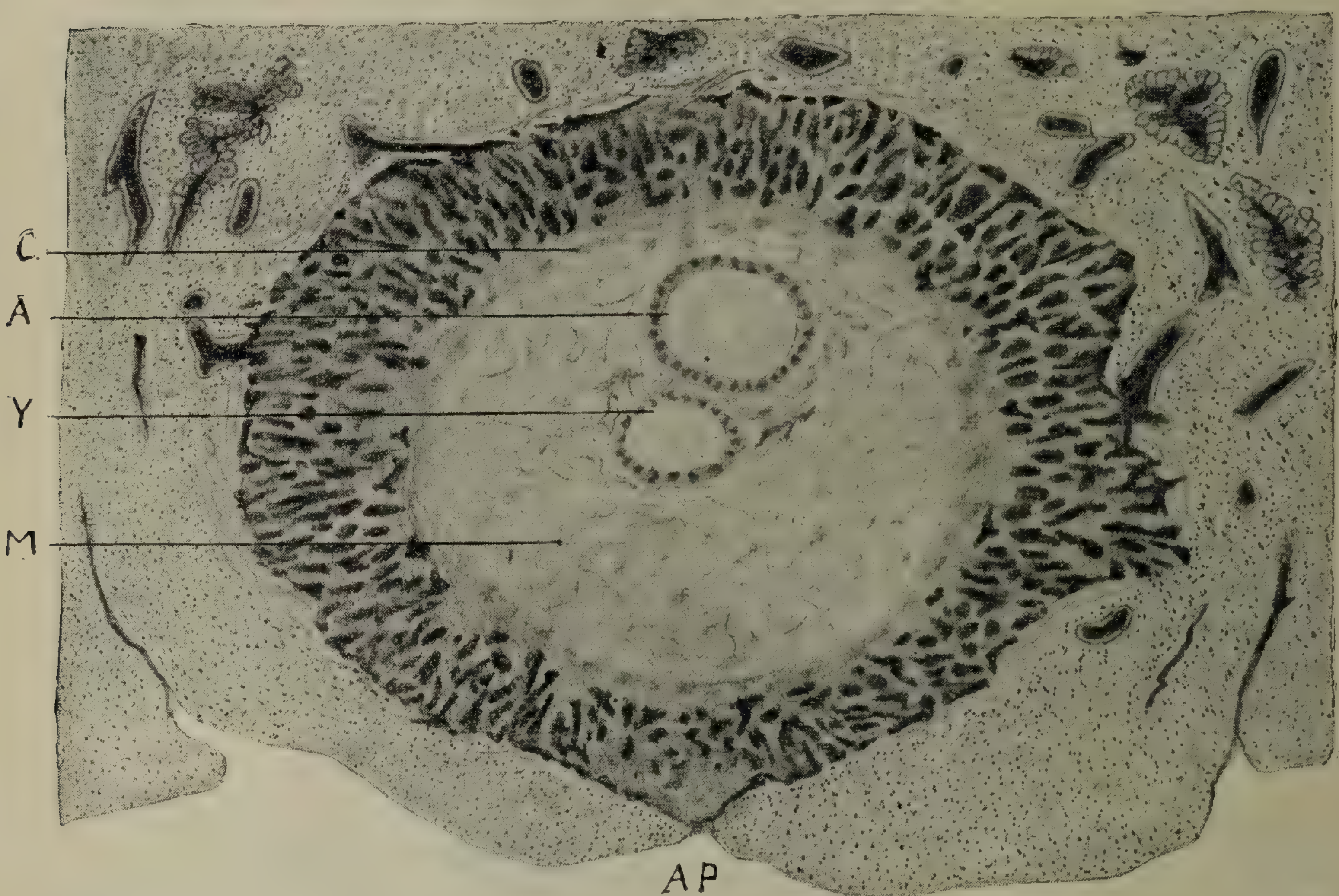


FIG. 16.—IDEAL SECTION THROUGH OVUM IN SITU.

A, cavity of amnion, lined by ectoderm; AP, aperture of entry; C, cytotrophoblast; M, primitive mesoderm; Y, archenteron.

and enlarged, giving this part a spongy appearance, whence it is called the **stratum spongiosum.** The more superficial part, nearer the uterine cavity, shows smaller gland tubes running towards the cavity, and is termed the **stratum compactum.** The stroma is composed of cells of embryonic type, and is very vascular. The uterine cavity is lined by a single layer of cubical ciliated cells.

The trophoblast covering the ovum quickly destroys the superficial parts of the decidua with which it is in contact, and in this way the ovum is very soon lying in a small 'implantation cavity' in the stratum compactum of the decidua. Here it increases rapidly in size owing to the absorption of fluid from the blood and semi-fluid detritus which

surround it in the implantation cavity. The cavity is also increased in size to contain it, not only by the enlargement of the ovum, but also by the continuing action of the trophoblast covering it. This layer is now, as already seen, in the form of a plasmodial network surrounding the ovum and stretching between it and the necrotic walls of the cavity. The diagrammatic section in Fig. 16 will give an idea of the conditions. The aperture of entry (AP in the figure) is quickly closed by swelling and infiltration of the covering decidua, and the subsequent growth and development of the ovum goes on within this cavity apart from the uterine cavity: the associated changes will be dealt with in the appropriate place. The site of embedding is frequently, but not by any means always, on the upper part of the posterior wall of the uterus.

Formation of Extra-Embryonic Cœlom, Chorion with its Villi and Body-Stalk.

To return to the ovum. The primitive mesoderm filling the ovum, in the stage last described, is a mass of loosely packed cells. Spaces appear between these and, running together, produce a fluid-filled cavity in the midst of the extra-embryonic mesoderm (Fig. 17). This cavity is the **extra-embryonic cœlom.** Its formation leaves the mesoderm applied, as a more condensed layer, on (*a*) the internal surface of the trophoblast, and (*b*) the surface of the ectodermal and entodermal vesicles that constitute the primitive amnion and archenteron respectively.

The new containing wall of the ovum, made in this way, is known as the **chorion,** and consists of *chorionic mesoderm* (CM, Fig. 17), covered externally by *trophoblast*; this layer is sometimes referred to as *chorionic ectoderm.* It can be seen in the figure that the chorionic mesoderm is invading the bases of the trophoblastic projections which pass from the surface to the surrounding network; as a matter of fact, the mesodermal growth into these begins before the formation of the extra-embryonic cœlom, and has made definite progress by the time this occurs. Each mesodermal outgrowth carries on it, as it grows, the two constituent layers of the trophoblast, the whole projection forming a **chorionic villus;** thus a chorionic villus consists of a core of mesoderm covered by cyto-trophoblast and plasmodi-trophoblast. Each villus has several side branches, but the growth of the mesoderm within it does not effect continuity with neighbouring growths through the plasmodial network. Each villus is a separate branched structure; it may be joined, by plasmodial bridges only, with a neighbouring villus here and there, but shows no other or more intimate connection with them, and even this plasmodial junction disappears after a short time. The villi are the special agents of absorption of nutriment from the maternal blood through their trophoblastic covering, and, like the chorion, soon become *vascularized* for this purpose. Further details about the chorion and its villi are given in the section dealing with uterine connections of the ovum.

Turning to the embryonic rudiments, it is seen (Fig. 17) that the wall of the **archenteron** is now composed of *yolk-sac* mesoderm* with an inner lining of *entoderm,* while the **amnion** has a layer of *amniotic mesoderm* with an inner *ectodermal* lining. The mesodermal coverings of these two sacs are continuous with each other all round the margin of the embryonic plate; when, later, the *intra-embryonic* mesoderm

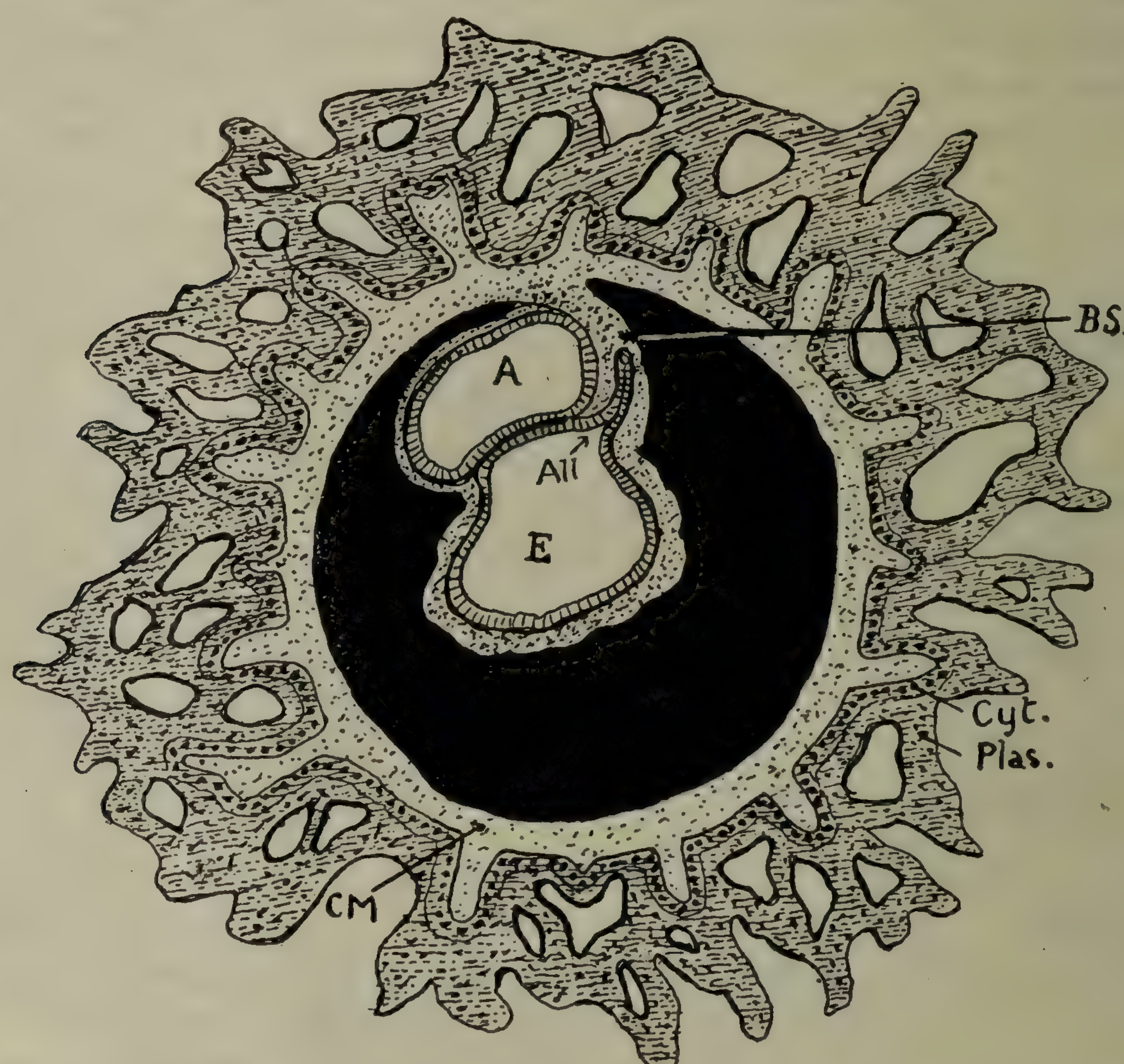


FIG. 17.—A COMPOSITE DIAGRAM SHOWING DIFFERENT STAGES OF THE OVUM, MORE ADVANCED THAN IN THE LAST FIGURE.

The mesoderm (stippled) has split to form the extra-embryonic cœlom (black). CM is the chorionic mesoderm; A and E are the cavities of the amnion and archenteron respectively; the mesoderm covering them externally has corresponding designation, and is continuous with chorionic mesoderm through the body-stalk, BS; an allantoic diverticulum, All, passes into the stalk from the archenteron; Cyt., Plas., are the cellular and plasmodial layers which make the trophoblast.

forms, *between* the ectoderm and entoderm of the plate, it will necessarily become continuous at this margin with these other mesodermal layers.

The embryonic mesoderm is already in process of formation at the stage represented in general by the figure, but has been purposely omitted.

The embryo and its associated vesicles (amnion and yolk-sac) are not completely separated, however, from the chorion. In Fig. 17 a

* The archenteric cavity and its walls form more than the definite yolk-sac of the human embryo, but it is customary, nevertheless, to use the term 'yolk-sac' for this part even at this stage.

thick mesodermal strand is seen at BS passing up from the *caudal* end of the embryonic plate, where it is continuous with the mesodermal coverings of the amnion and yolk-sac, and, between these, with the intra-embryonic mesoderm (not shown in figure). This is the **body-**

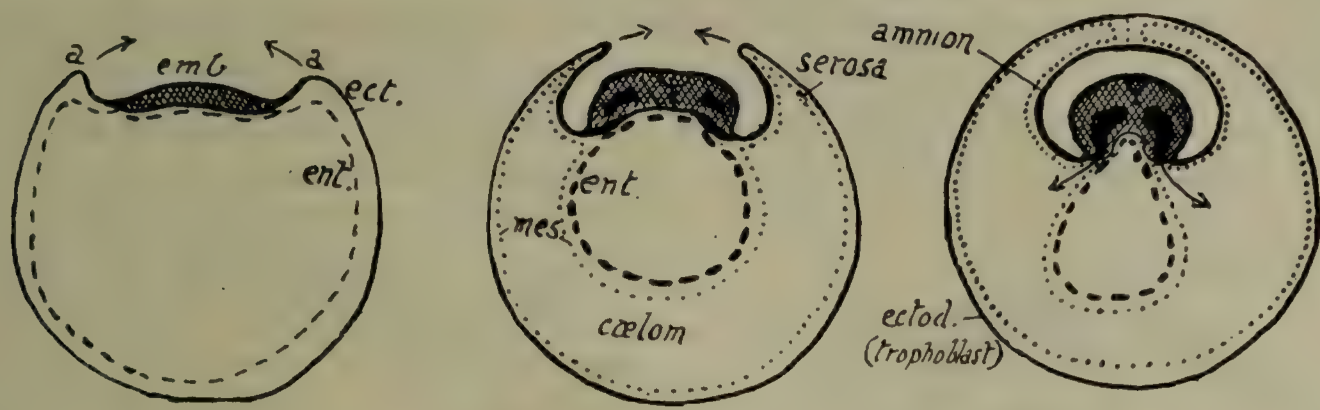


FIG. 18.

The amniotic folds (*a*, *a*) are shown, derived from the body-wall of a meroblastic ovum. They grow up over the embryo and meet. Having met, the inner wall of the fold becomes the amnion, and the outer wall (serosa) forms the superficial part of the chorion. The amniotic fold is made of ectoderm and somatic mesoderm. The cœlomic cavity of the embryo is shown black; when it joins the outer cœlom the amnion is left in continuity with the body-wall.

stalk; it reaches the chorion above the amnion. It is seen in the figure to contain a prolongation from the archenteron, the **allantoic diverticulum.** The body-stalk is a connection between the embryonic plate and the chorion, by means of which the circulatory systems of the

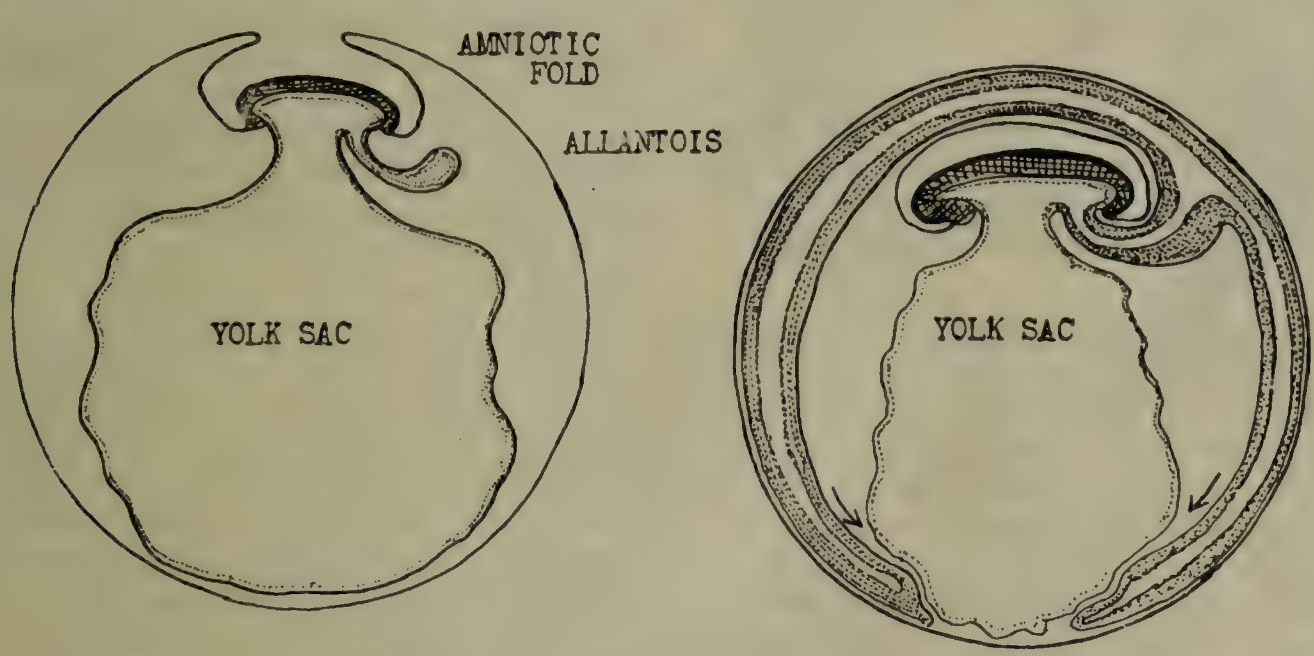


FIG. 19.—TO SHOW THE ORIGIN AND EXTENSION OF THE ALLANTOIS, WHICH ULTIMATELY SPREADS OVER THE DEEP ASPECT OF THE 'SEROSA.'

embryo will become continuous with the vessels developed in the chorion and its villi; the body-stalk is therefore necessary for the proper nutrition of the embryo until it is discharged from the uterus, and, in the later period of intra-uterine life, is elongated to form the

main part of the umbilical cord connecting the fœtus with the chorionic placenta.

The extra-embryonic cœlom is frequently traversed at first by irregular bands of mesoderm, due to incomplete splitting; it contains fluid, in which floats a fine reticulum, the *magma reticulare*, also probably of mesodermal origin, although not showing any definite cellular structures. The existence of the extra-embryonic cœlom allows the embryonic rudiments contained within the ovum to expand and alter their form independently of the containing wall, and its appearance therefore precedes the onset of a period of rapid growth and change in the embryonic plate and its associated structures.

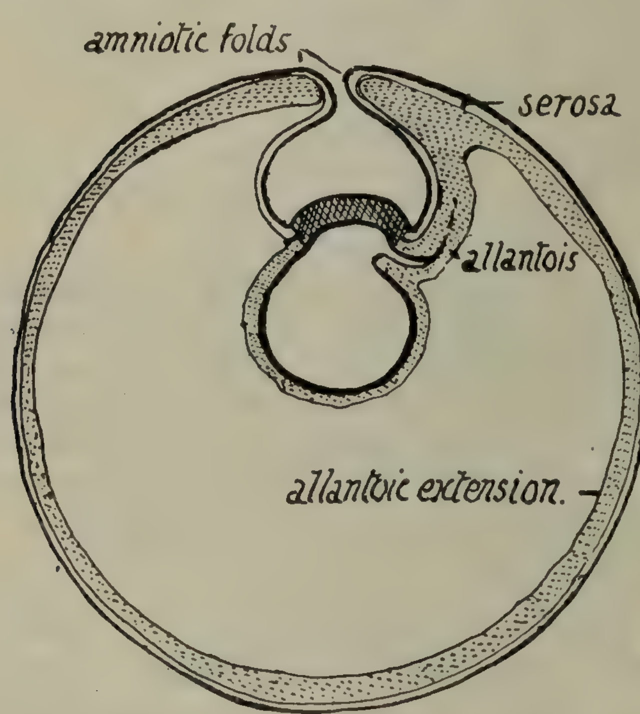


Fig. 20.—Scheme showing the Sauropsidan Elements in the Mammalian Ovum.

The amnion is represented with an opening to the surface, the amniotic duct or stalk, which is only occasionally and temporarily present. *Cf.* with preceding figures.

Morphologically, the amnion must be looked on as *part of the body-wall*; therefore, only able to develop as a covering of the embryo in meroblastic ova; the body-stalk and chorionic mesoderm are to be considered *modifications of the allantois*, a functional organ of nutrition in the Sauropsida; the extra-embryonic cœlom can only exist in a meroblastic type of development, and represents the most *ventral part of the body-cavity of the holoblastic body*, secondarily and precociously enlarged to admit of further changes taking place within the ovum.

The *amnion* develops in the Sauropsida and Mammalia. It was produced originally by an upgrowth (Fig. 18) of the wall of the ovum around the relatively small surface area which gives rise to the embryo. The amniotic folds, growing up, meet above the embryo. When they begin to grow the entoderm may be included in them, as in some reptiles, but the formation of mesoderm, with its (extra-embryonic) cœlom, releases the entoderm and allows it to fall back from the fold, which is now composed of (somatic) mesoderm and ectoderm only. An amniotic fold, made in this way, has two walls or sheets, continuous with each other at the free edge of the fold; the inner wall, which will be the definitive *amnion*, has its ectodermal surface looking toward the embryo, while the more superficial wall, the *false amnion* or *serosa* of von Baer, is directly continuous with the outer layer of the ovum, which outer wall it, in fact, now forms altogether. When the folds meet above the embryo and join together, the septum between them, formed by the fused walls, may persist in part or altogether, or may be completely absorbed, allowing the continuity of the cœlomic space from one side to the other. The amniotic cavity is thus cut off from the exterior, with which, however, it may retain continuity for a little time by means of an elongated 'amniotic duct' or 'stalk'; such connections have been found at times even in the human subject, and have been explained on morphological grounds such as these. This mode of formation of the amnion is found among reptiles, birds, and some mammals; but in higher mammals the formation has been shortened, and the human amnion is an example of abbreviation and precocity in the way in which it is developed.

The *allantois* appears in the Sauropsida as a hollow outgrowth from the ventral wall of the gut near its caudal end, projecting into the extra-embryonic cœlom (Fig. 19). It grows out through the cœlom to come into contact with the ' serous ' layer of the amniotic fold, lining the inner aspect of the shell of the egg. It spreads over this, and, being very vascular, is the agent of oxidation for the embryo.

In the mammals which have a chorionic placenta (made from chorionic villi), and develop in the uterus, the allantois is no longer of use for direct oxidation, and its vessels serve the placenta; hence its mesodermal stalk, which carries these vessels, becomes thickened and *forms the body-stalk*, and its extension over the internal aspect of the wall of the ovum constitutes the main part of the *chorionic mesoderm* in which these vessels ramify. The allantoic diverticulum is the degenerated remnant of the cavity of the allantois. It is evident that the coverings of the embryo or fœtus, its *membranes*, as they are styled by obstetricians, are all derived from structures which were secondarily adapted during what may, for convenience, be termed the ' reptilian stage ' of evolution, and for their formation and development it was necessary for the ovum to be of the meroblastic type.

A scheme is given in Fig. 20 to show these structures inherited from a sauropsidan-like stage in phylogeny; comparison with Figs. 18 and 19 makes the homologies apparent.

The Embryonic Area: Embryonic Plate or Disc.

If the amnion were cut away at a stage such as was represented in Fig. 17, and the embryonic plate looked at from above, it would be seen to be more or less circular in outline (Fig. 21). The ectodermal surface exposed in this way would show a longitudinal line, the **primitive streak,** in its posterior half. This line is produced by proliferation and thickening in the ectodermal cell-layer in this situation, and it is from this proliferating area that the **embryonic mesoderm** is formed and grows out.

The primitive streak may present a *groove* in the middle line, as the mesoderm grows on each side of it.

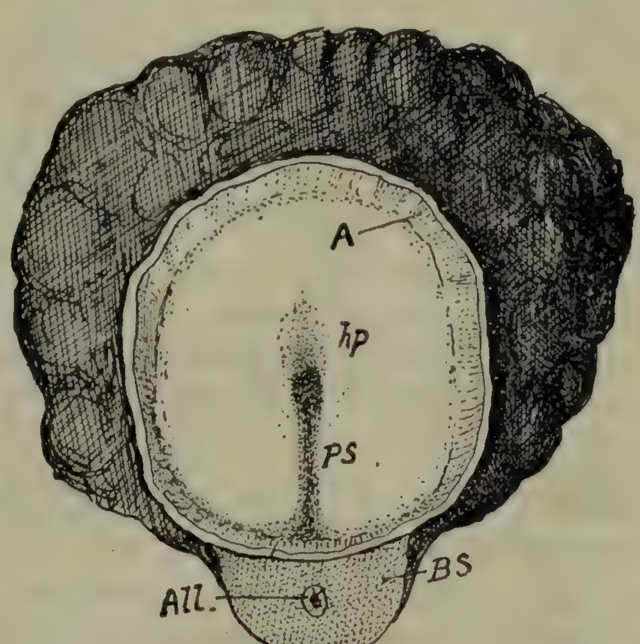


FIG. 21.—THE EMBRYONIC PLATE OR DISC, VIEWED FROM ABOVE, AND EXPOSED BY CUTTING AWAY THE AMNION (A).

The yolk-sac is the shaded structure on which the plates rest; PS, primitive streak; *hp*, its head-process; BS, body-stalk cut; All., the allantoic diverticulum within it.

The embryonic mesoderm extends into the plate, separating the ectoderm from the entoderm, except in the middle line; here the two earlier layers remain in contact for some little time. At the extreme front end of the plate, however, the right and left mesodermal layers meet. This is the region in which the primordium of the heart must be considered as existing (though not recognizable yet as a definite structure), lying partly in the yolk-sac mesoderm by the embryonic

rim and partly in the plate, on the edges of the right and left mesodermal layers as they come together. This region can therefore be termed for convenience the *proto-cardiac area.* The mesodermal sheet becomes continuous with the extra-embryonic mesoderm round the periphery of the embryonic disc. A *trilaminar* blastodermic area is thus formed, and replaces the original bilaminar one (Fig. 22).

The forward growth of mesoderm, from the region of the primitive streak into the plate, leads to its antero-posterior elongation in front of the streak, which thus assumes a position relatively more posterior, occupying less than the hinder half of the (now oval) disc. The area thus gained just in front of the streak shows now a longitudinal median groove in the ectodermal layer, which is slightly thickened here and raised at each side of the groove by mesodermal thickening; it is still in contact with the entoderm on its deep aspect. This groove is the **neural** or **medullary groove,** and its raised margins are the **medullary**

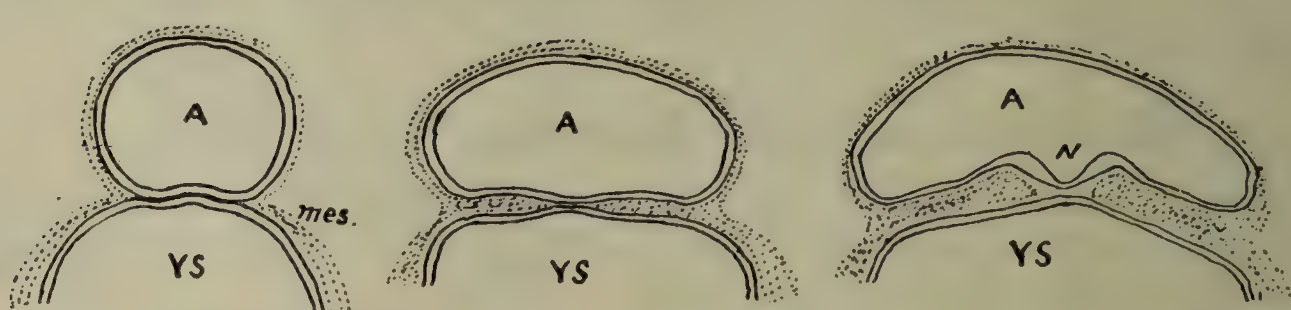


FIG. 22.—DIAGRAMS OF TRANSVERSE SECTIONS TO SHOW THE CONVERSION OF THE BILAMINAR PLATE (1) INTO THE TRILAMINAR (2) BY THE APPEARANCE OF INTRA-EMBRYONIC MESODERM ON EACH SIDE OF THE MIDDLE LINE: IT BECOMES CONTINUOUS WITH THE EXTRA-EMBRYONIC LAYER (*mes.*) AT THE MARGIN OF THE PLATE.

No. 3 shows the appearance of the neural folds and groove on transverse section, the intra-embryonic mesoderm being still shown as a solid plate on each side: actually, in a stage such as shown in the last section, this plate would be split by the embryonic cœlom.

ridges ; they diverge and fade away beside the primitive streak. The formation is seen in Fig. 23. This, the first indication of the formation of the central nervous system, is separated from the proto-cardiac region in front by a small area which contains no mesoderm, the *bucco-pharyngeal area,* which will become the bucco-pharyngeal membrane. The longitudinal section through the plate in Fig. 24 shows the relative position of these different parts in a schematic manner; Fig. 23 gives the surface view of such a plate. In this figure a perforation, the **neurenteric canal,** is seen in the plate at the anterior end of the primitive streak, and is also shown in the longitudinal section in the last figure. The neurenteric canal, as its name implies, passes to the enteron (as the gut-cavity may be termed) from between the diverging neural ridges; it is a little variable as to the time of its appearance, is not always well marked, and usually disappears very soon.

The early rudiment of the *notochord* is present, on the lower or entodermal aspect of the plate, in the form of a median longitudinal

groove, the *notochordal groove;* this extends forward from the lower opening of the neurenteric canal, lying immediately below the neural groove. It does not reach the level of the anterior end of the neural groove at first, but subsequently extends to the bucco-pharyngeal area, where the notochord is attached. The notochord is formed by the deepening of the groove and the subsequent separation of its walls from the roof of the cavity.

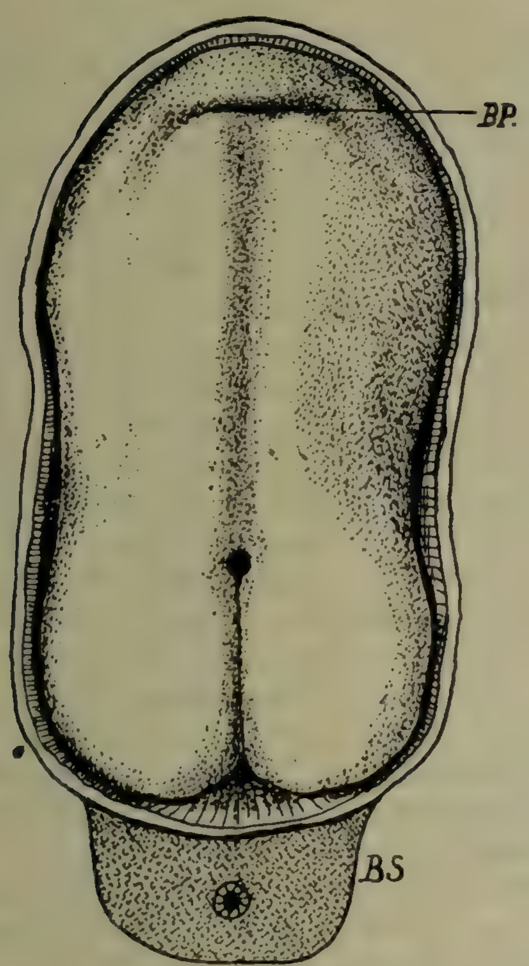


FIG. 23.—THE EMBRYONIC PLATE, SEEN AS BEFORE, BUT AT A LATER STAGE.

The neural groove is seen in the middle line, bounded by low ridges. Behind this is the opening of the neurenteric canal and the primitive streak, with ' caudal ' swellings on either side of it, made by forming mesoderm. BP, bucco-pharyngeal area; BS, body-stalk, cut. The whole enbryonic area is surrounded by the cut amniotic edge.

The neurenteric canal, mesoderm, and notochord are associated in their appearance and in their probable phylogenetic history. They are connected with the process known as *gastrulation,* a mode of formation of the enteric cavity which appears to be fundamental, and therefore to be taken into account in considerations of phylogeny. The simplest form of gastrulation is seen in Amphioxus. Here the blastula has a thin wall made

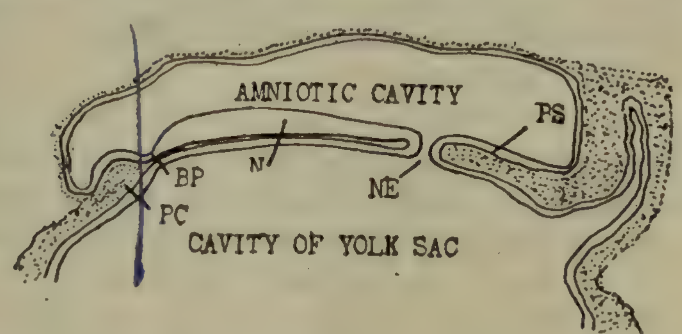


FIG. 24.—SCHEMATIC LONGITUDINAL SECTION OF EMBRYONIC PLATE AT THIS STAGE.

N, neural region; PS, primitive streak; NE, neurenteric canal; BP, bucco-pharyngeal area; PC, proto-cardiac area. The amnion is shown entire, and the body-stalk and allantoic diverticulum are seen.

by a single cell-layer surrounding a large segmentation cavity. Invagination of this wall at one part leads (Fig. 25) to the obliteration of the segmentation cavity and the formation of a new enteric cavity, surrounded by two layers (ectoderm and entoderm) and opening on to the surface by a *blastopore.* The result is aided by actual backward growth of the upper or ' dorsal lip ' of the blastopore, this being termed an *epibolic* growth. This growth of the dorsal lip in these eggs, which are holoblastic, is accompanied by a slow extension of the embryonic surface layers over the whole ovum, gradually closing in on the blastopore. In Fig. 26 are given some views of the blastoporic region in such eggs, showing how the ' opening,' filled in reality by a mass of yolk, is ultimately closed as a linear ' scar.' The primitive streak of higher forms may be considered to correspond with this scar, its appearance being largely of the nature of a phylogenetic memory; the

neurenteric canal is the anterior or dorsal part of the old blastopore, its open condition being doubtless associated with the nature of the formations connected with this margin in all vertebrates. This front part of the opening and invaginated area is that which makes the *roof* of the entodermal cavity as it is turned in, and from this roof, in Amphioxus, certain outgrowths arise; they are shown in Fig. 27, which gives diagrams of sections through the body of the embryo just in front of the blastopore. The outgrowths are separated from the entoderm a little later. The outgrowth in the middle makes the notochord, and those at the sides, which are in segmental series, become the mesodermal segments, and extend ventrally round the entoderm (Fig. 28). The notochordal invagination is not segmented, but is in the form of a continuous groove, which necessarily runs into the front part of the blastopore; in other words, the lining of the groove is directly continuous with the front margin of the opening, while the lines of segmented mesoderm would, if carried back, lie on either side of the opening. There is an active growth of mesoderm also at the sides of the blastopore, which growth is then really continuous with the series in front of it; but it is necessary for certain purposes to distinguish between them, and the mesoderm formed from the roof of the gastrula cavity is termed *gastral mesoderm*, while that formed beside the blastopore is *prostomial mesoderm*. The difference between them is probably only one of times of formation.

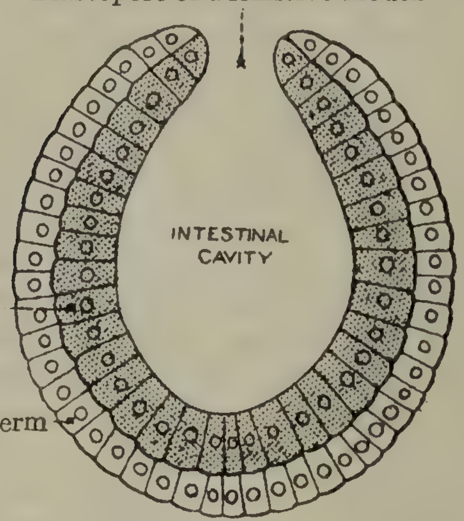


FIG. 25.—THE GASTRULA OF AMPHIOXUS (MODIFIED AFTER WIEDERSHEIM).

If, now, we consider the primitive streak to represent the closed blastopore, we must look on the mesoderm arising from it as 'prostomial.' The blastopore as a whole is closed, probably because the meroblastic embryonic area is so

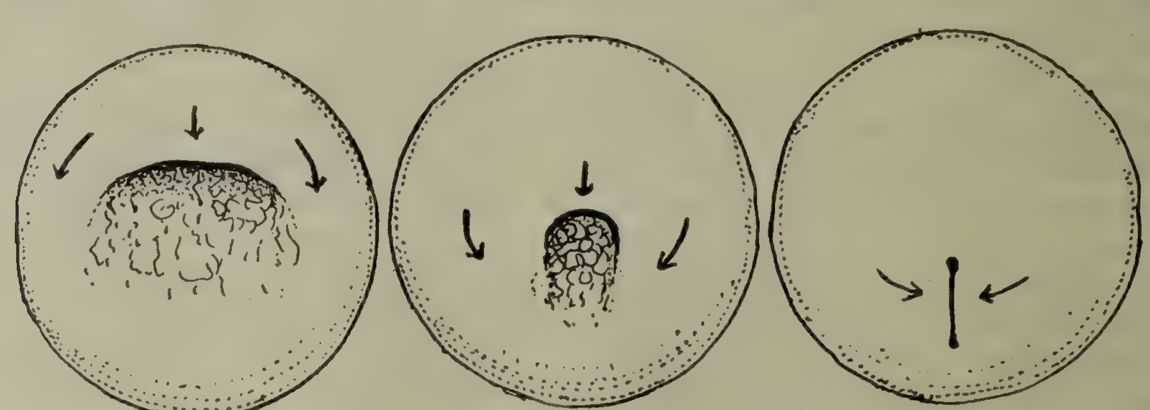


FIG. 26.—TO SHOW THE CLOSURE OF AN AMPHIBIAN BLASTOPORE.

The eggs are supposed to be viewed from behind. The arrows indicate the direction of spreading of embryonic ectoderm, the central one showing the growth of the dorsal lip. A yolk-plug occupies the blastopore before it is closed.

small, and does not include the yolk-mass (as in amphibians). Its front end, on the other hand, is open, and its front edge free, because this front edge is actively growing forward into the roof of the gut-cavity, as the plate elongates, and is forming there the notochordal groove as in Amphioxus.

There is evidently some kind of invagination here, though it is not quite so simple as appears so far. In Fig. 21 a prolongation forwards, the *head-process* (*hp*), is seen in front of the primitive streak, from which it is formed. The *head-process* can be looked on as the anterior part of the thickening of the

streak, and extends downwards and forwards from the ectoderm to the entoderm, thus making a prolongation from the streak, more or less visible through the ectoderm. The neurenteric canal, when it appears, opens through this head-process, and the entodermal extremity of the process, as it is carried forward in the elongating roof of the enteron, forms the notochordal groove, which is thus continued into the neurenteric canal behind. So far, then, the relations between canal and notochord are much as in Amphioxus; moreover, the lower and front part of the head-process appears to be prolonged at the sides into mesodermal cells, which may thus be taken to represent gastral mesoderm, continuous behind with that formed at the closed blastopore. But the recognition of the head-process and its associated formations as being part of a regular invagination is complicated by the fact that a layer of entoderm lies below it, already formed before the appearance of primitive streak or head-process, and it is only by secondarily breaking through this that the neurenteric canal comes to open into the entodermal cavity; the archenteric cavity is formed, in fact, before the occurrence of the invagination which, in other forms, brings the cavity into existence. The fact that the head-process is at first solid does not really affect the matter, but a similar state of things in which, however, the ingrowth is hollow, exists in some reptilian ova, and can be exemplified by the accompanying figure (Fig. 29). This shows a true invagination, which opens into what is essentially a segmentation cavity, the roof of the invagination temporarily replacing the roof of the second cavity, which has been broken through. A notochord and mesodermal outgrowths are formed from this temporary roof, the former taking first the aspect of a widely open groove; later, the original entodermal roof closes over again below these formations.

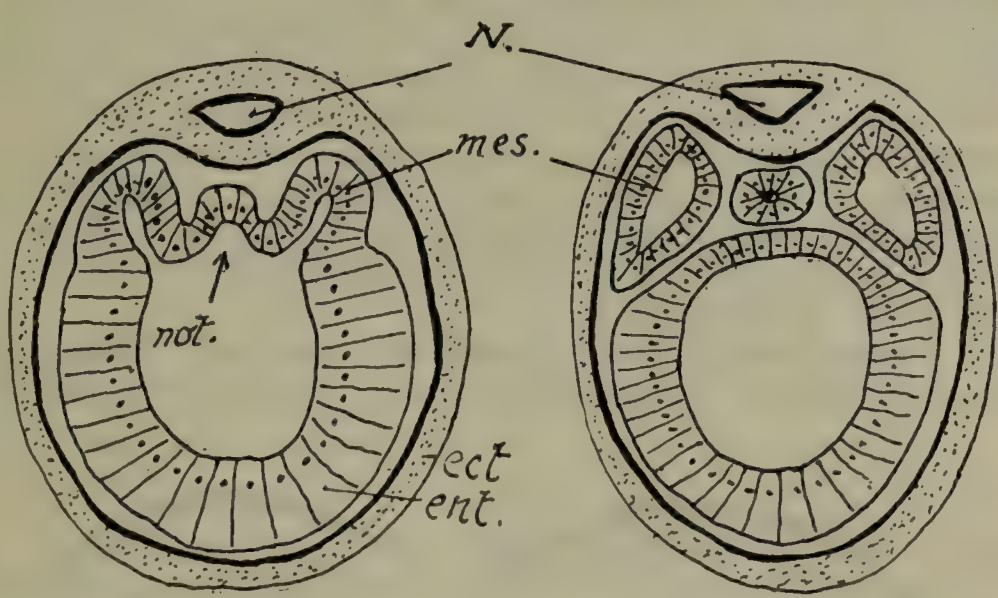


FIG. 27.—SECTIONS, COMPOUNDED OF VARIOUS STAGES, THROUGH AMPHIOXUS EMBRYOS, JUST IN FRONT OF BLASTOPORE.

The outgrowth of entoderm to form notochord (*not.*) and mesoderm (*mes.*) have closed in and separated off from the entoderm in the second section. The mesoderm will extend ventrally at a later stage (Fig. 28). N, neural tube.

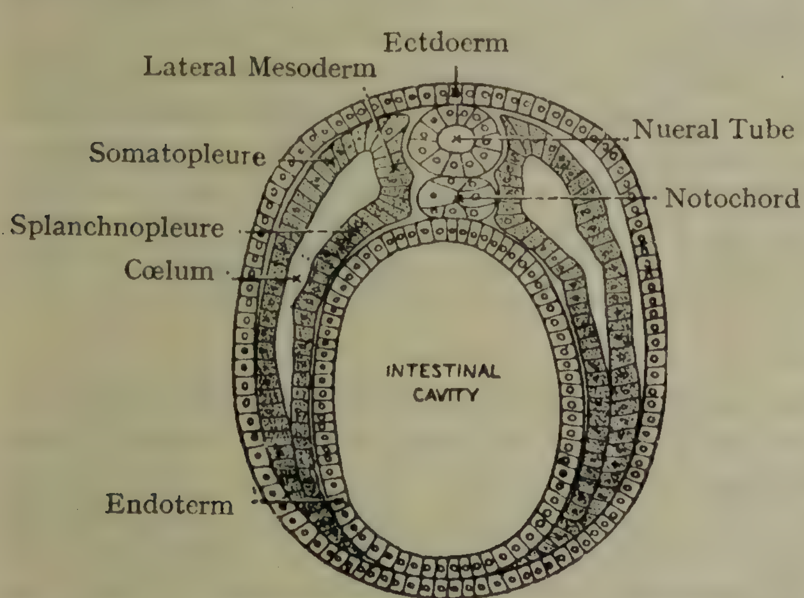


FIG. 28.—TRANSVERSE SECTION OF BODY OF AN AMPHIOXUS (MODIFIED AFTER ATSCHEK).

The process is essentially similar, though not so evident, in the human embryo, and the wall of the neurenteric canal (or anterior edge of the primi-

tive streak) can be looked on as being ' paid out ' in a forward direction as the embryonic area increases in length, laying down, as it does this, the notochordal rudiment; this rudiment is closely associated with neighbouring mesoderm, though not continuous with it. The temporary substitution of another layer for the earlier entodermal roof, and the development of the notochord from this, has led to the description of the notochord as a structure owning primitively a mesodermal origin. The argument does not seem to be well founded, for the supplanting layer is entodermal, being of the nature of an invagination, whence the description of the rod as being split off from the entoderm is fundamentally true. But to class it with the mesoderm because it arises, like the gastral mesoderm in more primitive forms, from the entoderm is another matter, and is a question of opinion depending on the definition that may be given to the word ' mesoderm.'

Finally, phylogenetic considerations may offer a theoretical explanation of what is found. In most fishes and amphibians, the alimentary cavity is made

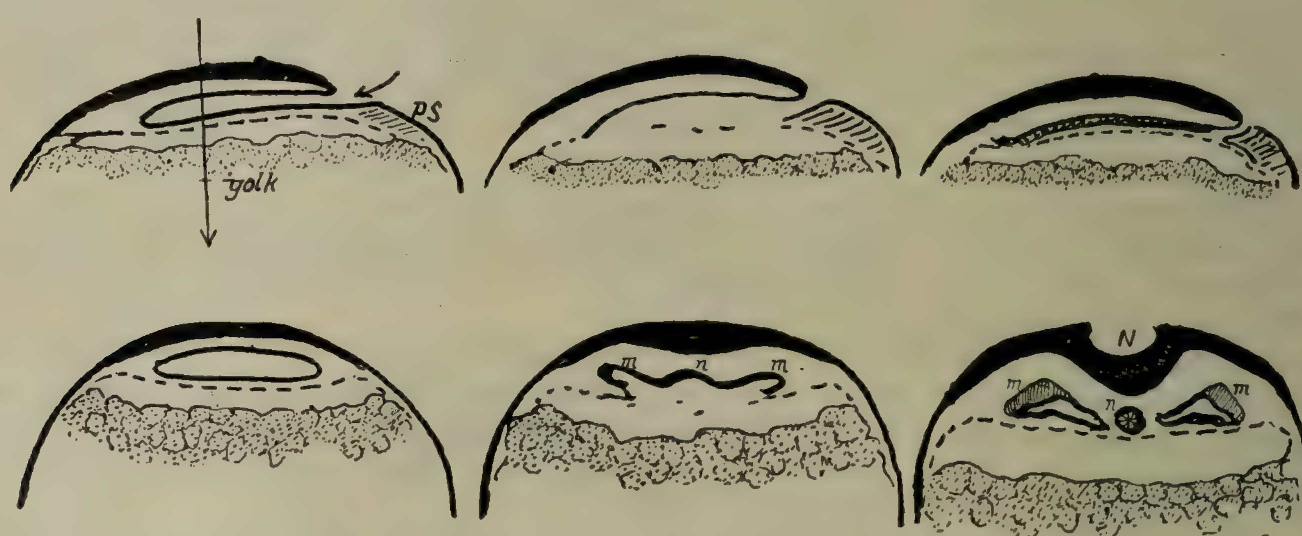


FIG. 29.—SIMPLIFIED DIAGRAMS OF THREE STAGES IN DEVELOPMENT OF EGGS OF CERTAIN LIZARDS.

Upper row, longitudinal sections; lower row, transverse sections of the same stages, made as along the long arrow in the first figure. An invagination occurs, growing forward from the region of the primitive streak (*ps*) in the direction of the short arrow. The floor of this invagination is separated from the yolk-sac cavity by the ' primary entoderm ' (interrupted line). In the second stage this primary layer and the floor of the invagination have given way; the roof of the invagination is now the roof of the yolk-cavity, and is beginning to form notochordal and mesodermal outgrowths. In the last stage the entoderm is reconstituted, and the notochord and (gastral) mesoderm are not connected with it.

by the process of gastrulation, delayed and otherwise modified, it may be, by the amount of yolk present, but ultimately forming a true invagination entoderm which obliterates the ' segmentation cavity.' In some amphibians, however, and possibly in some fishes, the invagination cavity breaks into the segmentation cavity, and the definitive enteron is lined in its lower part by cells which were not carried there by gastrulation. In reptiles the proportion of cells derived from the invagination decreases, the other cells correspondingly increasing their area in the wall of the cavity. In birds the process seems to go further still. Thus we reach a stage where only the lining cells of the roof are derived from the gastrular invagination, all the rest being of the nature of lining cells of what is probably a segmentation cavity. Though so far lacking demonstration, it seems at any rate a theoretical possibility that in the higher mammals the process has gone so far that the only derivatives of invagination cells now left are those forming the notochord; hence, when this has separated off, the lining cells have no gastrular representatives among them. Whether

or not this view ultimately proves to be correct, it at any rate gives a present explanation of the complicated conditions which appear in the early stages of the human embryo. If it turns out to be correct, the archenteric cavity of the earliest known form will then be classed as a segmentation cavity.

Developmentally, the head-process or chordal process, extending forward from the neurenteric canal, is the first indication of formation of the **notochord.** It is a cellular process, containing a minute central lumen, which lies on the entodermal roof in the middle line. Its cells fuse with those of the entoderm, then breaking down, so that a longitudinal groove in the archenteric roof remains, and elongates forward below the growing neural region: from the mode of formation it is evident that this groove is continued behind into the neurenteric canal. As the embryonic growth progresses, the length of the groove is increased by addition from behind, and at the same time it deepens, closes, and separates from the entoderm in its front part, and continues to do this from before backwards as it increases in length. All these changes belong to stages later than that reached so far, but the subject may be conveniently considered here. By continuation of these processes the notochord forms (when the proper proportionate length of the embryo is completed) a longitudinal rod of cellular composition lying between the entoderm and the neural structures, and extending from the bucco-pharyngeal region in front to the end of the caudal region behind. It is only a phylogenetic remnant, having no function in the body and no further development, and is surrounded by the vertebræ as they form.

Further Growth of Embryonic Area.

The rapid increase of the mesodermal layer is accompanied by some increase in size of the embryonic disc, which is now of an elongated oval shape. The margin, relatively fixed by the surrounding extra-embryonic mesoderm, is slower in its expansion, wherefore the embryonic area—which may now be definitely termed *the embryo*—begins to stand up in a curved fashion above the level of the margin, and projects into the amniotic cavity. This result is apparent in the transverse section shown in Fig. 22, and would be more marked in a longitudinal section. The rate of increase in length begins to exceed markedly that in width; this is due to the rapid growth of the central nervous axis, while the mesodermal layer alone is responsible for the general increase in width of the area. The neural groove is deepened by the increasing height of the medullary folds, its ectodermal lining begins to grow and thicken, and it receives constant addition to its hinder end by the pushing forward of the developing area which lies round the neurenteric opening and front end of the primitive streak; the medullary folds are produced here by the rapid mesodermal proliferation from the streak, so that the addition to the neural groove from behind goes on *pari passu* with the formation and pushing forward of mesoderm from this region. The neural region and its mesodermal

boundaries may thus be said to increase in length largely by addition from behind, but there is also a process of growth going on in the neural wall itself, and this is particularly marked in the front portion of this wall, the part which was first formed; it will become apparent subsequently that it is this front part which, by its increasing length, leads to projection forward of the anterior end of the embryo.

Formation of Somites and Closure of Neural Groove.

As the embryo lengthens, the mesodermal layer undergoes a striking change, which is very apparent on the surface. A longitudinal groove appears on each side, some little distance from the medullary margins. The mesoderm medial to this groove, lying under the medullary folds and beside the neural groove, can be termed *paraxial,* while that lateral to the longitudinal groove is the *lateral sheet.*

The *paraxial* mesoderm now begins to segment into blocks (Fig. 30), which appear quadrilateral when seen from the surface. These are termed *somites* or *primitive segments,* and lie in series on each side of the neural groove. They do not extend to the front part of the groove, nor are they visible beside its hinder end; here they are in process of formation, like the groove itself, and are added as they are formed to those already in position. These primitive segments are therefore produced from before backwards.

Although this is true of the majority of the somites, there is reason to believe that three or four additional segments are added in front of those laid down in series as in the figure; these additions are produced by aggregation in the mesoderm beside the hind-brain, and their delayed production is no doubt associated with the rapid growth of this part.

When the full number of somites is complete it amounts to thirty-five pairs or more. At the stage being considered at present, however, they are few in number, though increasing rapidly. They form thick mesodermal blocks lying beside the neural groove, and the edges of the neural folds in this neighbourhood come together (Fig. 30) and join, thus closing in the groove and converting it into a **neural canal.** The neural canal, however, remains open at first in front and behind (as seen in the figure), the openings being the **anterior** and **posterior neuropores.** The formation of somites is the earliest indication of *segmentation** in the body.

* The word is used now in a new sense. The morphological conception of the body is that it is composed of a series of successive segments fundamentally resembling one another. A complete bilateral segment would theoretically possess its own segmental skeleton, muscles, vessels, nerves, body-cavity, alimentary tube, and excretory organs. A body composed of such segments, unmodified, would be akin to a tapeworm, and the bodies of all animals higher than this class have their basic segmental structure largely obscured by secondary modifications. Nevertheless, the segmental basis shows in many places, as will be seen, and under many conditions. Body *segments,* then, imply by their name something more than when the word is used as meaning a division or part, as in ' segmenting ovum ' or ' segments of a limb,' and confusion in meaning can be avoided by attention to the context.

Their successive repetition is a simple example in development of 'serial homology,' an expression which implies a succession in series of structures in the body which possess essentially a genetic similarity.

The *lateral sheet* of mesoderm never exhibits any trace of segmentation like that in the paraxial portion. The intra-embryonic cœlom (described in the next section) splits the lateral sheet into *somatic* and

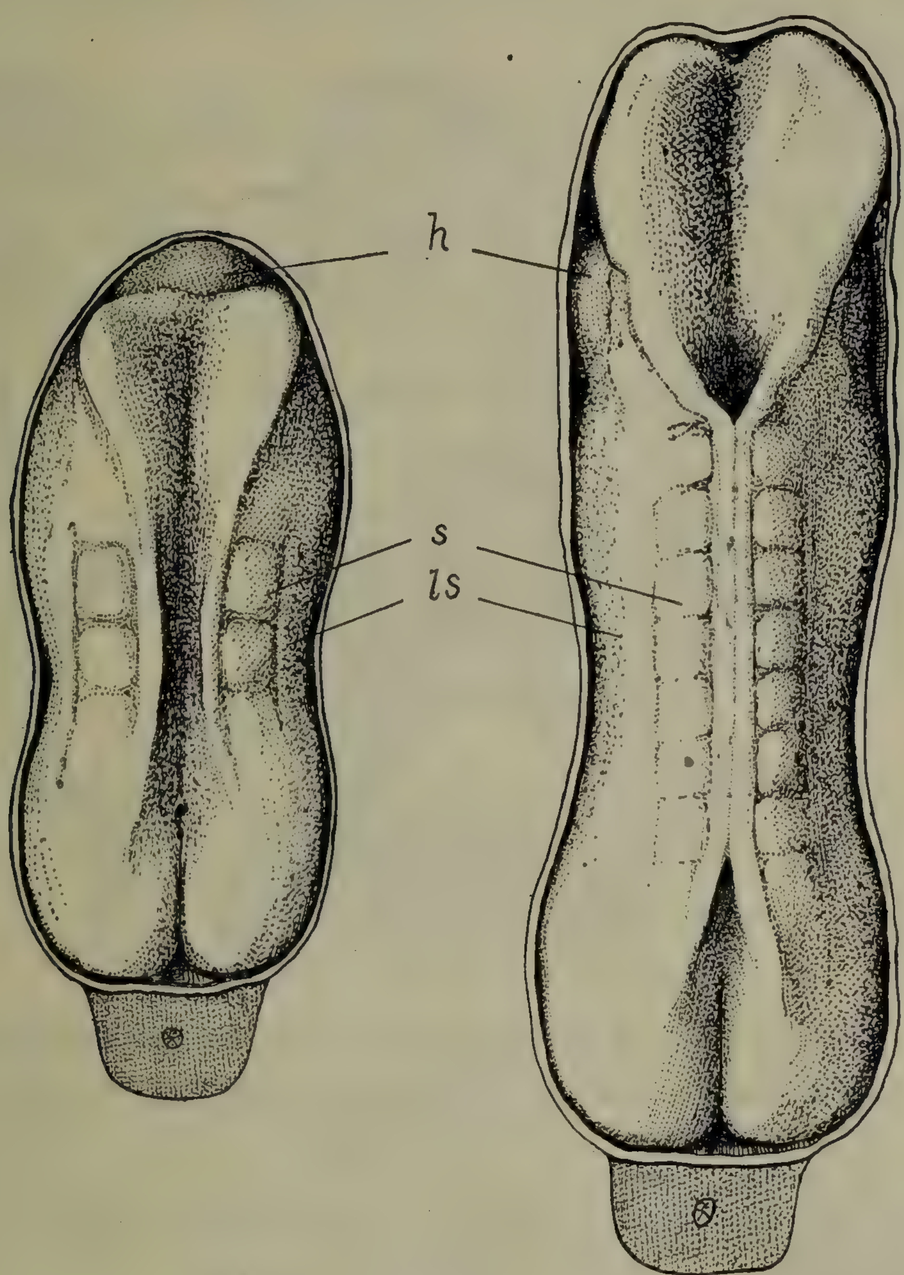


FIG. 30.—SHOWING THE FORMATION OF SOMITES AND THE CLOSURE OF THE NEURAL GROOVE TO FORM A CANAL.

The open ends of the canal are the neuropores. The somites (*s*) are segmentations in paraxial mesoderm, and are separated by a groove from the lateral sheet (*ls*). The rapid elongation of the front end of the neural walls leads to their projection beyond the heart region (*h*).

splanchnic layers when it appears, about the time of the formation of the early somites; the somatic layer is applied to the ectoderm, and constitutes with it the *somatopleure*, while the splanchnic layer makes with the entoderm, to which it is applied, the *splanchnopleure*. A transverse section through the body, therefore, as in Fig. 31, would show at this stage:

(*a*) The closed *neural tube* in the centre.

(*b*) The notochord below this.

(*c*) A *somite* on each side of (*a*) and (*b*). This is roughly triangular on section, and composed of somewhat elongated mesodermal cells arranged round a small enclosed cavity; a longitudinal section would show a certain very small amount of loose mesodermal cells between the successive somites.

(*d*) A solid cellular mass, the *intermediate cell mass*, connecting the walls of the somite with—

(*e*) *Parietal* and *splanchnic* layers of the lateral sheet, separated by the *intra-embryonic* body-cavity, which is continuous with the extra-embryonic cavity through the split margin of the embryonic area. The parietal layer, covered by ectoderm, is directly continuous with the amnion; the splanchnic layer, lined by entoderm, forms the wall

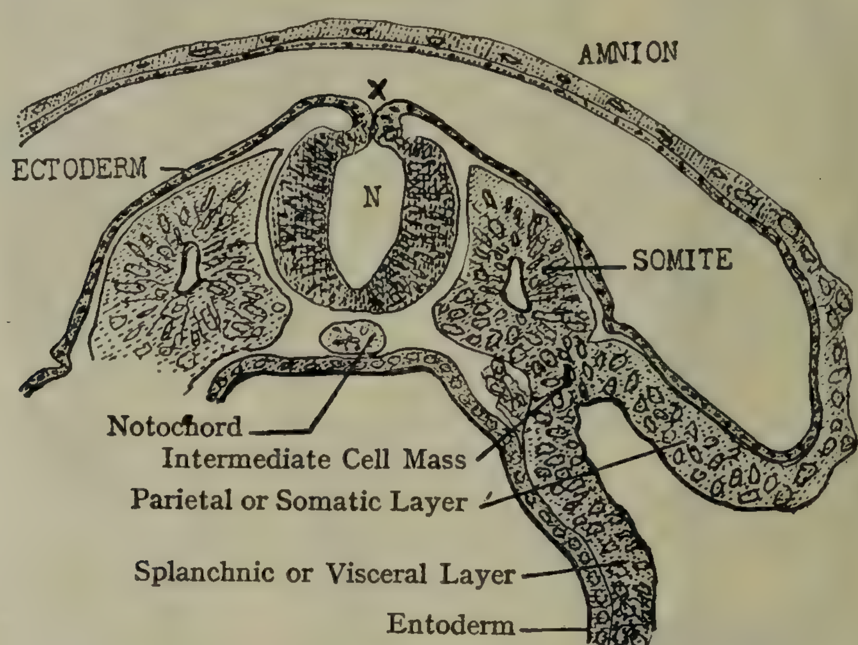


Fig. 31.—Diagram of a Section through the Embryonic Body.

The neural folds are represented as just closing, to show how the closure takes place (X).

of the enteron, as that part of the visceral cavity may be termed which is destined to form intra-embryonic structures.

The **intermediate cell mass,** which is the connecting link between the segmented paraxial and the non-segmented lateral mesoderm, is constricted, and thus produces the longitudinal groove on the surface already mentioned. It is a continuous, non-segmented cell condensation, running longitudinally along the roof of the body-cavity, and is the region from which the excretory organs of the embryo will develop.

Formation of Intra-Embryonic Cœlom (Fig. 32).

This appears about the time of formation of the first few somites, and is a splitting of the mesoderm into two layers, as has been seen already. The cavity begins at first in relation with the rudiments of the heart, and quickly extends round the front part of the plate:

it is separated, however, from the external cœlom by the thick mesodermal margin of the plate in this region. The cavity extends backwards by two lateral prolongations towards the lateral sheet of mesoderm; here they join with cavities in these sheets. The body-cavity in each lateral sheet is separated from its fellow by the somites and neural region, and, at first, from the extra-embryonic cœlom by the lateral mesodermal margin, as yet unsplit. The split, however, very soon

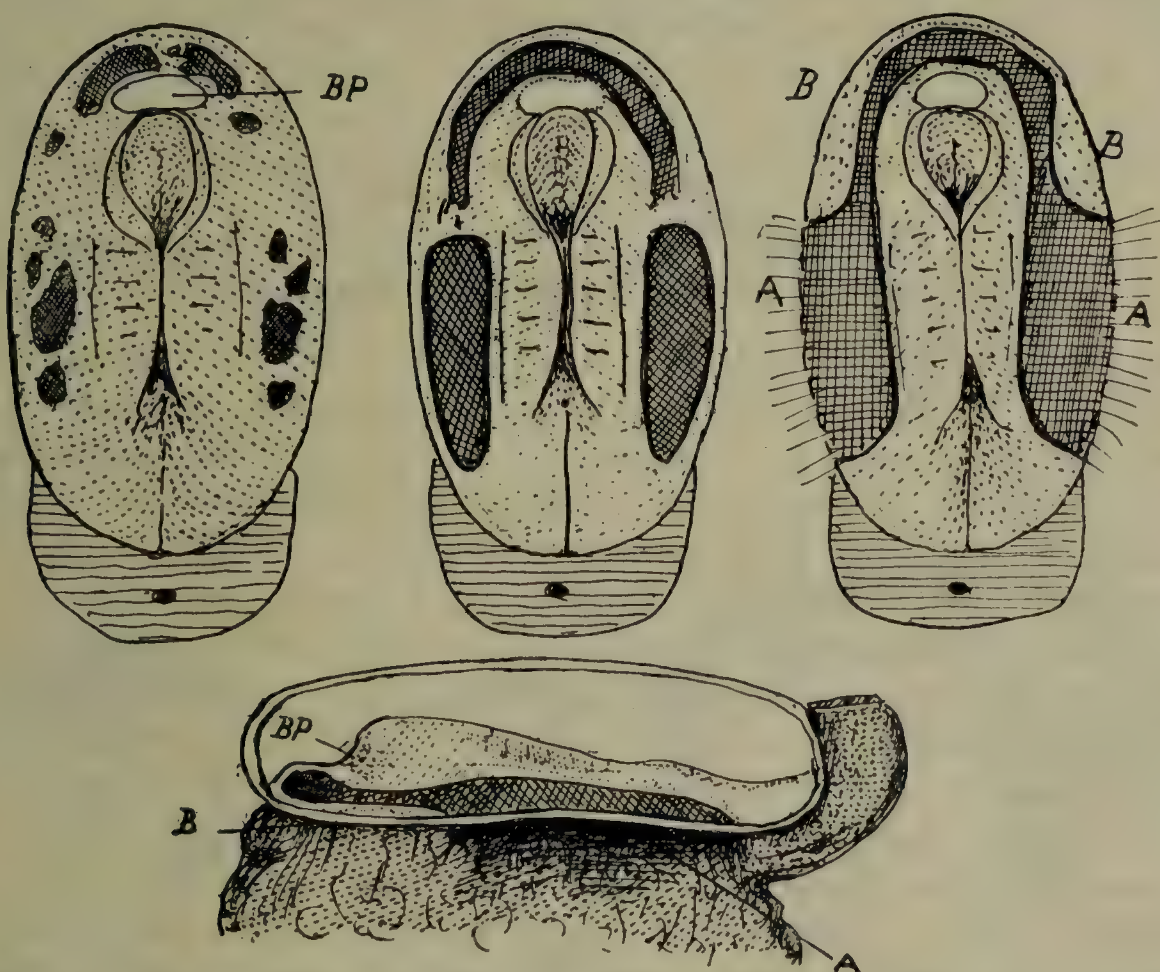


FIG. 32.—SCHEMES TO SHOW THE RELATIONS BETWEEN THE INTRA-EMBRYONIC CŒLOM AND THE FUNDAMENTAL CONSTITUENTS OF THE EMBRYONIC AREA.

Cœlomic spaces are shown as shaded areas projected on to (very schematic) embryonic plates. In the first figure the pericardial cavity is forming in front of the bucco-pharyngeal area (BP), and cavities are beginning to form in the lateral sheet. In the next scheme the cavities in the lateral sheets are formed, and the pericardium has two ' lateral recesses ' extending back toward them. In the third figure the cavities of the lateral sheets are not only continuous with the pericardium, but have also opened into the extra-embryonic cœlom by breaking through along the margin (A); the front portion of the margin (B) remains unsplit. The last figure gives the disposition of these cavities as they might be shown from the side, the embryo standing up somewhat into the amnion.

extends into this margin, and the inner and outer cœlomic cavities become continuous with one another. The front part of the margin, lying round the pericardium—as it can be termed now—and its lateral prolongation, remains unsplit. Hence the pericardium communicates *directly* only with the rest of the body-cavity, by means of its lateral channels, the *lateral recesses*, and *only indirectly* with the extra-embryonic cavity through these recesses and the body-cavity (peritoneal cavity).

The schemes in the figure show the disposition of the general cavity at this time.

It can be understood that, by the establishment of continuity between the outer and inner cœlomic spaces, the visceral or gut-wall loses its attachment to the body-wall, which (Fig. 31) now remains only continuous with the amnion. This loss of attachment, however, is only where the mesodermal margin has been split, and the two walls are still connected with one another along the front part of the margin. Here, then, as will be seen subsequently, the vessels of body-wall and gut-wall can meet and reach the heart. Persistence of connection occurs also (see Fig. 32) at the hinder part of the margin, but this is not so important, and is modified to a certain extent later.

Formation of Fore-Gut and Hind-Gut.

These are intra-embryonic recesses of the enteron. Rapid increase in axial length of the neural region is the dominating feature of the embryonic development at this stage. This is accompanied by addition to the number of somites and increasing length of the closed part of the neural tube; on the entodermal surface of the area there is corresponding addition to the notochordal formation, which is continually freeing itself from the entoderm and closing in from before backwards. The region of formed somites and closed neural tube, however, may be looked on (for present purposes) as *relatively* fixed, but the free anterior part of the neural groove (see Fig. 30) and the open posterior end, where actual addition is being made, are regions in which active growth and increase in length take place and affect the relations of neighbouring areas. Increasing length in both these regions leads to *projection of the growing parts over the anterior and posterior limits of the original embryonic disc.* This implies that the areas originally lying between the growing regions and the terminal margins *become reversed* and turned under the projecting ends of the neural structure. The progress and results of these changes are illustrated in a schematic manner in Fig. 33. At the anterior end, the extremity of the neural region projects forward and passes over the bucco-pharyngeal and pericardial areas, reversing these below itself as it grows forward, and a diverticulum of the general gut-cavity is necessarily produced and included between it and the reversed parts; this diverticulum is the **fore-gut** or **primitive pharynx,** which therefore lies above the pericardium and is closed, at what is now its front extremity, by the **bucco-pharyngeal membrane.**

The projection of the hinder end (tail-bud) has a similar effect. The region between it and the posterior margin of the embryonic area is that of the primitive streak, and this is reversed and turned under the growing caudal projection. The included cavity, comparable with the cavity (fore-gut) included in the anterior projection, can now be termed the **hind-gut**; but there is a complication that is not present in the case of the fore-gut. The allantoic diverticulum passes into the

body-stalk just below the level of the original embryonic margin, but the connection between body-wall and gut-wall remains here when the cœlomic split occurs, as has already been seen, so that, as the tail-bud projects and carries body-wall with it, this part of the enteron, with its diverticulum and attached stalk, is drawn into the body of the embryo. Thus, as shown in the schemes, the allantoic cavity comes to open into the ventral wall of the 'hind-gut.' A large cavity is formed in this way which receives the allantoic diverticulum ventrally, and, dorsally, a prolongation from the gut-cavity itself; it is

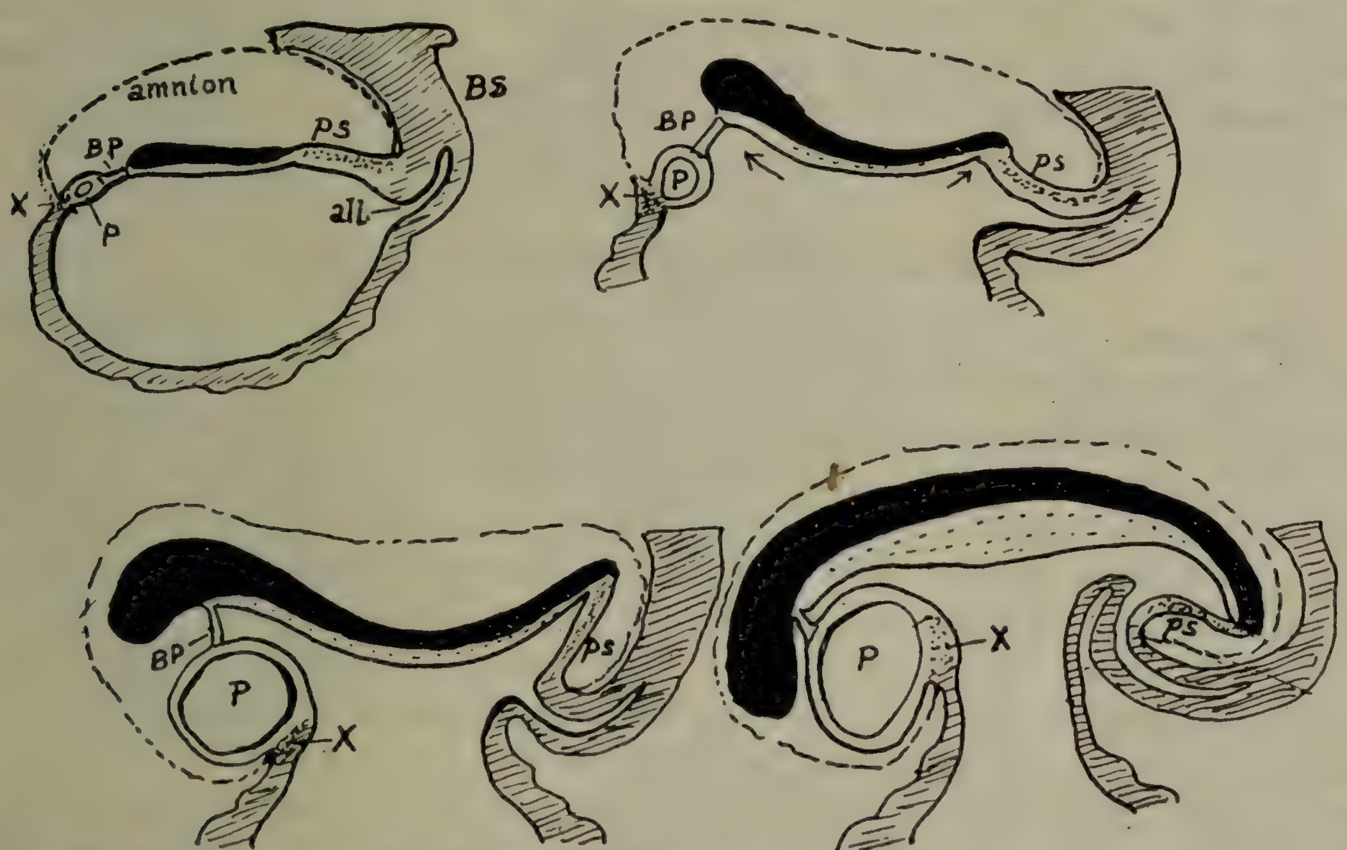


FIG. 33.—TO ILLUSTRATE THE RESULTS OF RAPID ELONGATION OF THE NEURAL AXIS, SHOWN IN SOLID BLACK.

ps, primitive streak; BP, bucco-pharyngeal area or membrane; P, pericardium. The fore-gut is made by the forward projection of the neural structures reversing the pericardium and bucco-pharyngeal membrane below itself. The hind-gut is made, in a similar fashion, by the growth of the caudal end reversing the area of the primitive streak below itself. X is the front margin of the original embryonic plate, which, when reversed, comes to lie behind the pericardium, and separates it (septum transversum) from the abdominal region.

convenient and customary to distinguish these parts by speaking of the common cavity as the **cloaca,** and restricting the term **hind-gut** to the tube (from the gut-cavity) which opens into the cloaca dorsally. As is apparent from the figures, the ventral wall of the cloaca is made in the middle line by the primitive streak, and this forms the **cloacal membrane,** closing off the cloaca from the surface, like the bucco-pharyngeal membrane in the fore-gut.

That part of the intra-embryonic enteron which lies between the anterior and posterior prolongations is termed the **mid-gut;** it very soon undergoes alterations in its disposition and appearance, but at

this stage it is widely open and continuous below with the extra-embryonic *yolk-sac.**

In Fig. 33 two other points may be noticed. The pericardium enlarges rapidly (keeping pace with the rapid growth of the heart), and is not only reversed by the neural elongation, but, owing to its own growth, bulges forward and ventrally over the original embryonic margin (shown at X in the figures). The neural tube not only elongates behind the bucco-pharyngeal area and pushes this forward in the reversing movement, but also extends forward over and in front of this as a free projection, which is the **fore-brain.** The prominent fore-brain and pericardium are separated by a depression, transversely disposed, which is the stomodæum; the bucco-pharyngeal membrane lies at the bottom of the stomodæum and shuts it off from the fore-gut.

Condition of Intra-Embryonic Cœlom.

Consequent on the growth-processes just considered, the body-cavity shown schematically in Fig. 32 undergoes a certain amount of change affecting its anterior and posterior parts; this can be easily understood by comparing the last scheme with those in Fig. 34, which represents the results of reversal. The reversal of the pericardium has carried each of its lateral openings dorsally and forward, but as the great relative size of the pericardium, when the movement is completed, is due to rapid growth and bulging forward of that structure, the ultimate openings of each lateral recess are on the dorsal side of the cavity, some distance in front of its caudal wall; each recess passes back from this to join the lateral cavity. The bulging of the pericardium, with its reversal, has led to the unsplit marginal mesoderm, which (p. 43) lay round it and its lateral recesses, being now concentrated behind it, below the lateral recesses. This concentration of mesoderm forms a septum between the pericardium in front and the peritoneal cavity behind, and is termed the **septum transversum.** The lateral recesses, therefore, pass back to the peritoneum above the septum transversum, which is forming the posterior or caudal wall of the pericardium; in doing this, the recesses must lie on either side of the fore-gut in this region, for this is above the pericardium and its caudal wall (see figures).

The septum transversum, being the original unsplit anterior margin of the embryonic area, is (as was previously pointed out) an area where body-wall and gut-wall still retain their connection. Hence the veins (vitelline) from the gut-wall meet here with those from the body-wall (umbilical and others), and at the junction form a large venous sinus. This *sinus venosus* is therefore embedded in the septum transversum, from which it opens into the venous end of the heart. At the caudal end the external cœlom, which is between body-stalk and yolk-sac at their junction, has been drawn into the body with these structures, and

* See note on p. 30.

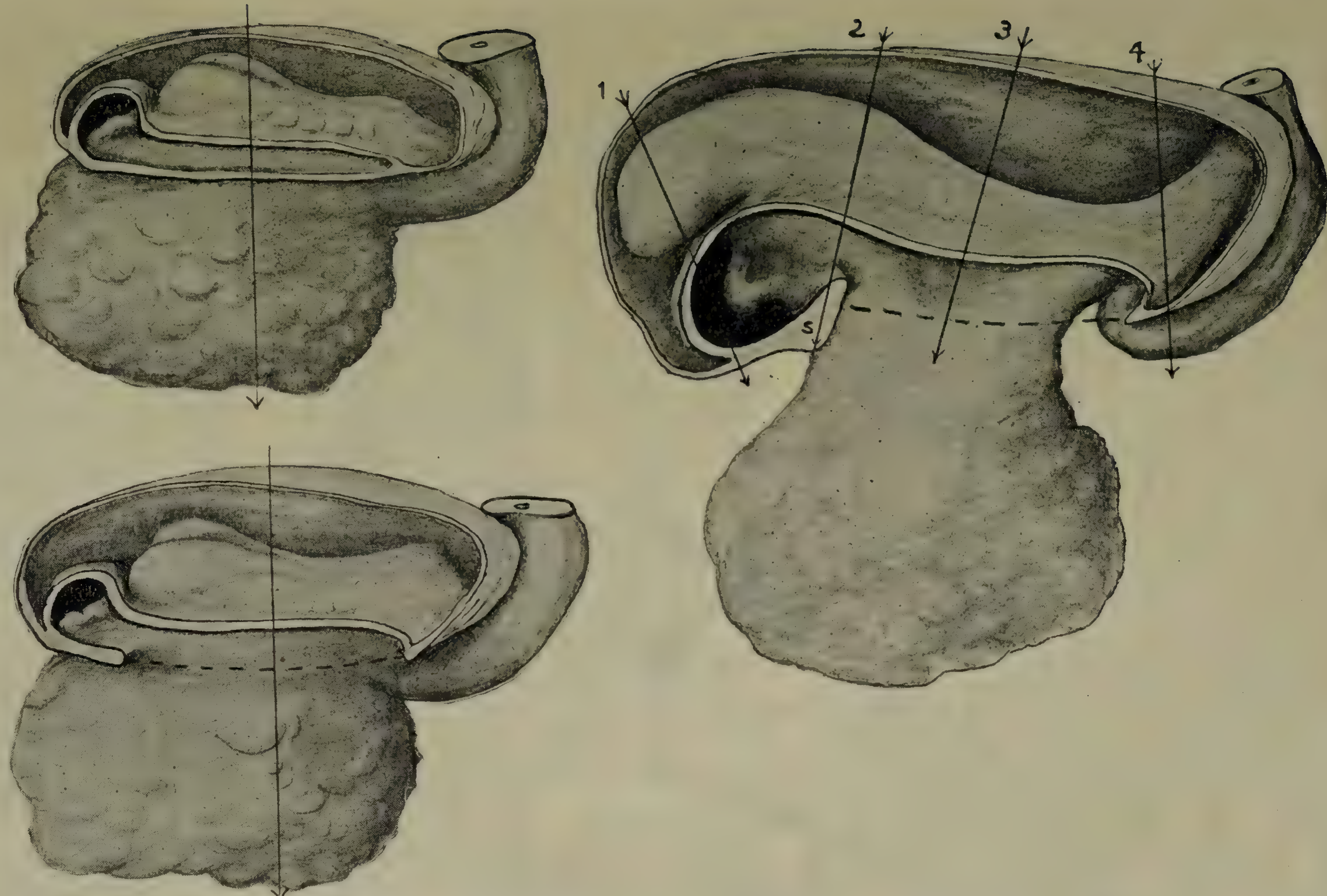


FIG. 34.—THREE IMAGINARY DISSECTIONS TO SHOW GENERAL DISPOSITION OF BODY CAVITY.

Lateral mesodermal sheet removed, exposing cavity. Rim of plate unsplit in first figure, but has given way (broken line) in others. Numbered arrows in third figure correspond with sections in Fig. 35.

forms a peritoneal recess passing from side to side between the hind-gut and the allantoic stalk. Sections through the embryo, in the directions indicated by arrows in the previous figure, are shown in Fig. 35 to facilitate comprehension of these relations of the body-cavity.

The embryo may now be fairly said to have reached the vertebrate level. It has an alimentary tube separated by a body-cavity from the body-wall, with a heart and pericardium ventral to the tube, and an axial skeleton (notochord) and central nervous system dorsal to it. It is very minute still; the embryonic plate, when the neural groove is first formed, is only about 1 mm. in length or less, and the greatest length of the embryo when it has completed the processes of reversion is not much more than 2 mm. The stage is reached during the third week, but exact data cannot be given about this matter. The broad details of subsequent development which are about to be considered are comprised under the term *organogeny*, including as they do the modes of formation of the various structures and organs that make up the

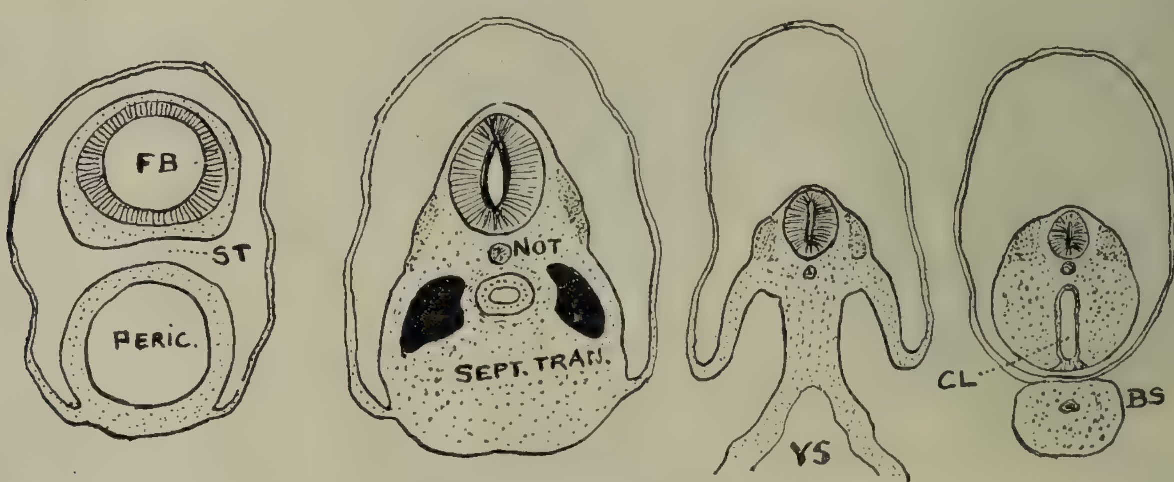


FIG. 35.—SECTIONS 1, 2, 3, AND 4, PASSING THROUGH THE DIRECTIONS SHOWN BY THE ARROWS IN THE LAST FIGURE.

ST, stomodæum; YS, yolk-sac; CL, cloaca; BS, body-stalk.

regions of the body. In attaining to their mammalian form, these several structures pass in a general way through stages that can be termed fish-like and reptilian, but the recognition of such stages is largely a matter of opinion; and in any case the phylogenetic influence of the past is much overlaid by the present and insistent influence of ontogeny. The action of the rapid neural growth does not cease with the stage which has been reached so far; it is only when the full number of somites (about thirty-five) has been produced that the rate of growth of the nervous axis included between the somites falls to that of the embryo as a whole. The anterior part, from which the brain is formed, is still relatively free from mesodermal restriction, however, and rapid growth and change goes on here for a considerable period. The result of the higher proportionate rate of growth being in the middle line, on the dorsal surface, is that the embryo rapidly assumes a markedly curved form, the elongating dorsal tube encircling the slower-growing ventral structures; this is indicated in the diagrams in the last few figures, but is in reality much more marked than appears in them.

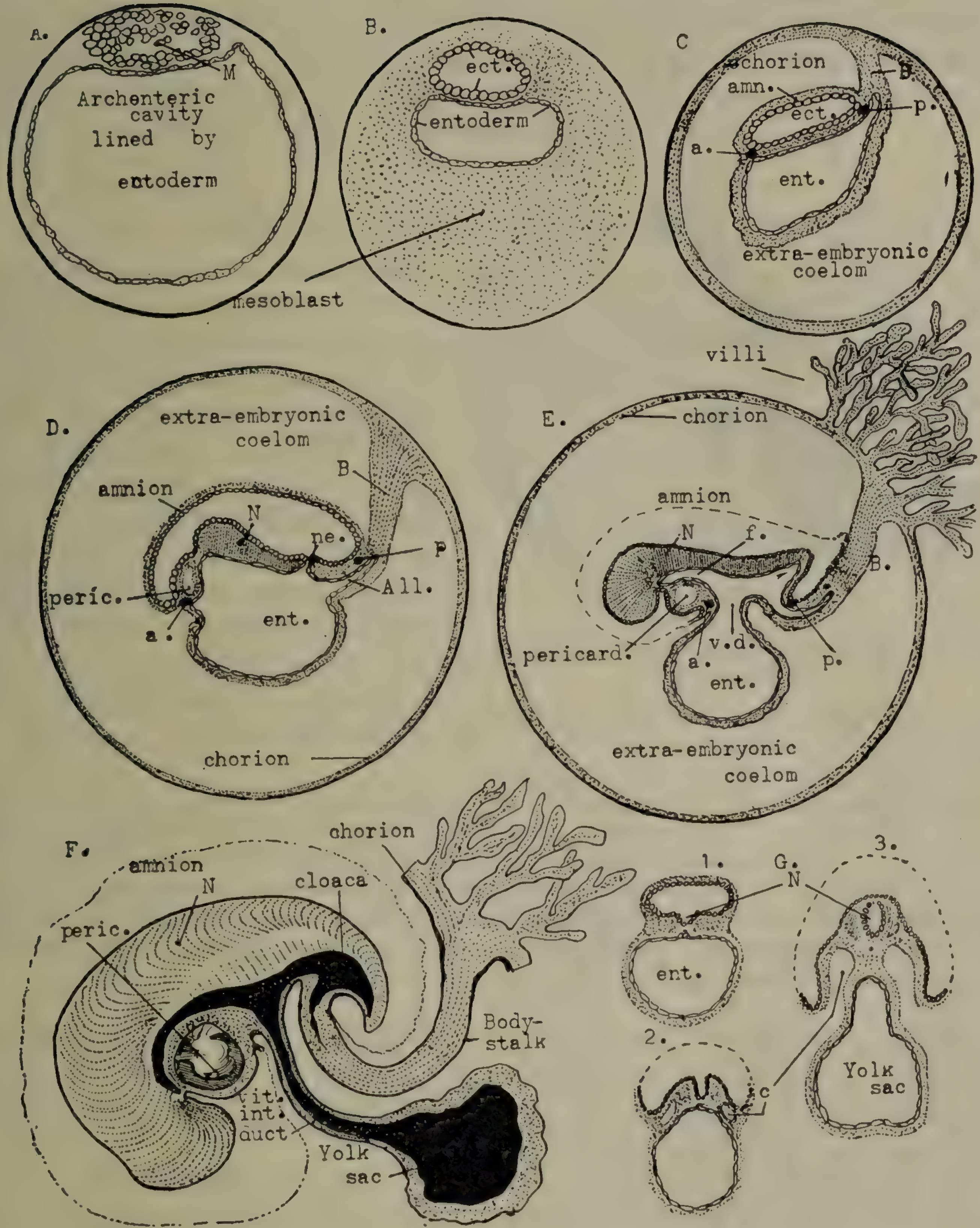


FIG. 35A.—SCHEMES SHOWING ATTAINMENT OF GENERAL FORM OF EMBRYO.

A, enveloping layer, whose fate is uncertain, represented by a line. Entoderm has grown round and enclosed the archenteron, and the inner cell mass (M) shows amniotic spaces. In B, primitive mesoblast, of uncertain origin, fills the ovum, surrounding the ectodermal amniotic sac and the entoderm. The embryonic plate lies between the two, made by ectoderm and entoderm only. C shows this mesoblast split, forming the extra-embryonic cœlom; this leaves the cells deposited either on the wall of the ovum (chorion), or on the included embryonic structures. A connection, however, persists (B) between these, the body-stalk, by which vessels can run between embryo and chorion. Situations of anterior and posterior poles of the disc are shown at *a* and *p* respectively. For rest, see text.

Fig. 36 gives a representation of an embryo considerably older (though still under 5 mm. in length) in which the extreme curvature is well seen, and it appears very soon after the movement of reversal has taken place. This curved state of the embryo remains a marked feature for some weeks, but, as the visceral growth within the body begins to make its influence felt, the tightness of the curve is relaxed; towards the last half of the second month it is much less in evidence, and in the third month it is not at all striking. The fœtus, however, always retains more or less of the curve of these months, owing to the necessities of the space it occupies, and the thoracic curve of the adult vertebral column is really a remnant of the old embryonic dorsal convexity.

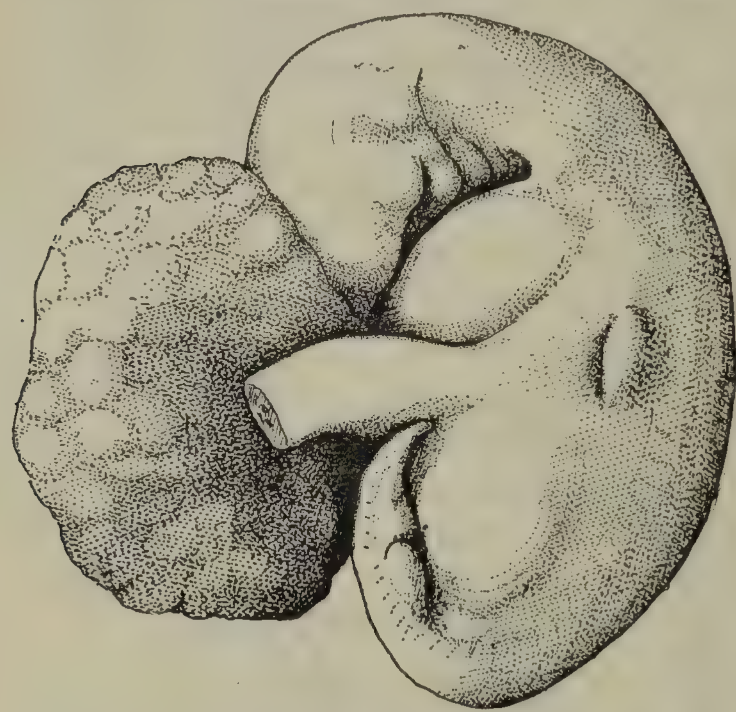


Fig. 36.—Human Embryo 4·9 Mm. in Length.

The body-stalk is cut short; limb buds are visible.

In the third schematic section in Fig. 33 a dorsal concavity is shown. This is not a necessity of the diagram, but is actually found in this and somewhat later stages. It is customary now to refer its existence to the effects of preparation of the embryo, but, since nearly every known embryo of these stages presents this angled bend, it is not improbable that the older view was correct, and that it is really a temporary normal stage, due to irregularities in growth-rates, which is corrected later, so that the full convexity is produced.

Before proceeding to describe the formation of organs and regions, however, it is necessary to consider two things to which reference has been occasionally made in the preceding pages—the *yolk-sac* and the early *formation* and *circulation of the blood.*

The Yolk-Sac.—This is a hollow sac, with the embryonic plate as part of its roof. Its general form and appearance can be gathered from the figures. It is empty, and, as seen in hardened and sectioned embryos, is wrinkled and collapsed.

The emptiness of the sac refers to the absence of any yolk-like material. It actually contains fluid, and presents a rounded appearance when fresh; its collapsed state is a result of the processes of preservation. The absence of yolk is a secondary result of the establishment of placental nutrition. The sac, especially in the later stages (in which the name is applied with most propriety to the sac), is the representative of the lower part of the visceral wall in the holoblastic ovum.

The wall of the yolk-sac is composed of mesoderm, lined internally by entoderm, from which short glandular outgrowths project into the mesoderm; it is possible that these secrete the fluid contained

within the sac. The mesoderm between the short glands is the seat of the earliest formation of blood-cells. The aggregation of blood-forming areas, or *blood islands*, causes the irregularly bossed appearance of the yolk-sac wall which is apparent in the figures. The subsequent fate of the structure will be dealt with later.

Blood Formation and Early Circulation.

The blood-corpuscles of the embryo are *nucleated*. They are first formed in the *wall of the yolk-sac*, probably from the mesoderm. Separate collections of special cells, erythroblasts, appear in the mesoderm, and these develop quickly into blood-cells and endothelial containing cells. The vascular islands formed in this way extend and run together, thus producing a vascular network on the yolk-sac. About this time spindle-shaped cells appear in the *chorion and body-stalk*, and, becoming connected, form another network in these parts of the ovum. Actually, vessels appear to be formed in the chorion before they are definitely recognizable in the yolk-sac. Blood-cells also seem to be formed in the chorion. The vitelline network soon joins up with the chorionic system by connection with the vessels in the body-stalk. At the same time, although the details are not known, the intra-embryonic circulation appears, connected with the chorionic and vitelline systems of vessels. This takes place at (or just before) the time when the somites begin to appear, and the circulation at this very early period may be represented as in the upper scheme in Fig. 37.

Vitelline veins run to the venous end of the heart, which at this stage is at the *front* end, and from the heart two *aortæ* run back, lying beside the bucco-pharyngeal area, and passing in the embryonic plate along the roof of the enteron, to reach the body-stalk; here they become *placental* or *umbilical arteries*, and reach the chorion and its villi. Blood returning from the chorion runs in the *umbilical veins*, which pass back in the body-wall close to the amniotic attachment; thus they reach the anterior part of the margin, where they join the vitelline veins in the venous end of the heart. Branches from the aortæ run down on the wall of the yolk-sac, and thus complete the vitelline circulation.

The process of reversal puts the venous junction at the *caudal* end of the heart, *in the septum transversum*, and the arterial end of the heart, now in front, gives off aortæ, which must turn back to run their course; this is at first on the roof of the fore-gut. The lower diagram in the figure shows these results of reversal. The necessary changes in position of the umbilical and vitelline veins are also seen. In addition, when the excretory system begins to form along the dorsal wall of the body-cavity, a longitudinally running *cardinal vein* is developed in association with it; this passes forward, and joins with a *primitive jugular*, draining the region of the growing head. The junction of the two forms a large vein, the *duct of Cuvier*, which reaches the septum transversum by turning down in the body-wall on the outer

side of the lateral recess of the pericardium. On each side of the body, therefore, there are three main veins which meet in the septum transversum: the duct of Cuvier, and the umbilical and vitelline veins; when they join they form a large venous lake known as the sinus

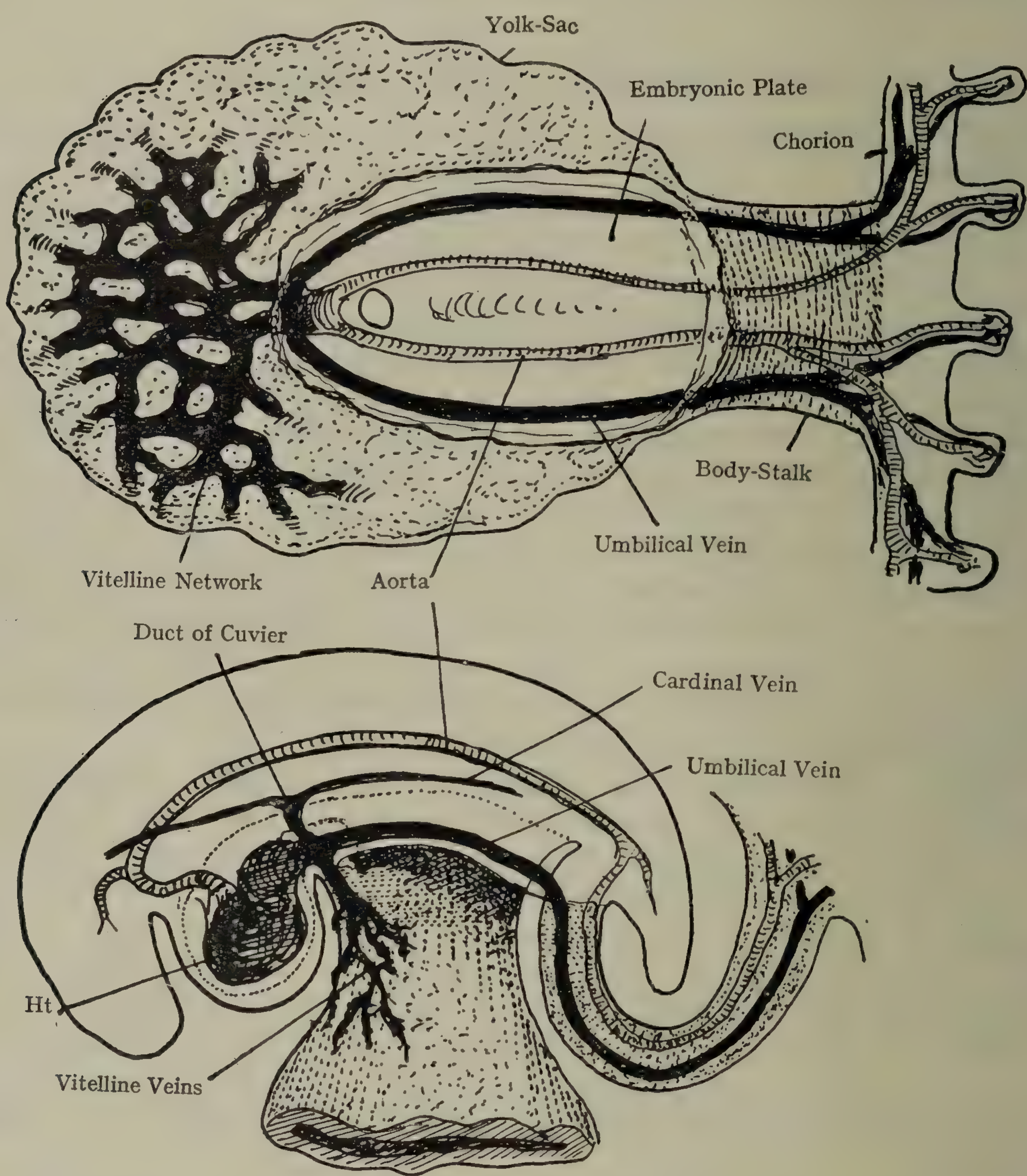


FIG. 37.—TWO SCHEMES TO ILLUSTRATE THE CIRCULATION IN THE EMBRYO.

The upper figure is a representation of the 'plate' stage, opened out on the flat; the bucco-pharyngeal area is seen between the aortæ at their beginnings. The second figure shows the effect of reversal. The dotted line marks the outline of the body-cavity.

venosus, whose side parts, or *horns*, are made by the threefold junction on each side. The sinus venosus is then a *large blood-sinus embedded in the septum transversum*, and opening in front into the venous end of the heart tube in the pericardium.

BROAD OUTLINES OF DEVELOPMENT OF SYSTEMS AND ORGANS.

Nervous System.

The **spinal cord** is formed from the neural tube, lying between the rows of paired somites. The ectodermal walls of this tube, proliferating rapidly and thus thickening the walls laterally, soon convert it into a structure (Fig. 38) in which a cavity, elongated dorso-ventrally,

FIG. 38.—THREE SECTIONS FROM DIFFERENT LEVELS OF CORD IN EMBRYO OF 4·9 MM.

Left lower figure, under higher power, shows nerve-fibres leaving ventro-lateral wall.

lies between two thick *lateral walls* connected by a thin *roof-plate* and a thicker *floor-plate.* The cavity becomes ultimately the central canal of the cord, its shape being much modified by the developments in the walls. The side walls are syncytial in structure, the nuclei being embedded in a protoplasmic network, the **myeloplasm.** The nuclei proliferate in the layer immediately adjoining the cavity, the additional

nuclei formed in this way being pressed out into the myeloplastic network. In this way certain layers can be distinguished before long in the walls:

(*a*) An inner *ependymal layer* surrounding the canal; there are large clear ' germinal cells ' in this layer, which are thought to be particularly concerned in the proliferation.

(*b*) A *mantle layer,* covering the ependymal layer, and showing many nuclei in the syncytium.

(*c*) A *marginal layer,* consisting of protoplasmic processes, *without nuclei,* sent out from the syncytium.

The mantle layer cells, when they differentiate from the early syncytium, are *neuroblasts* and *spongioblasts*; the former develop into nerve-cells, the latter into neuroglial (supporting) cells. The mar-

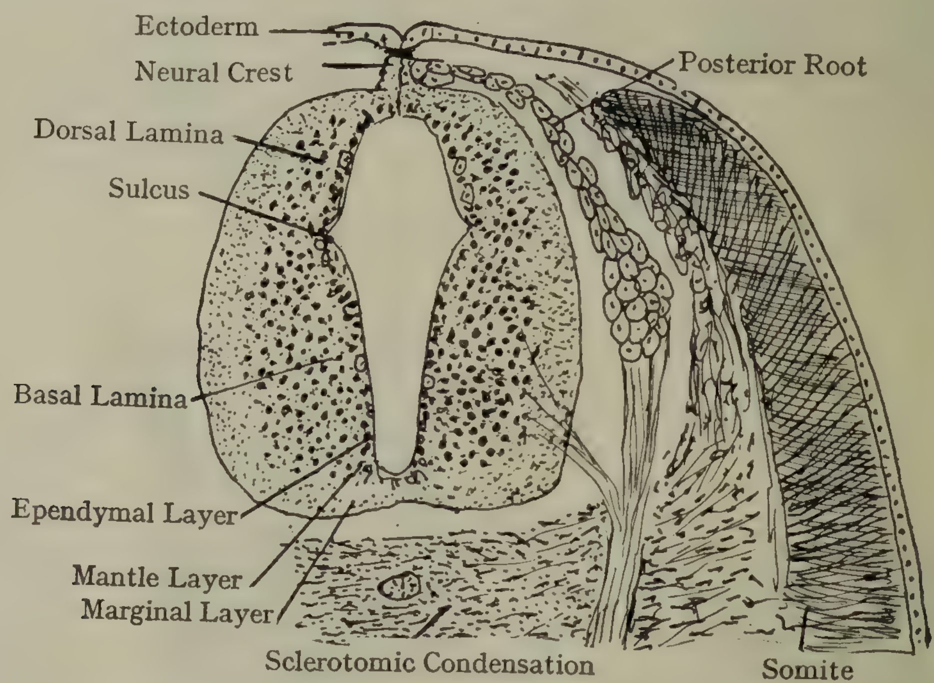


FIG. 39.—COMPOUND SCHEMATIC FIGURE TO SHOW THE VARIOUS POINTS DESCRIBED IN THE TEXT.

It is supposed to represent part of a transverse section through the body.

ginal layer forms a network or scaffolding within which the white fibres of the cord, when they develop, can pass up and down.

Rapid formation of neuroblastic nuclei takes place especially in the ventro-lateral and dorso-lateral parts of the side walls, so that these parts bulge into the cavity, and produce longitudinal columns, the **dorsal** (alar) and **ventral** (basal) **laminæ,** separated by an **interlaminar sulcus** (Fig. 39).

The neuroblasts in the basal lamina send out processes which form the ventral (or anterior) roots of the spinal nerves. The ganglia of the dorsal (or posterior) roots are derived from the *neural crest,* a longitudinal ridge on the roof-plate made by fusion of the edges of the neural folds. Extension of cells from this makes a continuous sheet of cells, applied to the dorso-lateral aspect of the cord on each side: within this sheet, at segmental intervals, the cells are gathered into definite masses which are the precursors of the **ganglia.** These gangli-

onic rudiments, therefore, are connected with each other at first by the remnants of the sheet lying between the masses, and only become 'free' when such remnants disappear. The ganglion cells send out processes to meet the ventral roots and complete the nerve.

Each spinal nerve extends by degrees into its proper position in the developing body. There are at least three main theories concerning the nature of their extension:

1. *Outgrowth theory* of His: This, the most generally accepted, describes the nerve-fibres as direct growths from the neuroblasts, hence ectodermal in origin, but acquiring mesodermal sheaths.

2. *Cell-chain theory* of Balfour: This regards nerves as chains of

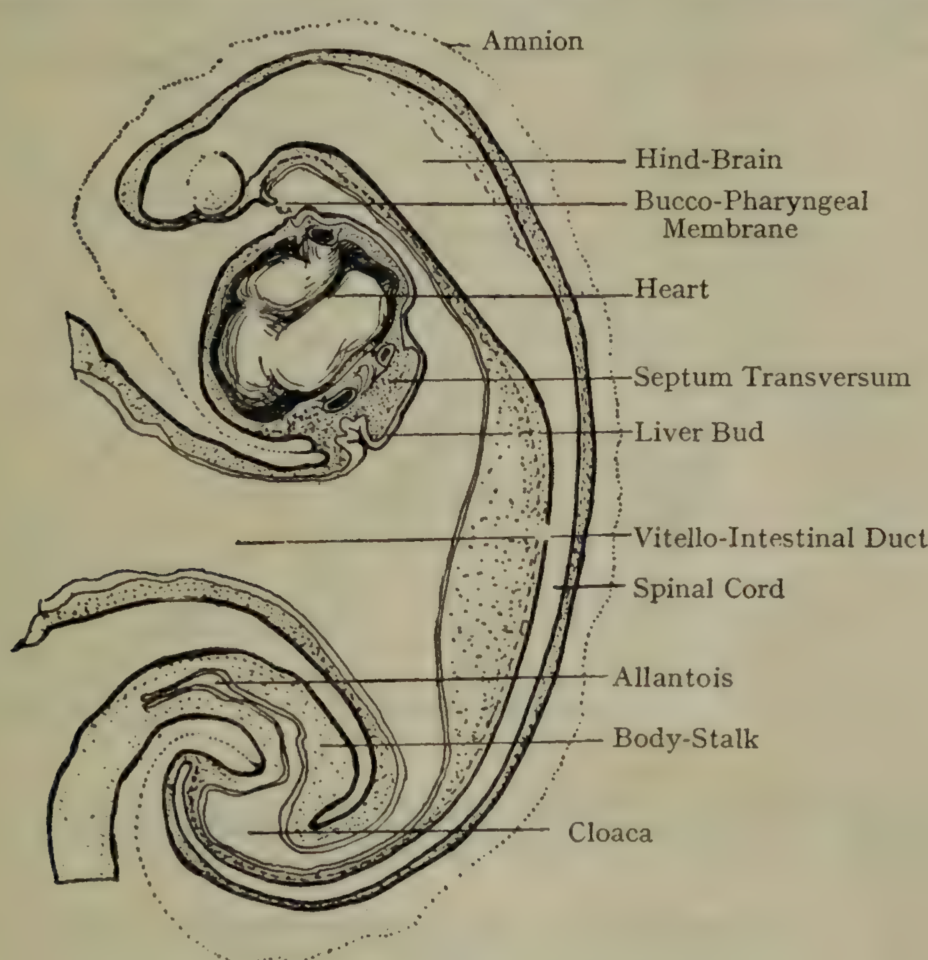


FIG. 40.

cells, but opinion is divided as to the ectodermal or mesodermal origins of these cells.

3. *Primitive continuity theory* of Hensen: This view postulates the (syncytial) continuity of ectodermal and mesodermal layers from the beginning, so that the potential path of the nerve impulse, and so of the fibre, is present *ab origine*. An increasing number of recent observers adopt this view.

Brain.—The most anterior part of the neural groove, that first laid down, forms the brain. The widely open portion shown in Fig. 30 is the **hind-brain**; its anterior end, where the two folds meet in a low ridge, contains the primordia of what will later develop into *mid-brain* and *fore-brain*. The hind-brain is the part which, by its rapid elongation, leads to the initiation and carrying out of the movement of reversal already considered. When the reversal is accomplished, the hind-brain

extends practically along the whole dorsal length of the fore-gut; the notochord lies between it and the roof of this recess. As it is prolonged forward it closes in from behind forwards, so that the position of the anterior neuropore is moved forward. Before the reversal is completed its anterior end begins to grow rapidly, and projects (Fig. 33) beyond the bucco-pharyngeal membrane; this makes the **fore-brain,** which is therefore a free projection forward from the front end of the neural region. As the fore-brain projects forward, the hind-brain closes in completely, and the anterior neuropore is now only a small opening which has been carried forward on the projecting fore-brain, and closes rapidly. The fore-brain is now a small and rather elongated part, connected with the large hind-brain by a short constricted neck which will soon develop into the **mid-brain,** and may be so called now.

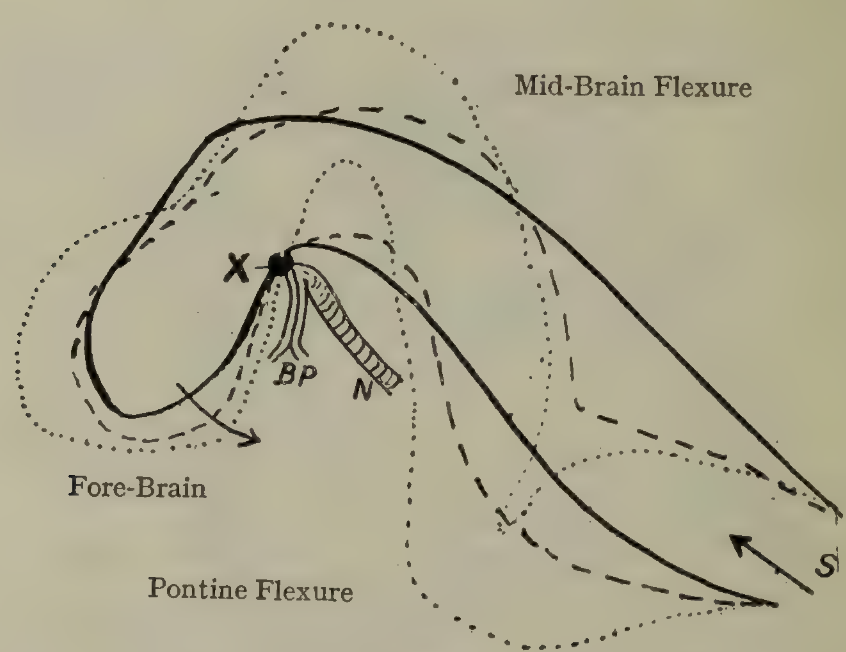


FIG. 41.—TO SHOW HOW THE BRAIN TUBE, BETWEEN THE FIXED POINT (X) AND THE REGION OF THE SOMITES (S), IS BENT TO ADMIT OF ITS RAPID GROWTH.

N, notochord; Bp, bucco-pharyngeal membrane.

The brain at this stage is seen in Fig. 40; the relation of the fore-brain to the remnants of the bucco-pharyngeal membrane is seen, and it can be observed that the notochord is attached to the upper part of this membrane. The anterior neuropore has closed. The lower aspect of the fore-brain is in direct contact with the covering ectoderm, no mesoderm intervening: this contact and attachment persists in the middle line for a short time, and for a considerable time just in front of the region of the bucco-pharyngeal membrane, long after the membrane itself has disappeared.

The mesoderm covering the fore-brain is at first very scanty, and forms an incomplete covering. It is derived from the paraxial portion of the middle layer, but no segmentation occurs in this part of the human embryo.

The point X in Fig. 41 marks the place where the fore-brain is attached to the ectoderm and top of the bucco-pharyngeal membrane, with the posterior layer of which the notochord is continuous. This

part, then, can be looked on as a relatively fixed point, round which further processes of growth may effect rotation, or may produce flexures against its resistance. Both these results are seen. They are schematically represented in Fig. 41, in which the black line represents the brain as in the last figure, and the interrupted and dotted lines two imaginary later stages. The 'fixed' point is at X, where ectoderm, bucco-pharyngeal membrane (BP), and notochord (N) meet. Between this and the region of somites (S) the disproportionately increasing length of the brain leads to flexures; the hind-brain, opening out with a wide roof-plate, makes a sharp **pontine flexure,** convex ventrally, and the mid-brain stands up in a **mid-brain flexure,** concave ventrally.

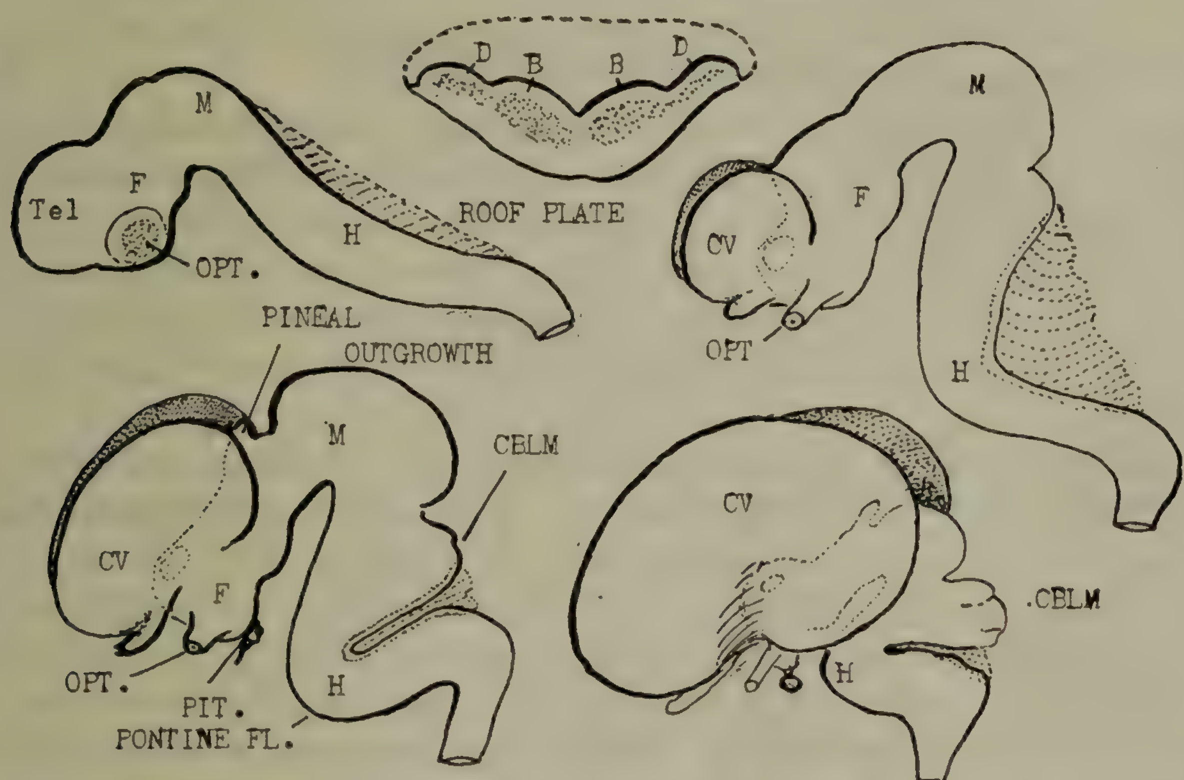


FIG. 42.—OUTLINES ILLUSTRATING STAGES IN DEVELOPMENT OF FORM OF BRAIN.

Though diagrammatic, the four stages may be taken to correspond, in a general way, with the conditions in embryos of the fourth week, fifth week, seventh week, and third month respectively. F, M, H, fore-, mid-, and hind-brains; Tel, telencephalon; CV, cerebral vesicles; CBLM, cerebellum; PIT., pituitary; OPT., optic outgrowth, cut away in later stages, leaving only the stalk. The topmost figure shows a section through the hind-brain in its wide part; D., B, dorsal and basal laminæ.

In front of X the 'push' of the mid-brain tends to rotate the lower part of the fore-brain backwards and downwards round X, so that it comes to be firmly pressed against the projecting pericardium; but its anterior and upper part is free, and from this region outgrowths take place to form the optic and cerebral vesicles.

Further stages in the general development of the form of the brain are shown in Fig. 42; the **hind-brain** is seen to become more sharply bent at the *pontine flexure,* so that, at this bend, it is widely opened out; thus the dorsal and basal laminæ come to lie in what is now the floor of a wide lozenge-shaped cavity, the roof being formed by the broad and undeveloped roof-plate. The breadth of the cavity and roof-plate

decreases as one passes forwards or backwards from the pontine flexure. This 'open' part of the hind-brain is called, from its shape, the *rhombencephalon,* and the name of *isthmus* is given to its narrower upper end, where it is about to join the mid-brain. A *nuchal flexure* is formed secondarily below it, being a compensating curve due to the presence of the pontine bend. The **cerebellum** develops, at a fairly late period, from the *dorsal laminæ of the front limb of the bent hind-brain*; it begins as a thickening in each lamina, spreading into the roof-plate and standing out prominently behind. The cavity of the rhombencephalon becomes that of the *fourth ventricle.*

The cavity of the **mid-brain** becomes the Sylvian aqueduct. The cerebral crura are formed below its floor by the fibres that grow down, at a later period, from the cerebrum and, lying in the marginal zone, obliterate the ventral concavity in this part. The *roof* develops symmetrical elongated *corpora bigemina,* which are subsequently divided by a transverse groove, thus producing *corpora quadrigemina.* During a great part of the embryonic period the mid-brain makes a prominent convexity (Fig. 40), which constitutes the highest part of the head, or most anterior point; towards the end of this period the relative rate of growth of the part falls, and the cerebral vesicles begin to cover it.

The **fore-brain,** as it appears in the early stages, is known as the **thalamencephalon** or **diencephalon.** Two **optic outgrowths** project from its lower part, one on each side, in contact with the ectoderm of the surface; they make the optic nerves and inner layers of the eyeballs, the surface ectoderm forming the lens in each case. The dorsal laminæ of the fore-brain thicken to form the *optic thalami,* and the basal laminæ form the *corpora mammillaria, tuber cinereum,* and *subthalamic nuclei.* The infundibulum of the *pituitary* body is an evagination from its floor, and the *pineal* body from the hinder end of its roof.

But, before developments take place in the thalamencephalon, there occurs a dilatation or projection forward of its anterior part, in connection with the dorsal laminæ. This newly added part of the fore-brain is termed the **telencephalon;** it appears when the embryo is about 5 mm. long. The side walls of the telencephalon very soon begin to project laterally to form the **cerebral vesicles.** As the cerebral vesicles enlarge they project to some extent forwards, but their main enlargement is in a backward direction, as well as upwards and outwards; they extend back, separated from each other in the middle line by a mesodermal septum (falx cerebri), and cover successively the fore-, mid-, and hind-brains. Each has a large cavity at first, continuous with that of the telencephalon at its site of origin; the cavity becomes the *lateral ventricle,* and its opening into the telencephalon is the *foramen of Monro.* The thalamencephalon and telencephalon constitute the *third ventricle.* The cerebral vesicles have the *corpora striata* forming in their floors and outer walls; their roofs, thin at first, thicken subsequently to form the main masses of the cerebral hemispheres.

The elongated brain of the embryo is altered, by the changes shortly sketched out above, into the compact organ of descriptive anatomy. The hind-brain, originally extending along the dorsal length of the fore-gut, is much shortened by flexure; this, with the rapid growth and elongation of the fore-gut, soon leads to the definite cranial situation of this part of the brain. The fore-brain, at first forming the roof of the stomodæum, is soon separated from this by the growth of mesoderm below it, as will be described when dealing with the formation of the face. It is then hidden from view by the growth of the cerebral vesicles, and these, growing upwards and backwards, become the highest parts of the whole structure when the head is brought into the vertical position.

Vertebræ and Body-Wall.

In the region of the somites the inner wall of each of these mesodermal blocks begins to break up, with rapid proliferation of its cells. A large extension inwards of cells takes place toward the notochord; this extension is known as the *sclerotome.* Each sclerotomic ingrowth (Fig. 43) meets its opposite fellow round the notochord, which thus comes to be embedded in a mesodermal mass lying between the neural tube and the structures connected with the roof of the alimentary tract. The *vertebral centra* and *intervertebral discs* are developed in this mesodermal mass, and extensions from it pass dorsally round the tube and form the *neural arches* and the *ligaments between them.*

The vertebræ, however, are not segmental in position, like the somites from which they are indirectly made, but *intersegmental.* This result is attained (Fig. 43) by the splitting of each sclerotomic ingrowth into two parts, anterior and posterior; the anterior part of one sclerotome joins with the posterior portion of the sclerotome in front of it, and thus an intersegmental mesodermal mass is formed, in which the vertebral centrum is developed. The dorsal extensions, and lateral ones, are also between the somites, and therefore intersegmental. The *lateral* extensions form *transverse processes,* and also the vertebral ends of the *ribs*; the latter extend gradually into the somatopleure or body-wall.

Body-Wall.—The lateral outgrowths from the sclerotomes are still intersegmental in the body-wall, for, between them, extensions *from the somites* pass ventrally into the body-wall to form the muscles of this wall; such a downgrowth from a somite is, of course, segmental in position. In the abdominal wall there are no costal extensions from the sclerotomic derivatives, and the muscle growths from the somites are separated from each other only by mesodermal cells of the lateral sheet into which they are growing. No muscles are formed from the mesoderm of the lateral sheet where this has been split by the development of the body-cavity, but they are all derived from these ventral downgrowths from the somites. There is a part of the lateral sheet, however, which is not involved in the cœlomic splitting; this lies on each side behind the bucco-pharyngeal area (see Figs. 32 and 34), and

makes the side-wall of the front portion of the fore-gut when this comes into existence, and here certain muscles are developed directly, as will be seen later.

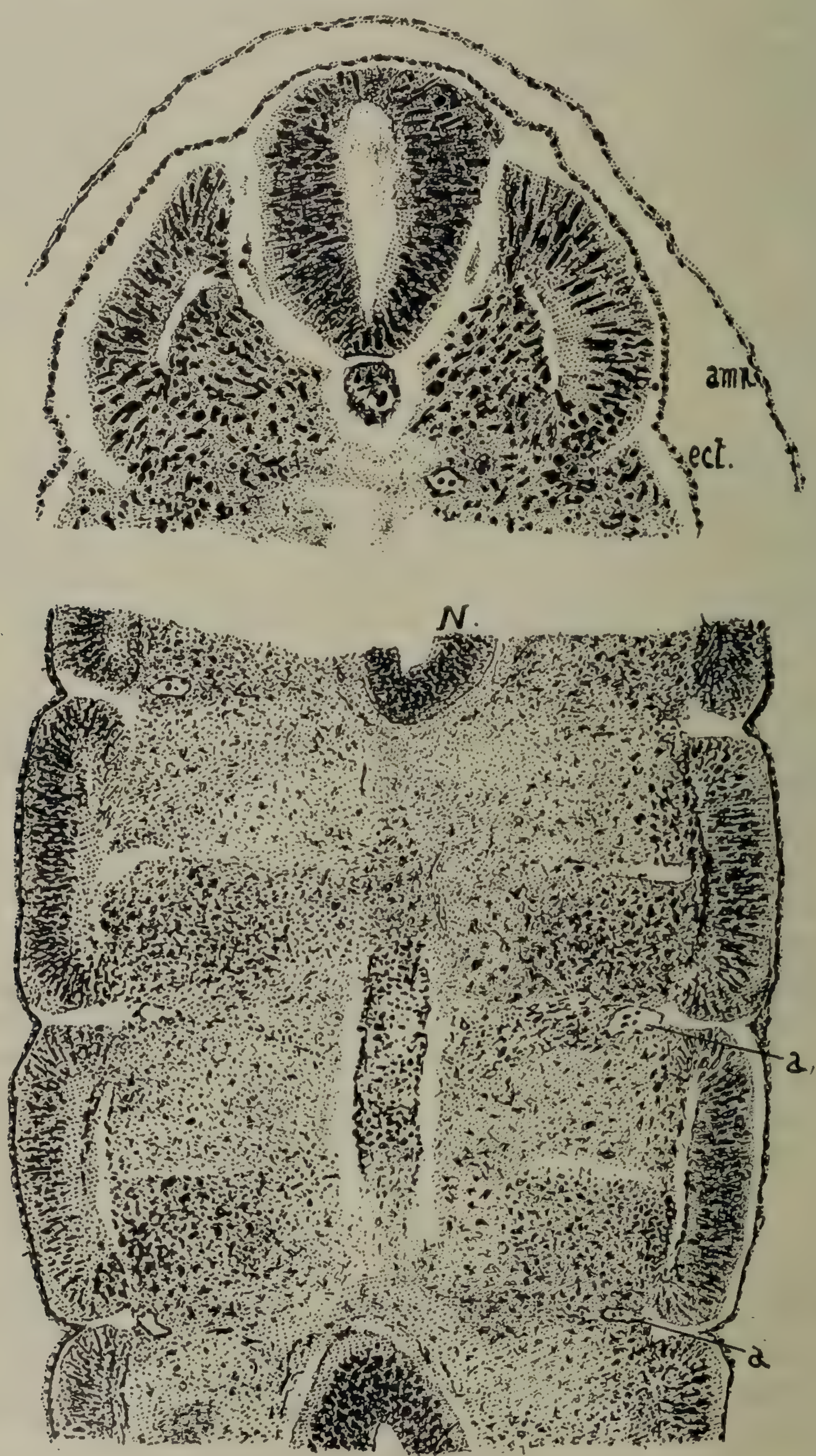


FIG. 43.—SECTIONS OF HUMAN EMBRYO.

Upper section, transverse, shows the sclerotomic ingrowths from somites towards notochord: lower section, horizontal, shows the (dark) posterior and (lighter) anterior subdivisions of sclerotomes. *a*, intersegmental arteries; N, neural tube.

The ventral downgrowths from the somites are accompanied by growing nerves and vessels, which become the vascular and nervous supplies of the wall.

Changes in the Mid-Gut.

It has been seen that the mid-gut is at first a cavity within the embryonic body, into which the fore-gut and hind-gut open, and is in wide continuity with the yolk-sac outside the embryo (see Fig. 33). Its roof shows at first the notochordal groove, but this soon closes in and separates from it. The width of its roof (Fig. 31) is small compared with that of the embryo, owing to the presence of the body-cavity. During the third week the roof of the mid-gut begins to come away from its original position immediately below the notochord, and the dorsal parts of the body-cavity on each side are approximated above it; in this way a two-layered *mesentery* is made, in the middle

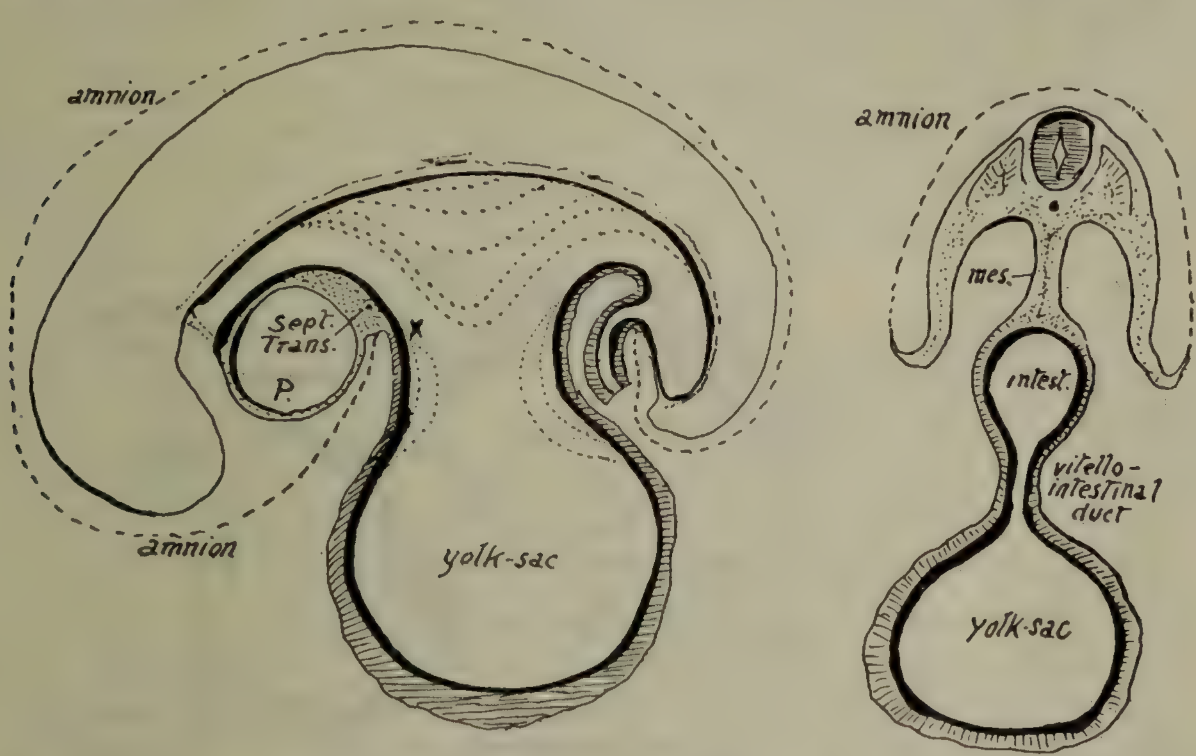


FIG. 44.—DIAGRAMS TO SHOW CHANGES IN MID-GUT.

In the first figure the dotted lines indicate the successive limits of the mesentery, and, at the junction of intra- and extra-embryonic parts of the enteron, the increasing constriction producing the vitello-intestinal canal. The second figure shows, by transverse section, the resulting production of a mesentery and a vitello-intestinal canal.

line, between the receding roof of the gut and the dorsal wall of the body, carrying between its layers the vessels that were at first supplied more directly to the gut-wall. At the same time the region of continuity between the intra- and extra-embryonic gut-cavities begins to show a constriction, which definitely marks off the permanent gut from the outer yolk-sac. The constricted region is drawn out to form the **vitello-intestinal duct** or **canal.** Thus, by the fourth week, there is an angled *loop* of embryonic mid-gut (Fig. 44) suspended by a *median dorsal mesentery* and, at its most ventral point, attached by a narrow and elongated *vitello-intestinal duct* to the *yolk-sac.* The hind-limb of the mid-gut loop is continuous with the hind-gut, and the front-limb with the fore-gut, but in this case the place of continuity is not so evident at first sight. Examination of the diagram will show that the

gut-tube, when followed forward, passes up behind and in contact with the septum transversum, and so forward over the pericardium; all that part in relation with the septum is to be regarded as *fore-gut*, whence the *mid-gut* must be described as beginning at the lower edge of the septum, or, in other words, as soon as the ventral wall of the tube is free from this attachment (X in Fig. 44). The hinder end of the fore-gut is thus seen to have a median dorsal mesentery directly continuous with that of the mid-gut, and coming into existence with it.

It will possibly have become apparent already that the division into fore-, mid-, and hind-gut is more descriptive than morphological in value, and that the fore-gut and hind-gut are only comparable in a very general way. The beginning of the mid-gut at the lower end of the septum is necessary for the conception of the human fore-gut, but does not apply to some other forms. The beginning of the hind-gut can be more clearly appreciated later.

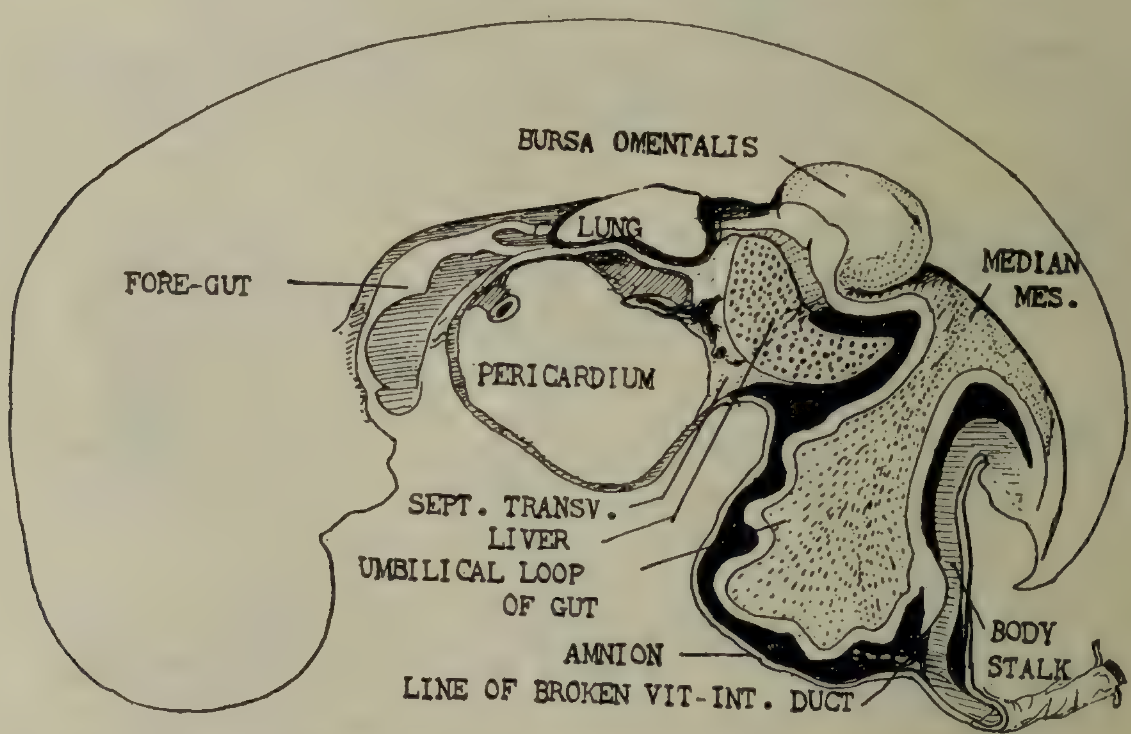


FIG. 45.—COMPOUND SCHEME TO SHOW THE GENERAL RELATIONS OF THE CHIEF DERIVATIVES OF THE ALIMENTARY TUBE.

The umbilical loop of gut, when it is first formed, is much shorter and simpler than that illustrated in the scheme. The figure does not in any way represent any particular stage, but is compounded of several.

The mid-gut now grows in length somewhat rapidly between its two extremities, which may be considered to be more or less fixed. Its growth is accompanied by elongation of the dorsal mesentery, and it forms a long U-shaped loop which projects ventrally out of the body; the vitello-intestinal duct is attached to the ventral convexity of the loop. The condition is present at the beginning of the second month. The loop, external to the body, lies against the front of the body-stalk (Fig. 45), and is covered in by amnion; it is, of course, in a small part of the extra-embryonic cœlom. It is sometimes described as lying here in an 'umbilical sac.'

The vitello-intestinal duct now separates from the loop of gut, which begins to increase in length rapidly by growth of its *front limb*; the *posterior* limb of the U-shaped loop does not elongate to any

extent, and shows an early swelling a little distance from its lower end, which develops into the **cæcum and appendix.** The coils formed by the anterior limb lie on the *right* side of the non-coiled posterior limb. This goes on through the second and into the third month, by which time the cæcum is a long cone-shaped projection from the straight posterior limb, while the closely packed coils lie to its right; the lower portion of the posterior limb, beyond the cæcum, also shows some tendency to elongate the coil. In the tenth week (40 mm. embryo) the umbilical loop enters the abdomen, and its constituent coils are brought into their normal relative positions *after* this has taken place. The contents of the sac do not enter the abdomen *en masse*, but in continuous sequence, the anterior limb of the loop passing in first, from before backwards, and then the posterior limb. Their subsequent disposal in the belly, and the factors concerned in the movement, will be dealt with in the appropriate sections. The common median mesentery still connects them with the dorsal wall, and the definitive peritoneal arrangements and attachments are only acquired secondarily and subsequently as the bowels attain their positions, some weeks after their withdrawal into the abdomen.

The *vitelline artery* runs in the common mesentery of the loop, and gives branches, in front and behind, to the two limbs of the loop as it passes between them. It is carried on to the vitello-intestinal duct and yolk-sac at first, but, when these separate, it is confined to the mesentery, and can now be called the *superior mesenteric* artery. When the coils enter the abdomen and are disposed within that cavity, the artery and its branches are laid out with the mesenteric folds, and supply all that part of the intestine which is derived from the mid-gut. This extends from just below the entrance of the bile and pancreatic ducts (derivatives of fore-gut) to the junction with the hind-gut; the junction is at first about half-way along the 'transverse' colon, but subsequent modifications shift the point more towards the left to about two-thirds of the length of the transverse colon.

The vitello-intestinal duct very rarely remains as a cord extending from the gut to the umbilicus, or even as a patent canal. Less rarely, however, its intestinal end may remain as *Meckel's diverticulum*, a hollow gut-like protrusion from the ileum, of variable length, about 40 inches from the cæcum; this 40 inches of the ileum is derived from the lower end of the posterior limb of the U-loop, below the cæcal projection. The vitelline artery may persist as a fibrous cord passing from a corresponding place in the mesentery to the umbilicus. The distance from the cæcum is very variable.

The *vitelline vein* does not accompany the artery, but passes, free in the peritoneal cavity, in front of the mid-gut loop, and runs to the pancreatic region; its persistence in later life is excessively rare.

The Umbilicus.

The margin of the embryonic disc, after the movement of reversion has taken place, extends, as has (Fig. 33) been seen, from the *posterior* wall of the pericardium (*septum transversum*) in front to the *anterior* end of the (*reversed*) *region of the primitive streak* behind; round the

margin, at and between these points, the *amnion* is attached. If the amnion and the visceral wall below the embryo were removed by section along the margin, the embryonic area, viewed from below, would be as shown in Fig. 46. The first diagram represents the condition before the embryonic body-cavity has broken through the margin; the second shows the result of this split after the proximal part of the body-stalk has been drawn into the embryo. The body-stalk now forms a projection into the opening enclosed by the margin; two umbilical arteries, two umbilical veins, and the allantois are cut in its section. It can be seen, in the second figure, that the umbilical veins run forward from the body-stalk to the septum transversum *in the body-wall,* close to its continuity with the amnion.

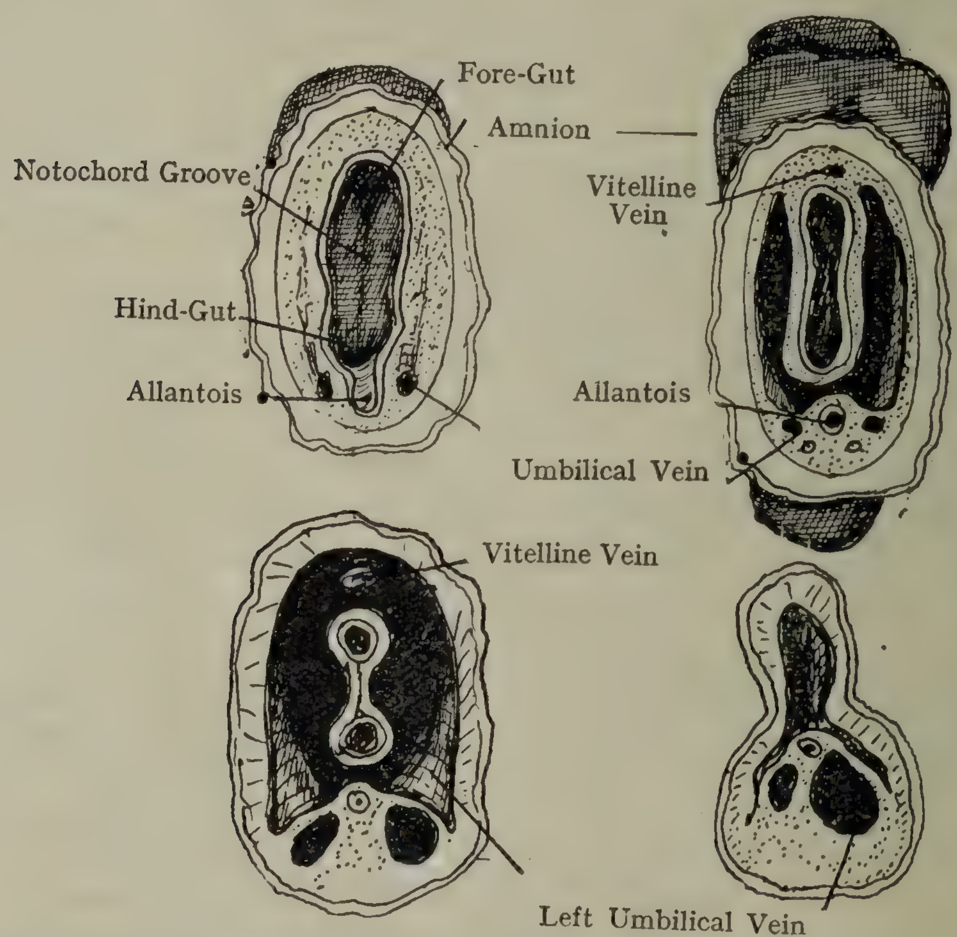


FIG. 46.—TO SHOW THE FORMATION OF THE UMBILICUS.
(Description in text.)

In the third diagram, the U-loop of gut is cut as it passes out of the body, and the *vitelline vein* is ' free ' in front of it, no longer attached to the septum at this level.*

The last diagram shows the state of the opening when the intestinal loop has entered the abdomen and the vitelline vein has disappeared. It can be understood that, at the beginning, the embryonic margin corresponds with the size of the embryonic area or embryo. But, as the embryo grows, it overlaps the margin to an increasing extent. Thus the margin now marks out an area which, even though it *actually* increases slowly in size, nevertheless *relatively,* compared with the size of the growing embryo, becomes rapidly smaller and smaller. It is

* This is a secondary change that need not be considered now.

already considerably shorter than the embryo at the stage represented by the second diagram, and by the time the intestinal loop is about to enter the abdomen, it is represented by a region, only a few millimetres long, on the ventral wall of the belly. When the passage of the gut has taken place, the amnion and the muscular wall of the abdomen contract down on the body-stalk attached to the middle of the belly-wall, where it forms the fœtal end of the *umbilical cord.* When the cord separates from the wall *after birth*, the resulting scar constitutes the **umbilicus**; therefore, from this scar the remnants of the allantois (urachus) and umbilical vessels pass to the parts with which they were connected in intra-uterine life. The umbilicus of the adult is not, then, quite the same thing as the umbilical opening of the embryo; the *scar* really corresponds with the *posterior* margin of the *opening*, which would be represented by a small and almost linear area in front of this. If this area is taken into account, then it would not be very wrong, though not exactly true, to speak of the umbilicus as representing the area from which the body originally grew.

Fore-Gut and its Derivatives.

It has been seen that the early fore-gut has its floor formed by the roof of the pericardium and the septum transversum. It has also been seen that, in the development of the mid-gut, that part of the fore-gut which passes down *behind* the septum transversum acquires a median dorsal mesentery directly continuous with the similar structure suspending the mid-gut. It will be convenient to consider separately this last portion, the part with a dorsal mesentery, and to restrict the account for the present to the part lying above the pericardium and above the septum. The roof of the fore-gut is made by the mesoderm beside the notochord. A strip of mesoderm (Fig. 32) on each side, between the roof above and the pericardial wall below, makes the side-wall; this mesoderm is continuous with the lateral sheet farther back, and is, of course, covered by ectoderm and entoderm. There is *no cœlomic split* in the mesoderm of the side-wall where it lies *above the pericardium*, but a split is present where it lies above the *septum transversum*; this split is continuous, below and in front, with the pericardium, and opens into the lateral body-cavity behind, and is, in fact, the ‘ lateral recess ’ of the pericardium (or pericardio-peritoneal canal) already described.

We find, accordingly, that the fore-gut can be divided here into two parts. In front, dorsal to the pericardium, is a cavity with unsplit side-walls, which extend from the covering of the hind-brain above to that of the pericardium below; therefore the general width of this cavity will correspond with that of these structures—particularly the hind-brain—and its growth is associated with *changes on the surface.* The pharynx and related structures will be developed from this part, and it can be termed the **primitive pharynx.**

This front part is continued backwards into the second portion,

which has the *lateral cœlomic passage on each side of it*; this is the part above the septum transversum. Here, then, is a definite splanchnic wall separated by the body-cavity from the somatic wall, and the splanchnic wall of this portion of the fore-gut can be narrowed and elongated without reference to the dimensions of the somatic wall and without affecting surface form. This is what occurs here, the part being gradually elongated to form the *œsophagus*, and the name of **primitive œsophagus** or **œsophageal part** of the fore-gut can be given to it.

Primitive Pharynx.

The thin unsplit mesoderm of the side-wall of the front part begins to increase in thickness. The growth is not uniform, but takes place in a series of dorso-ventral ridges or bars of condensation placed one behind the other. These regions of growth and condensation are known as **visceral arches,** or **pharyngeal arches,** and the intervening lines, where no growth takes place, are the corresponding **grooves.** As the condensations involve the whole thickness of the side-wall, this wall presents, on both ectodermal and entodermal aspects, a series of visceral arches, visible as projections and separated from one another by grooves; on the ectodermal aspect they are **external** *pharyngeal arches and grooves* respectively, and on the entodermal surface they are **internal** *arches and grooves*. The arches do not appear simultaneously, but rapidly in sequence from before backwards, and are six in number on each side.

A surface view shows only five arches, but the last one is really the sixth, the true fifth being buried, as will appear later.

They are numbered from before backwards, the *first* arch being usually spoken of as the *mandibular arch*. When their number is complete they extend back to the lateral recess of the cœlom, the condensation of the last arch being in relation with this.

The *grooves* between the arches are numbered according to the arches *in front of* them; thus, the first groove is between the first two arches, the second groove between the second and third arches, and so on. Ectoderm and entoderm meet at the bottom of the grooves, where these are to be seen on the surface of the side-wall. The meeting of these two layers here constitutes what is sometimes termed the *closing membrane*.

In fishes and amphibia this membrane gives way, and thus the *gill-slits* are established. In Sauropsida the closing membrane may be frequently seen to be perforated, but in mammals it is doubtful whether such perforation is ever a part of the normal course of development. It certainly does not occur in the human embryo.

The ventral ends of the arches extend rapidly towards their fellows of the opposite side, under the entoderm of the floor of the cavity, and above the pericardial roof. In this way a new mesodermal floor

is made for the primitive pharynx, separating it from the pericardium. This frees the pharyngeal walls, which can now grow forward with the rapidly elongating cranial end of the embryo, leaving the pericardium in its original position.

The change in relation between pharynx and pericardium, in which the latter is found farther and farther back as the development proceeds, is usually described as a *retrogression of the pericardium*, but, as this retains its relation to the fixed parts of the ventral portion of the embryo, the explanation of the change given above is a truer description.

The rapid growth forward, which succeeds this freeing of their ventral ends, leads to obliquity of the arches, which are now found to be directed downwards and forwards, and inwards at their lower ends.

The short fore-gut of the early embryo, after reversal, has reached a considerable length by the time that all the arches are visible (embryos of 4 to 5 mm.), as the result of rapid anterior elongation and pericardial growth. The shape of the primitive pharynx corresponds with that of the hind-brain, which covers it. It is broadest a little behind its front end, where it lies under the widest part of the hind-brain, narrows slightly just behind this, and continues to lose width as it is traced back, finally reaching the small size of the primitive œsophagus, into which it is continued. Thus its arches *become shorter and smaller in the posterior part* of the primitive pharynx.

Changes in (Ectodermal) Surface Form.

In Fig. 47 the head of a young embryo is seen from the left. The **external pharyngeal arches** are shown plainly marked in Roman figures. The second arch is the most prominent, tending to overhang the third; this tendency becomes marked a little later. The third and fourth arches are thus somewhat sunk in a triangular area bounded in front by the second arch, above and behind by a thick, rounded ridge (made by downgrowths from occipital myotomes), from the lower end of which a lower limiting ridge (epipericardial ridge) turns forward above the pericardium. This sunken area is the *precervical sinus*, which becomes deeper as the second arch enlarges. In some animals this arch seems to cover in the third and fourth arches more completely by fusing from above downwards with the posterior border, so that an ectodermally lined recess is formed, opening to the surface ventrally and having the two next arches in its floor. In the human embryo, however, this does not take place. The second arch soon begins to atrophy, except at its upper part, where it is forming part of the *pinna*; its lower portion, diminishing rapidly, becomes an appendage of the dominant *first* or *mandibular arch*. Thus the third arch, remaining on the surface, becomes flatter; the line of the second groove becomes the ' flexure line ' of the neck, so that the area of the third outer arch corresponds practically with the ' carotid triangle ' of human dissection.

Muscle-cells extend from the second arch superficially over the first arch in front and the depressed area behind; these form the **platysma** and subcutaneous **facial musculature,** supplied by the facial nerve—the nerve of the second arch.

The *upper end of the first groove* remains, however, as the **external meatus.** The **pinna** is formed round this by the coalescence of certain **auricular tubercles,** which develop behind, above, and in front of it. It results from this that the outer ear is situated at first at a much lower level, compared with the face, than that which it occupies later.

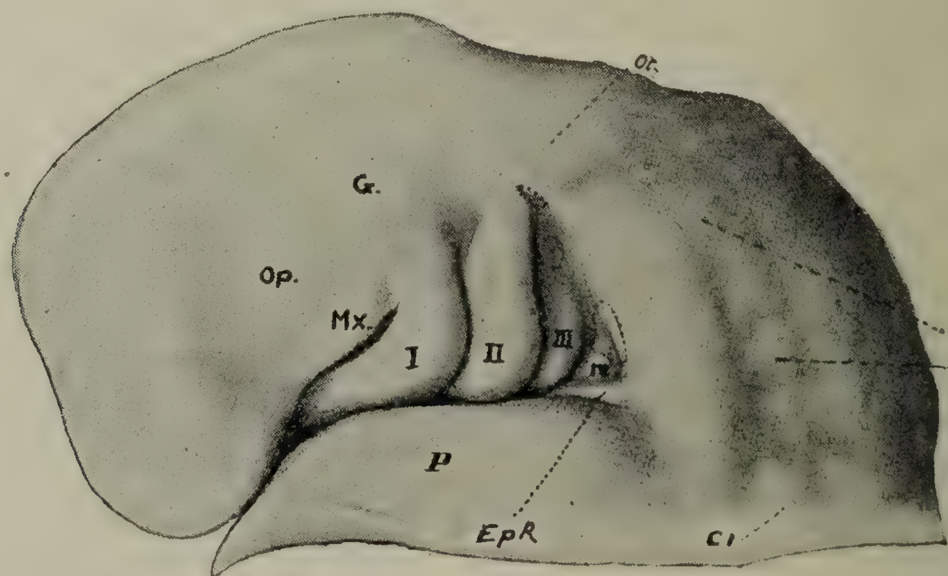


FIG. 47.—HEAD OF EMBRYO NEARLY 5 MM. IN LENGTH, SHOWING EXTERNAL PHARYNGEAL ARCHES I., II., III., AND IV.

Dotted areas mark placodes for 7th, 9th, and 10th nerves. C1, first cervical somite; OM, occipital myotomes; OT, otocyst; G, trigeminal ganglion; OP, eye; Mx, maxillary process; P, pericardium; EpR, epipericardial ridge continuous with caudal boundary of the arch field.

Deeper Changes.

The mesodermal masses, which make the visceral arches, not only extend ventrally toward their fellows of the opposite side, but reach the level of the roof of the primitive pharynx, and turn inwards over this roof for a very short distance; the greater part of the roof, between these 'roof-processes' of the visceral mesoderm, is covered by paraxial mesoderm round the notochord (Fig. 48, A). Associated with these 'roof-processes,' and lying on their inner edges, are two longitudinally running arteries, the right and left **dorsal aortæ,** into which open **aortic arches** running up through the mesoderm of the visceral arches. These vessels will be dealt with later; it is enough here to say that each visceral arch has a corresponding aortic arch arising from a **ventral stem** and passing dorsally to the dorsal vessel; that the aortic arches are developed successively from before backwards, more or less with the arches, and are never all found at the same stage; and that the first two break up very soon after their appearance.

A *skeletal bar* (cartilaginous) is developed in the first three or four arches. Each arch has also a nerve which is distributed to it, and

muscles are developed from the mesodermal cells. The nerves (Fig. 48, B) pass down from the hind-brain, thus lying *lateral* to the dorsal aortæ, and enter their arches *in front of* the corresponding arterial arch.

This relation between nerve and artery within the arch will be better understood if it is pointed out that the nerves are really distributed to the clefts (Ichthyopsida) in front of the arches; thus, for instance, the nerve of the fourth arch would be more truly described in some ways as the nerve of the third cleft. But its larger division (known as *post-trematic*) lies in the fourth arch near the posterior edge of the cleft, and its smaller branch (*pretrematic*) loops over the top of the cleft to run down the hinder part of the third arch. In the human embryo the absence of clefts co-exists with the disappearance of distinct pretrematic branches, the only one that seems to come under this heading being the chorda tympani from the facial, but even this is more than doubtful.

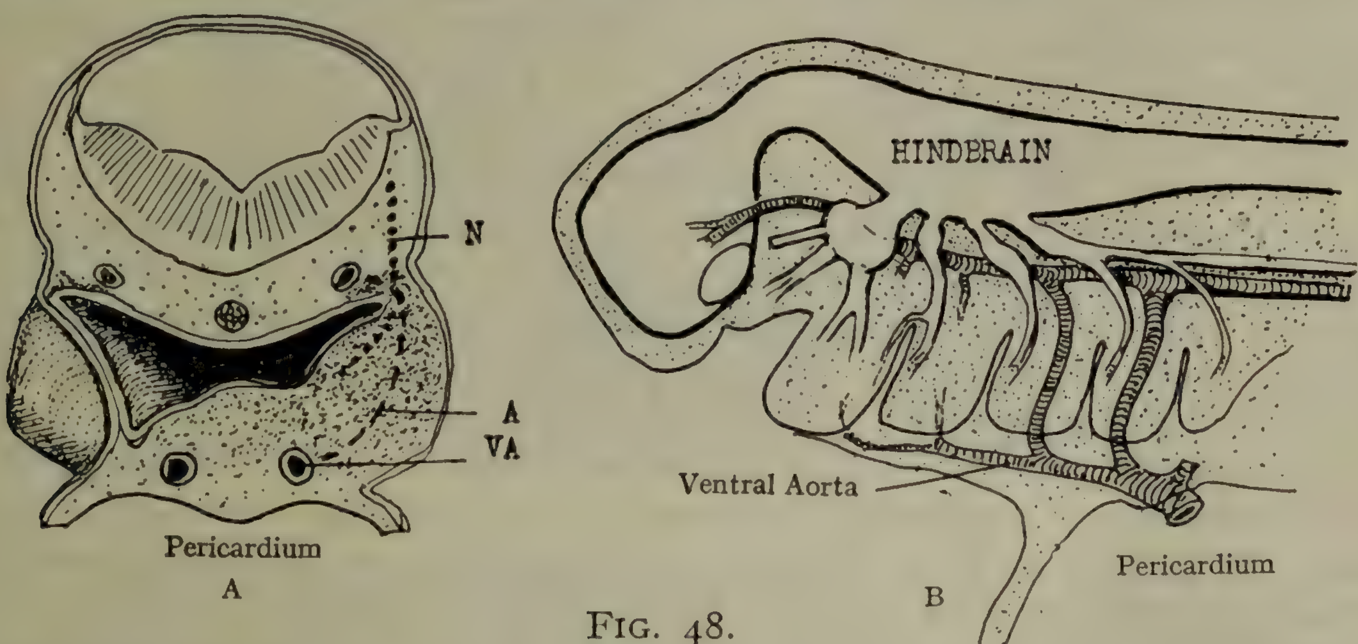


FIG. 48.

A, diagram showing on one side the mesodermal mass of an arch, projecting within and without; on the other side the section is supposed to pass along a groove, between two arches, showing the dorsal and ventral angles of the 'lateral pouch,' where ectoderm and entoderm are in contact. The line A indicates the course of an aortic arch from the ventral aorta (VA) to the dorsal aorta, and the line N, showing the course of the nerve of the arch, crosses in front of it to reach its internal distribution. B, a plan to illustrate the fundamental relations of vessels and nerves in the arches. Remnants of the first two aortic arches are shown, and the forward prolongation of the dorsal aorta on the side of the fore-brain.

The nerves of the different arches are:

I. Mandibular division of fifth.
II. Facial.
III. Glosso-pharyngeal.
IV. Superior laryngeal of tenth.
V. (? possibly joined with next.)
VI. Recurrent laryngeal.

Entodermal Aspect.

The arches begin to form at the stage of about 2·5 mm., and after this they present definite prominences, with intervening grooves, in the floor of the primitive pharynx. The **bucco-pharyngeal membrane** breaks up and disappears about the time that the arches begin to appear.

As the arches form, and project internally, they extinguish the original appearance of a side-wall to the cavity; this has actually only a floor and roof when the arches are fully developed.

If a horizontal section were made along the pharynx, separating the roof from the floor, and the latter were exposed from above in this way, the aspect of the *floor* at the 6 mm. stage, when the arches are well formed, would be as in Fig. 49. The oblique direction is seen in the *hinder* arches, and becomes more pronounced as growth goes on; they are, in fact, 'telescoped' within one another, so that each of these arches is not only behind, but also internal to, the one in front of it. A small *tuberculum impar* lies in the middle line between the first and second arches. An elongated median *hypobranchial eminence* lies behind this, and receives the ventral ends of the third and fourth arches; the second has a later temporary connection with it.

The *pulmonary outgrowth*, which arises at an earlier period, when the arches are first beginning to appear, takes place from the floor of the posterior end of the primitive pharynx; at the stage shown in the figure, the opening of the pulmonary outgrowth is seen in the shape of a median sagittal slit, immediately behind the hypobranchial eminence and between the two last (sixth) arches, which are approximated by their obliquity.

The grooves are clearly seen between the arches. Towards their outer ends there is contact between entoderm and ectoderm, these being the parts of the grooves corresponding with those seen externally; but farther in, where the growing arches have replaced the pericardial roof in the floor, the grooves (see Fig. 48) have mesodermal floors. Hence it comes that the outer parts of the grooves are much deeper than the rest, and constitute the **lateral pouches** of the pharynx. A lateral pouch is shown on one side of the section in Fig. 48, and it can be seen here that each pouch, made in this way, presents *dorsal* and *ventral angles*; certain growths take place from each of these angles, as will be described later.

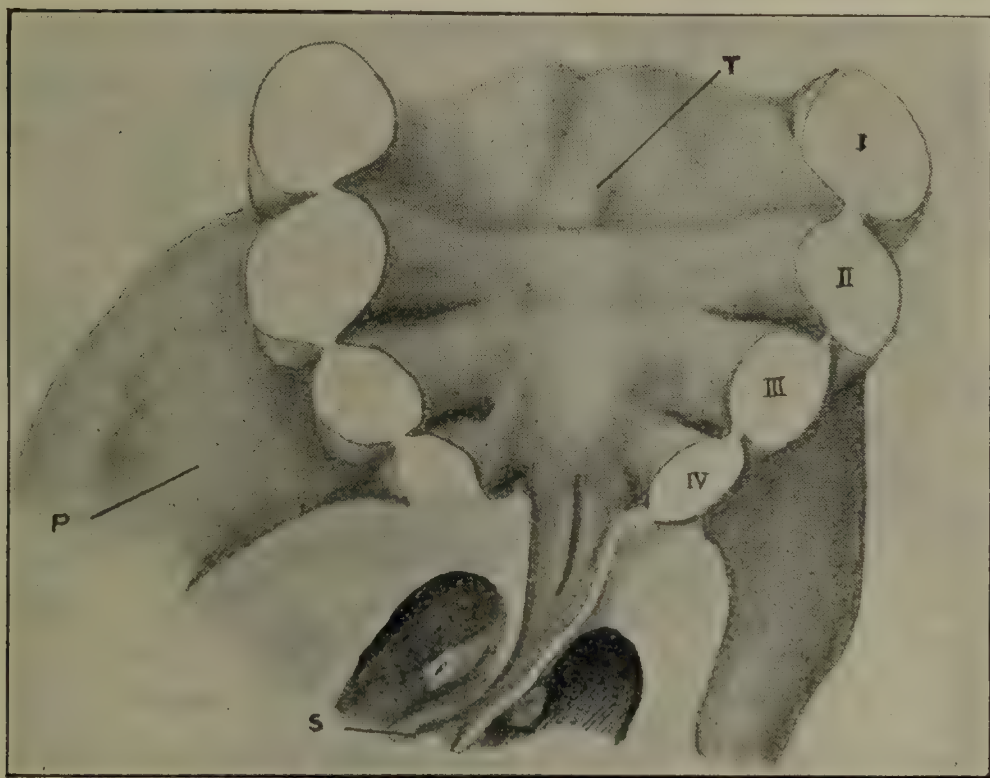
The 'fourth lateral pouch' is really a complex, because the *rudimentary fifth arch* appears in its *floor* for a short time, and it presents two (incomplete) sets of dorsal and ventral angles giving origin to outgrowths.

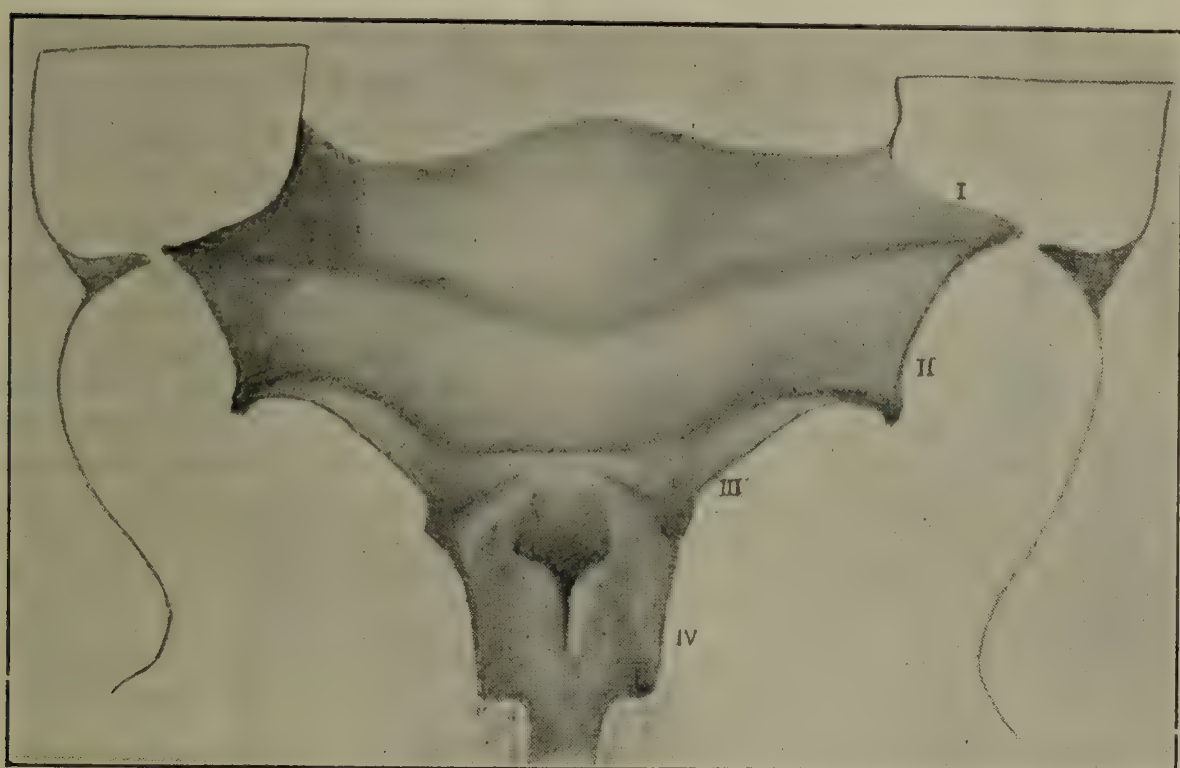
The lateral pouches are the only parts of the system of grooves which correspond with the gill-bearing region in fishes. But the term 'branchial' ought not to be used in connection with the visceral arches. The first branchial arch of fishes corresponds with the third visceral arch, and much confusion would be avoided if the term were dropped altogether when dealing with mammalia, with which it has nothing to do.

The **thyroid outgrowth** takes place very early in the middle line. It is, with the exception of the pulmonary bud, the only median outgrowth from the pharynx, and occurs just behind the tuberculum impar. It comes into close relation with the dividing aortic stem

coming out of the pericardium, and is 'carried back' with this as the pharynx is growing forward. It soon loses its connection with the entoderm. It forms the lateral lobes and isthmus of the thyroid gland.

Fig. 50 shows the floor of the pharynx at later stages, schematically





FIGS. 49A AND 49B.—RECONSTRUCTION MODELS, SHOWING THE PHARYNGEAL FLOORS IN EMBRYOS OF 5 MM. AND 12 MM.: THE ARCHES ARE NUMBERED.

P, pericardium; T, tuberculum impar; S, stomach. In the first embryo (A), which is somewhat twisted, the two lateral recesses have been opened where they are becoming continuous with the abdominal cavity, and the roots of the lung-buds, which have been cut away, are seen in them. In the 12 mm. (B) embryo the tubo-tympanic recess is apparent.

combined, and indicates the modifications taking place in it. The **tongue** is seen to be formed, as to its front part, by a swelling on the mandibular arch, which is formed from the tuberculum impar. Later, a forward growth from the front part of the hypobranchial eminence comes against the back of the earlier formation; it is a paired growth

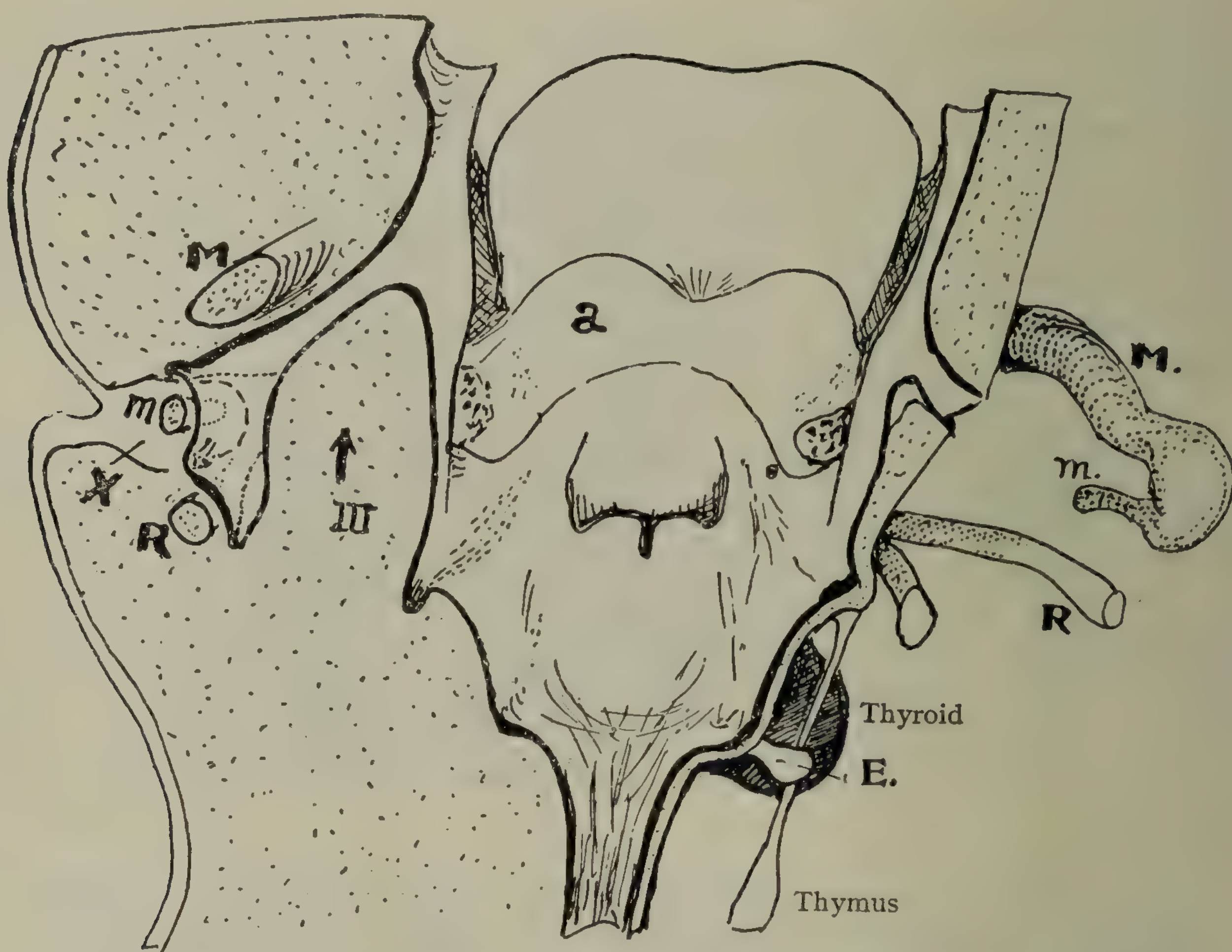


FIG. 50.—A COMPOUND SCHEME TO SHOW THE DEVELOPMENT OF VARIOUS PARTS FROM THE SIMPLER PHARYNGEAL FLOOR.

On the left the tympanum has been separated from the pharynx by the third arch, which has grown forward in the direction of the arrow and obliterated the inner part of the original tubo-tympanic recess, only leaving the front part as the tube. The meatal plate (X) has extended below the tympanum, with the handle (*m*) of the malleus interposed. The tympano-hyal lies behind this. The palate-fold has formed along the inner side of the (maxillary process of the) first arch, below the tubal orifice, and has a backward extension derived from the third arch. This arch has also sent a process (*a*) forward to the back of the tongue. On the right side the cartilaginous bars are shown. M is Meckel's cartilage, and *m* its manubrial process. R, Reichert's bar. The remnant of the third bar is seen behind this. The relations of the formations from the lateral pouches are shown. The thymus passes back between the thyroid lobe, and the epithelial growth (E) from the fourth pouch.

with an included angle, and is really derived from the third arch, growing over and burying the second arch which originally lay in front of it. This compound development of the tongue accounts for the difference in nerve supply of its front and back portions. The *foramen cæcum* becomes evident as the hinder part of the tongue is formed, and is the depression corresponding with the angle between

the two halves of this hinder part; owing to its development in this way, its position is necessarily over the point from which the thyroid outgrowth had originally grown, and it marks this point in this way, although it is not directly connected with it at all.

The **epiglottis** is formed from the posterior part of the hypobranchial eminence, just behind the part that is built into the tongue. The epiglottic portion is connected with the third and fourth arches; the third arch becomes the *pharyngo-epiglottic fold* and the fourth forms the *aryepiglottic fold*.

The **larynx** is formed, behind the epiglottis, by swelling of the sixth arches, which stand up behind the hypobranchial eminence, and thus produce a *transverse* slit-like cavity, at the bottom of which is the original *sagittal* slit of the pulmonary opening. The sixth arches have the fourth arches lying outside them, and, when they swell up, a somewhat similar upgrowth of the fourth arches keeps pace with them; as the fourth arches pass on to the hypobranchial eminence, it follows that the ' transverse slit ' is bounded laterally by these connections—that is, by the aryepiglottic fold. The larynx, therefore, has two parts developmentally: an upper part is developed by modification of the pharyngeal floor, and is enclosed by the *epiglottis* in front, the sixth arches (*arytenoids*) behind, and the *aryepiglottic folds* laterally; the lower part is a modification of the opening of the pulmonary outgrowth, and is bounded by the deeper parts of the sixth arches, in which the *cricoid* develops. The rima glottidis and incisura interarytenoidea mark the line of the original sagittal slit.

The cavities of the **tympanum and Eustachian tube** are developed from the lateral part of the pharyngeal cavity. The widest part of the cavity (Fig. 49) is opposite the second arches. As development progresses, the upper end of the first arch thickens in front of this on each side, and the third arch behind it, so that a **tubo-tympanic recess** is formed; this has its *front* and *back* walls made by the *first* and *third arches*, and in its *floor* are small parts of *these arches*, the *first and second grooves*, and the *whole breadth of the second arch*. The second groove here is the lateral pouch; the dorsal and outer angle is at the outer end, the lower and inner angle is not within the limits of the recess. There is no apparent lower angle in the first groove. Contact with ectoderm is lost along the floor of the second lateral pouch; this is a result of the growth of the arch already seen on the surface. It is on the roof of the tubo-tympanic recess that the otic capsule lies, and quickly becomes surrounded by cartilage (Fig. 51).

The *outer part* of the tubo-tympanic recess is cut off from the general cavity of the pharynx (see Fig. 50) by a forward growth of the third arch affecting its more *medial part*; this obliterates the intermediate part of the second lateral pouch, spreads over the inner portion of the second arch in front of this, and comes up against the first arch. It presses against and fuses with the lower part of the inner portion of this arch, exposed in the front wall of the recess.

In this way the *first groove is obliterated in this region*, but the process stops there, and a narrow passage, the **tube**, is left between the (upper part of the) first arch and the growth from the third arch; the tubal passage leads outwards and backwards from the pharyngeal cavity to the tympanum. It is more or less parallel with the first groove, but *is not formed from it*, being at a higher level.

The **tympanic cavity** is the outer part of the recess, the part which has not been obliterated by the growth thrown forward from the third arch. Its *floor*, which slopes upwards and outwards (Fig. 51), is thus seen to be made by the *outer end of the second arch*, with a small part of the *first*; the extremity (dorsal angle) of the second

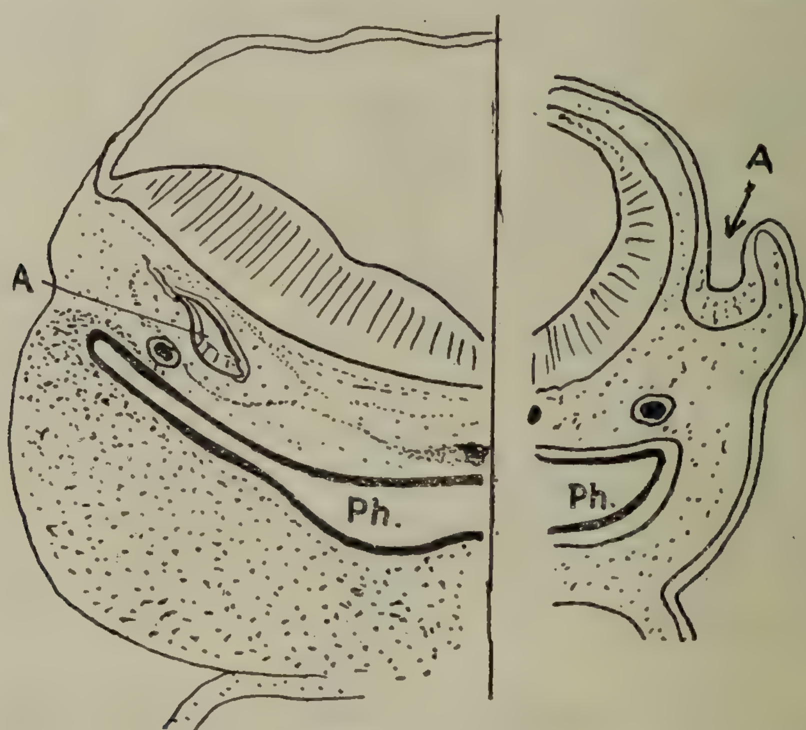


FIG. 51.

Schemes to show, on the right, how the otocyst begins as an invagination (A) of ectoderm beside the hind-brain, and, on the left, how this invagination, becoming a closed ectodermal sac and separating from the surface, becomes placed on the roof of the widest part of the pharynx (tubo-tympanic recess), with the dorsal aorta below it. The displacement is probably due partly to actual sinking of the vesicle, and partly to increasing width and opening out of the hind-brain. The cartilaginous capsule of the otocyst is continuous with the cartilage of the basis cranii of this region.

groove is behind, and the outer end of the first groove in front, of the second arch.

The upper part of the first skeletal bar (*Meckel's cartilage*) lies in the first arch area mesoderm, but a secondary downgrowth from it (with surrounding mesoderm) passes over the upper end of the first groove into the area of the second arch, and occupies a large part of it. The posterior part of the second arch area, however, remains unchanged, and the second skeletal bar (Reichert's cartilage) lies under the entoderm here.

The upper end of Meckel's cartilage forms the **malleus**, the secondary downgrowth into the arch behind being its *manubrium*, and the upper part of Reichert's bar becomes the *tympano-hyal*; this bar,

at a higher point still, and at an earlier prechondral stage, turns inwards above the tympanic roof and, coming into relation with the otic capsule, is continuous with the rudiment of the **stapes,** which separates from it subsequently.

The roof of the tympanum is made by third arch mesoderm passing forward below the otic capsule; it becomes the inner wall (Fig. 50). On the lateral side the growth of the mesodermal masses has led to great thickening, but contact between the ectoderm and the first dorsal angle has practically persisted, so that there is at this point a depression leading inwards from the surface; this is the *upper end of the first external groove.* A secondary solid ingrowth of ectodermal cells (*meatal plate*) takes place from the lower part of this depression, and passes (Fig. 50) below the floor of the tympanum, but separated from it by the handle of the malleus and its mesodermal bed. Thus, when this solid ingrowth hollows out centrally to form the meatal canal, the **tympanic membrane** is left in position, the manubrium, etc., being between its entodermal and ectodermal layers.

To sum up, the tympanum is the persisting outer part of the tubo-tympanic recess, separated from the pharynx by the forward growth from the third arch; it has in its floor (outer wall) remains of first and second arch structures, and of the outer ends of their grooves, and its roof (inner wall) is made by structures derived from the third arch. The Eustachian tube is not derived from the first groove (which is obliterated here), although it lies more or less parallel with the line of this, but at a higher level. It is the remaining front part of the tubo-tympanic recess, that part which has escaped obliteration owing to the fact that the third arch has only been applied to the *lower* part of this portion of the first arch, and has fused only with this part; the lateral wall of the tube is therefore derived from the first arch, and its medial wall from the third.

The forward growth of the third arch, which separates the tympanum from the pharynx, is a lateral manifestation of the active growth of this arch, which forms the back of the tongue. Between these two regions a similar process, as will be seen later, makes the pharyngeal pillars of the palate and the tonsil. The second arch drops out altogether from the floor of the pharynx, except where, at its outer extremity, it forms the tympano-hyal.

A distinct tympanic cavity first makes its appearance among the amphibians.

The Skeletal Structures of the Arches.

1. Meckel's cartilage, well developed in its whole length, meets its fellow in the middle line. The lower jaw is formed in membrane near it, and encloses it secondarily. The lower end of the cartilage appears actually to undergo ossification in the process. The upper end forms the malleus (see Fig. 50), and the intervening portion disappears.

2. Reichert's bar. The dorsal end, in the precartilaginous stage, forms the stapes, which separates from it; below this, the bar makes the tympano-hyal and stylo-hyal (styloid process). Its ventral end

forms the small cornu (cerato-hyal) of the hyoid. The stylo-hyoid ligament (epi-hyal) is a part of the bar which never actually chondrifies.

3. Only the ventral portion of the bar of the third arch remains. It makes the great cornu and part of the body of the hyoid.

4. Still less of this bar remains. It is represented by the thyroid cartilage.

5 and 6. No recognizable bars are formed, but they may possibly be represented in a highly modified form by the other laryngeal cartilages.

Pharyngeal Grooves and Lateral Pouches.

A typical lateral pouch is supposed to give origin to two entodermal outgrowths, one from each of its angles (dorsal and ventral). In some cases these remain as small undeveloped epithelial bodies, in others they develop into glandular masses. When the angles are modified no growth takes place from them. The formations in the human embryo may be shortly summed up as follows:

First Pouch.—Dorsal angle retains contact with ectoderm, and has no outgrowth. There is no ventral angle.

Second Pouch.—Dorsal angle, in the tympanum, has no outgrowth. *Ventral angle,* in side-wall of pharynx, has no proper outgrowth, but **tonsil** is formed (by third arch tissue) in it.

Third Pouch.—Dorsal angle gives off *lower* parathyroid. *Ventral angle* gives off a bud to form the **thymus.**

Fourth Pouch.—This is a complex of true fourth and rudimentary fifth pouches. From the true *fourth,* the *upper* parathyroid arises from the *dorsal angle,* while the *ventral angle* affords origin to an *epithelial body* with which the lateral lobe of the thyroid comes into contact, but which does not appear to undergo further development. The rudimentary *fifth* pouch gives origin (? dorsally) to a small epithelial body (*ultimo-branchial body*) which soon disappears.

The **thymus,** like the median thyroid growth, already mentioned, comes into relation with the ventral arterial channels, and pericardium, below the pharyngeal arch system, and assumes with these a more caudal position in relation to the overlying pharynx. See relations to other outgrowths in Fig. 50.

The median **thyroid** growth, dividing into two, forms the lateral lobes of the gland, and these, extending laterally, come into secondary relation with the ventral buds of the fourth pouches (see Fig. 50).

Position of Former Pouches in Adult Pharynx.

The formations from the pouches having separated, the lateral pouches become shallower, but their original situations are still indicated in the adult pharynx:

Second pouch (ventral part only): Tonsillar fossa.
Third pouch: Pyriform fossa.
Fourth pouch: Lower end of pharynx, beside cricoid cartilage.

The lateral fossa (Rosenmüller) of the pharynx is not a pouch-remnant, but a later enlargement.

All the changes so far described as taking place in the primitive pharynx are effected by the third month. At the *end of the first month* the early condition of the simple arches has been modified by the beginning of the tongue-swelling, the early growth of the sixth arches in the larynx, and a definite but shallow indication of the tubo-tympanic recess. *During the second month* changes progress rapidly as described, and at the end of this month the hinder part of the tongue is formed. Thus, early in the third month, the human condition of things is present, but not, however, in proper proportionate size and disposition; this is brought about during later development by different growth-rates, etc.

Formation of Lungs, Trachea, and Pleural Sacs.

The *pulmonary outgrowth* takes place at an early stage, in the shape of an elongated unpaired groove or pouch, from the middle line of the extreme end of the primitive pharynx; owing to the obliquity of the last pair of arches, the opening of the outgrowth is placed between them, thus leading to the impression that it is situated farther within the pharynx than is really the case.

The pulmonary bud lies dorsal to the pericardium and, to some extent, the septum transversum, and thus comes to lie between and above the front parts of the lateral cœlomic recesses. It elongates and divides quickly at its caudal end into two lung-buds. Each of these thus comes into direct relation with one of the pericardio-peritoneal recesses, and, growing outwards, backwards, and somewhat dorsally, invaginates the inner wall of the recess into the cavity of the canal, which it thus comes to occupy—covered, of course, by the reflection over it of the inner wall. Increasing in size within the lateral recess, each lung projects caudally into the peritoneal cavity, and in front is in relation with the dorsal surface of the venous end of the heart through the pericardial opening of the canal.

In the meantime the original unpaired common root of the lung-buds, connecting them with the pharyngeal floor, has lengthened with the general growth of the parts. The front end, situated between the two sixth arches, has been seen already to be converted into the *infraglottic part* of the *larynx*; the remainder becomes the **trachea,** in which cartilaginous rings are developed from mesodermal condensation during the latter part of the second month.

The outgrowth, taking place between the sixth arches, apparently derives its mesodermal basis from these arches. This view is supported by the nerve-supply to the trachea, and by the derivation of the right and left pulmonary arteries as side branches from the sixth aortic arches.

The trachea is sometimes described as formed from the original longitudinal groove, the margins closing over to separate it from the œsophagus. This view appears to lack confirmation by absolute observation in the human embryo.

Pleural Cavities.

The lungs continue to grow *in the lateral cavities*, which enlarge with them. Their caudal ends are withdrawn from the abdominal cavity with the increasing length of the parts, and the opening into this cavity is closed during the sixth week. The pericardial opening is closed earlier. The pleural sacs enlarge with the lungs, splitting the septum transversum to a very small extent ventrally and internally, but growing mainly at the expense of the body-wall. They extend into this and *split it into deep and superficial layers*, gradually extending ventrally and cranially round the pericardium, and to a smaller extent caudally beside the abdominal cavity. The superficial layer of the body-wall thus split off affords an area for the downgrowths, which make ribs and intercostal muscles, the deep layer becoming the ventro-lateral wall of the pericardium and, in the abdominal region, the muscular part of the diaphragm. The unsplit portion of the septum transversum corresponds with that part of the diaphragmatic tendon which is attached to the pericardium.

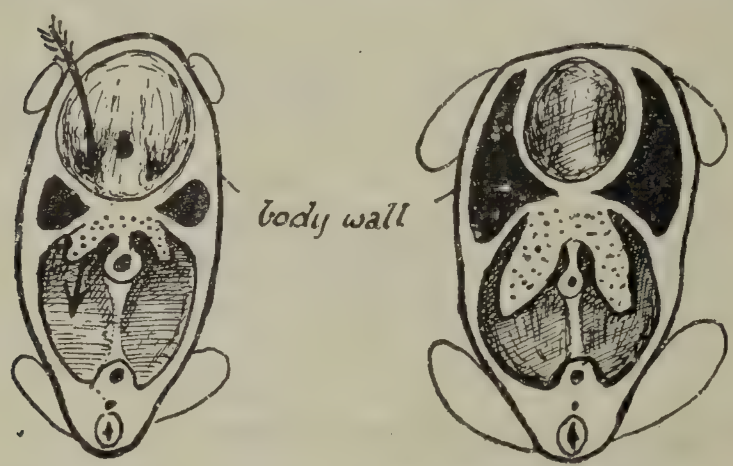


FIG. 52.—DIAGRAMS TO SHOW THE ENLARGING PLEURAL SACS SPLITTING THE BODY-WALL.

The inner layer of the split wall forms part of the pericardium. The arrow passes through the recess, which is dilating to make the pleural sac.

Animals that depend solely on lungs for oxygenation must have these large, and under conditions of best advantage in action. Consequently we find that a definite thorax does not begin to appear before the Sauropsida, and is more efficiently developed in the higher members of this class, and in the Mammalia. Ribs, in lower types of animals, are of use as bars for muscle attachment and for the general support of the body-wall, but in mammals they are specialized for the purpose of keeping the lungs from collapsing, and for allowing their full use in breathing, while their value for muscle attachment has become of secondary importance. The development of a thorax and diaphragm, then, is an indication of the attainment by the embryo of a high or mammalian level in formation.

The Post-Pharyngeal Portion of the Fore-Gut.

This part of the fore-gut lies above the septum transversum, and behind it. It is in relation laterally with the two pleural (lateral) recesses above the septum, and with the abdominal cœlom behind it (see Fig. 49).

Œsophagus.—The part *above* the septum becomes the œsophagus. The enlargement of the lungs and pleuræ is accompanied by elongation of the region, and development of a thorax, and there is a necessary concomitant elongation of the œsophagus.

Part behind the Septum Transversum.

Liver.—The œsophageal part leads directly into that part lying *behind* the septum. This part is at first (see Fig. 46) broadly applied to the septum, but when the intra-embryonic cœlom breaks through the margin of the 'plate,' its attachment to the septum becomes relatively and actually *narrower*. At this time an ingrowth into the abdominal aspect of the septum takes place from the *lower end* of this part of the fore-gut. This is the **liver bud.** It spreads rapidly in the mesoderm of the septum, breaking up the veins (*vitelline*, see Fig. 37) which are running through this region to reach the *sinus venosus* farther forward; thus the foundation of the liver is laid in the septum transversum, consisting of columns of hepatic cells surrounded by vascular channels connected with the alimentary system.

The attachment of the fore-gut to the septum transversum has now narrowed considerably, and it soon comes away slightly from the septum, drawing this attachment after it in the shape of a **ventral mesentery.**

This is a convenient term in description; but it must not be forgotten that the ventral mesentery is nothing more than an attenuated part of the mesoderm of the abdominal surface of the septum transversum.

In the meantime the *dorsal* mesentery has been formed, and extends forward (see Figs. 44 and 45) on to the fore-gut, as already explained. It extends for a little distance above the septum, and forms here a partial meso-œsophagus, but the continuity of this with the common dorsal mesentery is broken later by the growth of the diaphragm.

Stomach, Bursa Omentalis, and Mesoduodenum.

The posterior part of the fore-gut is now held by dorsal and ventral mesenteries. At its lower end, just before it passes into the mid-gut, the elongated stalk (bile-duct) of the liver outgrowth extends from it to the septum between the layers of the ventral mesentery. The upper part of the gut-tube here shows a dilatation, the early **stomach,** but this is still in the middle line. When the embryo is about 3 mm. long an outpouching of the dorsal mesentery begins, pushing this out towards the left in a bag-like manner; this occurs just dorsal to the stomach. Thus there is quickly produced a thin-walled, hollow, and rounded projection (Fig. 53) into the left half of the abdominal cavity. The hollow **bursa omentalis,** as it is termed, has its relatively small opening or 'mouth' on the right side of the dorsal mesentery, or **mesogaster,** as this part can now be called.

The *bursa omentalis* carries the stomach on its anterior or ventral wall, so that this viscus now has its right side looking into the cavity of the bursa, and its left side looking ventrally and toward the left. In the meantime the liver has grown so rapidly that it projects into

the abdominal cavity from the abdominal aspect of the septum. Thus the ventral mesentery is now attached to the projecting liver, and becomes the *gastro-hepatic omentum.*

The dorsal mesentery, immediately below the opening and projection of the bursa omentalis, supports that part of the tube from which the hepatic outgrowth took place. It can therefore be termed the *mesoduodenum*, although the portion of the tube which it supports, and which will become the curved duodenum, is very short at first.

FIG. 53.—SECTION THROUGH ABDOMEN OF 15 MM. EMBRYO.

The bursa omentalis is seen lying free in the left peritoneal cavity. It is only attached to the median dorsal mesentery. The section just misses the opening from the right into the bursa.

The mesoduodenum is *thicker* than the neighbouring parts of the dorsal mesentery, and its *upper end forms the lower edge of the opening into the bursa omentalis.*

Pancreas and Duodenum.

Just after the hepatic outgrowth has taken place two secondary formations appear, growing *from it* close to its origin from the duodenum; these are the *right* and *left* **pancreatic buds.** The *left growth disappears* very soon. The *ventral* attachment to the gut of the hepatic and (right) pancreatic outgrowths now becomes shifted to the *dorsal aspect* of the tube by the operation of certain agencies which are

not fully understood. Thus the common opening of these two growths is on the dorsal wall of the duodenum, and the **pancreatic bud** grows *into the mesoduodenum*; developing here, it forms the **head** of the **pancreas.**

The **neck and body** of the gland are formed by a second *dorsal* outgrowth, springing a little higher up from the dorsal wall of the tube. Thus this second bud enters the *upper end* of the mesoduodenum, and passes from this directly into the lower part of the dorsal wall of the *bursa omentalis*, where it extends towards the left.

The lumina of the buds, hepatic and pancreatic, become the lumina of their ducts; the *dorsal* pancreatic bud thus forms the *duct of Santorini*, and the right (originally *ventral*) bud forms the *duct of Wirsung*.

The duodenum is elongated and gradually moulded into its curve by the growth of the head of the pancreas within the mesoduodenum, the process going on during the second and third, and even the fourth, months.

The spleen begins to develop during the first half of the second month. Mesodermal thickenings occur simultaneously at several neighbouring points in the lateral and dorsal part of the *bursa omentalis*; they are produced by proliferation of the outer lining cells (mesothelium) of the bursa. The thickenings join, but the presence of variable notches in the adult spleen indicates its original development in distinct parts.

The **bursa omentalis** grows to a considerable size, lying ' free ' on the left side of the median mesentery. The liver, enlarging rapidly, fills all the available space in the abdomen, lying on the right beside the median mesentery, but on the left separated from this to a great extent by the bursa omentalis. When the intestines enter the abdomen, in the tenth week, they pass below the liver and push the *median mesocolon to the left*; they also, in doing this, raise up the lower and dorsal part of the bursa, invaginating it into the sac. Thus the lower and ventral part of the bursa lies on the ventral aspect of the intestinal coils, forming the **great omentum.** The bursa, however, is as yet quite free, except where it is continuous with the median mesentery, and it is only at a period considerably later that it becomes adherent to the mesocolon and to the dorsal wall, and thus forms nearly the whole of the **small sac** of the peritoneum.

Development of Regions of Face, Mouth, and Base of Skull.

The transversely disposed depression which exists at first between the pericardium and projecting fore-brain, and is termed the *stomodæum*, is quickly modified by the appearance of partial side-walls to it. These side-walls are the **maxillary processes,** which are continuous behind with the upper parts of the mandibular arches. They come into evidence with the mandibular arches, from which they are often described as arising. They extend forward below the optic outgrowth (Fig. 47), like a bracket on each side under the overhanging fore-brain.

Each maxillary process is *not* applied to the ectodermal surface of the projecting structure, but its mesoderm extends forward in *immediate* contact with the proper (paraxial) mesodermal covering of the eye and brain, deep to the common ectodermal layer.

The *maxillary processes* form two mesodermal masses which rapidly

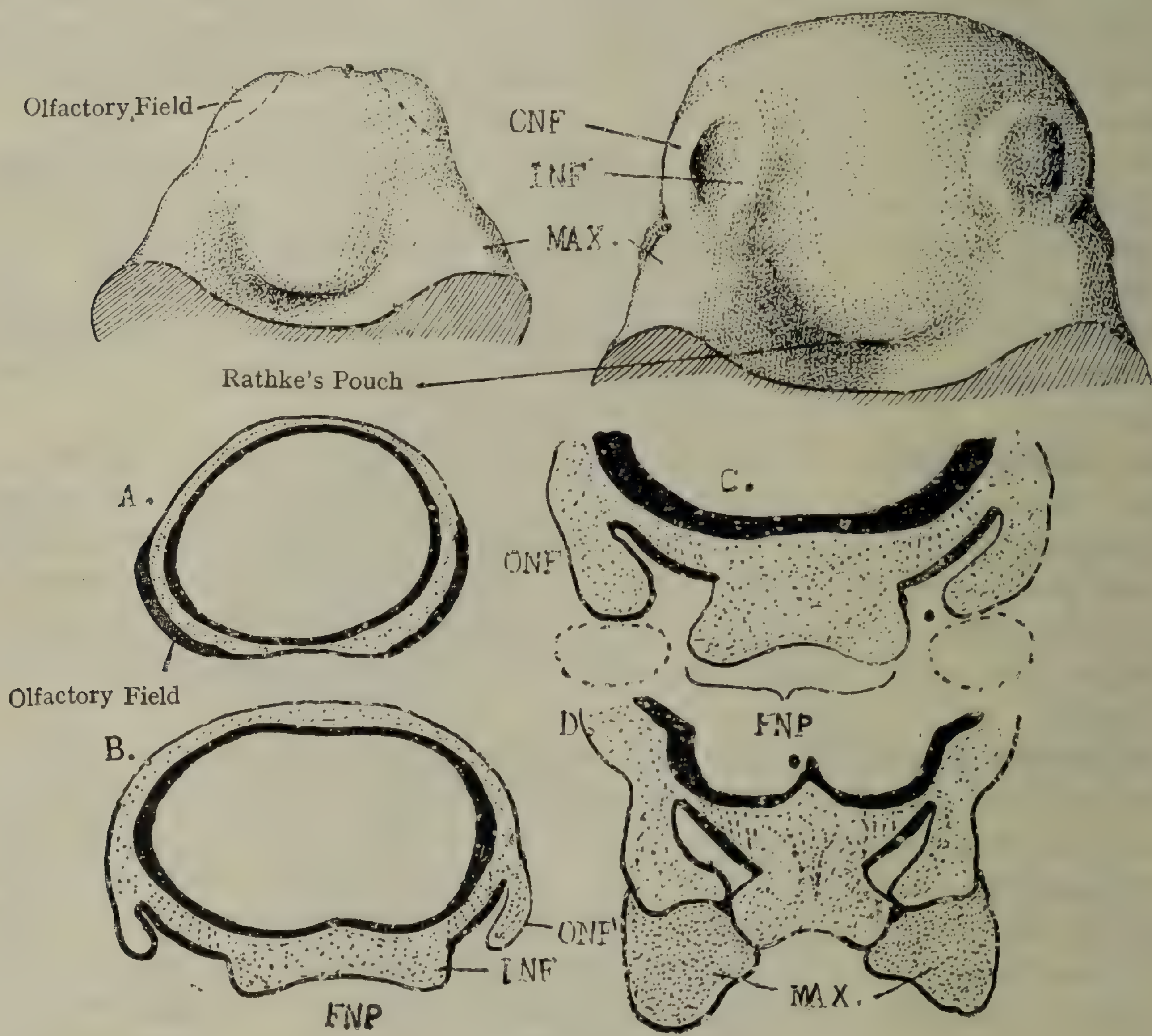


FIG. 54.

The two upper figures show the lower aspects of the projecting heads of embryos of 4 mm. and 7 mm. (From reconstruction models.) The change in position of the olfactory region is due to the presence of the telencephalon in the 7 mm. specimen. This not only advances the front of the head beyond the site of the olfactory fields, but also, as a result of increase in breadth, turns them more on to the lower aspect. A and B in the lower figures are sections through the olfactory fields of the two embryos, showing formation of olfactory pits and fronto-nasal process. C and D are diagrammatic sections to illustrate the further changes. The maxillary processes are indicated by interrupted lines to show where they will come into position, as in D. ONF, INF, outer and inner nasal folds; FNP, fronto-nasal process.

increase in size and thickness. A view of the lower aspect of the projecting part of the head, as in Fig. 54, shows them as *lateral prominences lying below the eyes*, and having between them a hollow in which the rounded *posterior part of the fore-brain* is readily recognizable. This is possible because the paraxial mesoderm of the fore-brain is very thin on its lower surface in the middle line, and is completely absent

here in the hinder part, so that the *wall of the back of the fore-brain is in contact with, and adherent to, the ectoderm here,* thus the shape of this part of the brain is apparent on the lower surface, between the maxillary processes, which hide the optic outgrowths from view, though this part of the brain is continued into them on each side. The depression between the maxillary processes is the early form of *Rathke's pouch,* which is thus a recess in contact from the beginning with the fore-brain.

The paraxial mesoderm on the lower aspect of the fore-brain begins to increase in depth, and the maxillary mesoderm extends over its surface, as will become evident later. The *cartilaginous base* of the skull is formed in the paraxial mesoderm. The *membrane bones* of the face, and of part of the skull-base, are developed in the maxillary mesoderm.

Formation of Nasal Pits.

An *olfactory field* of thickened ectoderm lies on each side on the ventro-lateral aspect of the projecting head (Fig. 54) just in front of the region of the eye; this ectodermal area is probably in connection with the lower part of the cerebral vesicle from an early stage. As the mesoderm thickens, each field, maintaining its original level to all practical intent, assumes a sunken position, with medial and lateral **nasal folds** projecting on either side of it (Fig. 54). The two folds are continuous in front of the **nasal pit** formed in this way. The two inner nasal folds, with the depressed median area between them, constitute, when taken all together, the **fronto-nasal process.**

Formation of Primitive Nasal Fossæ.

The maxillary process, growing forward below the eye, comes into relation with the hinder ends of the two nasal folds of its own side, and applies itself to them. That part of the process applied to the lateral fold increases rapidly in thickness and depth (Fig. 54), and thus forms a definite *lateral* boundary to the mouth-cavity here. Its front portion then turns somewhat inwards, as shown in Fig. 55, lying below and behind the lateral nasal fold, and, extending *across the posterior part* of the opening of the olfactory pit, comes against the medial fold, with which it fuses.

In doing this it converts the *nasal pit* into a primitive *nasal fossa* by making a new floor to its hinder part. The unclosed anterior portion of the mouth of the pit is now a *primitive anterior naris.* The *primitive posterior naris* is at this stage merely a potential opening, lying behind and above the new ‘ floor ’ of the fossa; it is little more than a point, where the hinder end of the cavity of the pit has been covered in by the approximation and fusion of the ectoderm-covered maxillary mesoderm applied to the bases of the inner and outer nasal folds respectively. The adherent ectoderm makes an epithelial plug which fills the very small potential opening, and is known as the **bucco-nasal membrane.**

Completion of Limitation of Roof of Cavity of Mouth.—The fusion of the maxillary processes with the fronto-nasal process is quickly followed by the *extension of maxillary mesoderm into and over* the fronto-nasal process, and this makes a definite anterior boundary to the region of the mouth; the main maxillary mass has been seen already to form its lateral boundary. Thus the (potential) posterior nares open into the mouth far forward, just above its anterior border.

This stage is reached in the fifth week.

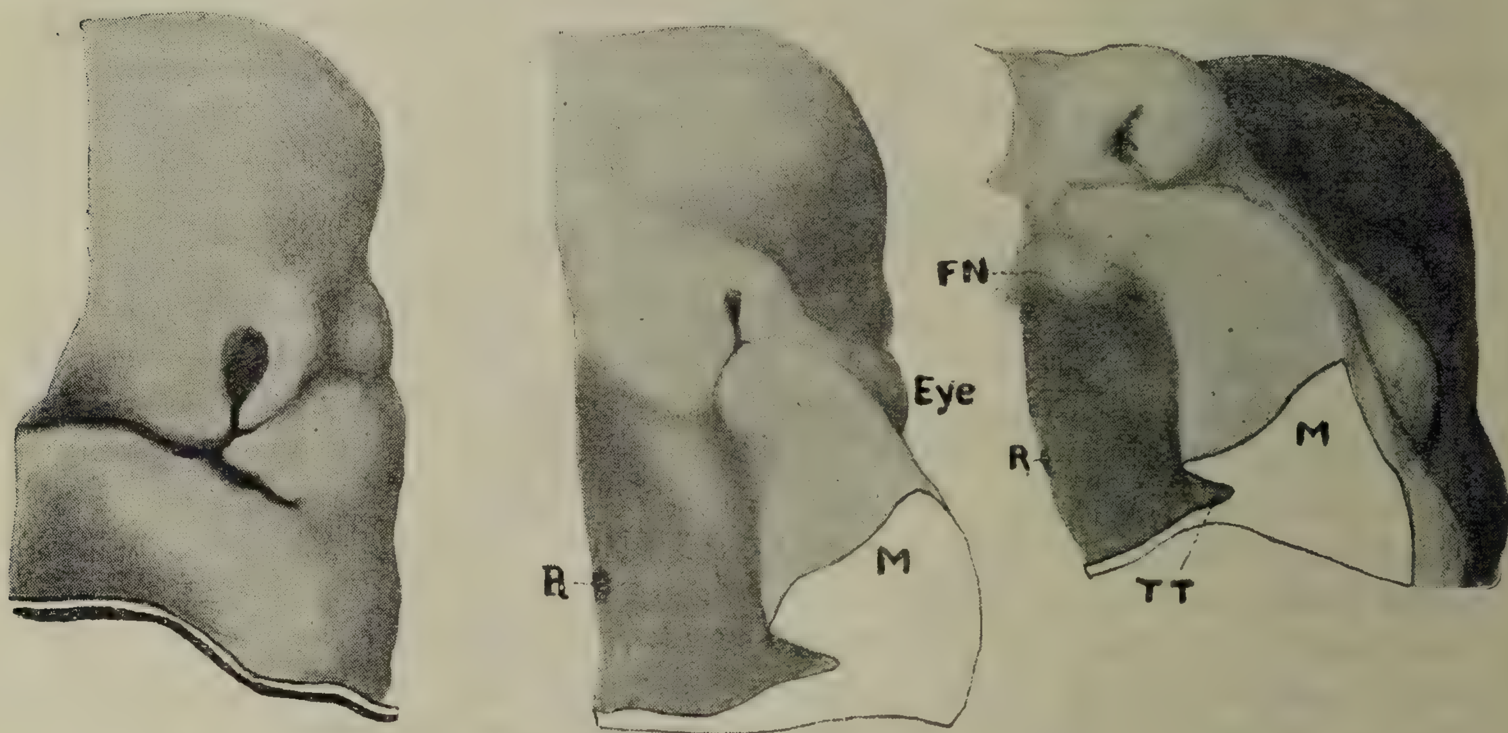


FIG. 55.—EMBRYOS OF 10 MM., 12 MM., AND 13·5 MM.

The mandible has been left in position in the first, but cut away in the other two specimens. To show the extension of the maxillary process, and the early form of the palate fold, compare with Fig. 54. *Pit.*, pituitary (opening of Rathke's pouch); *pal.*, palate fold. This is not so well shown in the older embryo. The last shows the invasion of the fronto-nasal process by the maxillary mesoderm.

Formation of Palate Folds.

As the lateral maxillary process increases in depth, its inner surface or 'edge' begins to show a longitudinal ridge (Fig. 55), which extends as far as the process itself—that is, it reaches the *fronto-nasal process in front*, passing therefore *below* the posterior nares, and ends *behind* just internal to, and *below, the front part of the opening of the tubo-tympanic recess*. This ridge is the main, or *maxillary*, **palate fold.** It lies for the most part against the side of the growing tongue, and increases in size as much as the restricted space will allow. At a later stage a pharyngeal extension of the fold is formed; this is derived from the mesoderm of the third arch (Fig. 49), and is associated with the general forward extension from this arch, which covers in the second arch and excludes it from the pharyngeal floor.

Formation of Definitive Nasal Fossæ and Mouth.

Nasal Fossæ.—The mesodermal bed, in which the small fossæ are placed beneath the cerebral vesicles, increases in depth fairly rapidly. The depth of the fossæ increases also *pari passu* with that of the mesodermal bed. Their increase, like that of the mesoderm, is in an *upward direction*, for the level of the 'floor' is fixed by the mass of the maxillary process fused with the fronto-nasal region, and by the fact that these are supported by the pericardium and the mandibular arch. The fossæ, in extending upwards, necessarily leave a wall of undisturbed mesoderm between them, which comes into increasing evidence with their growth. This is the **nasal septum,** and the structures

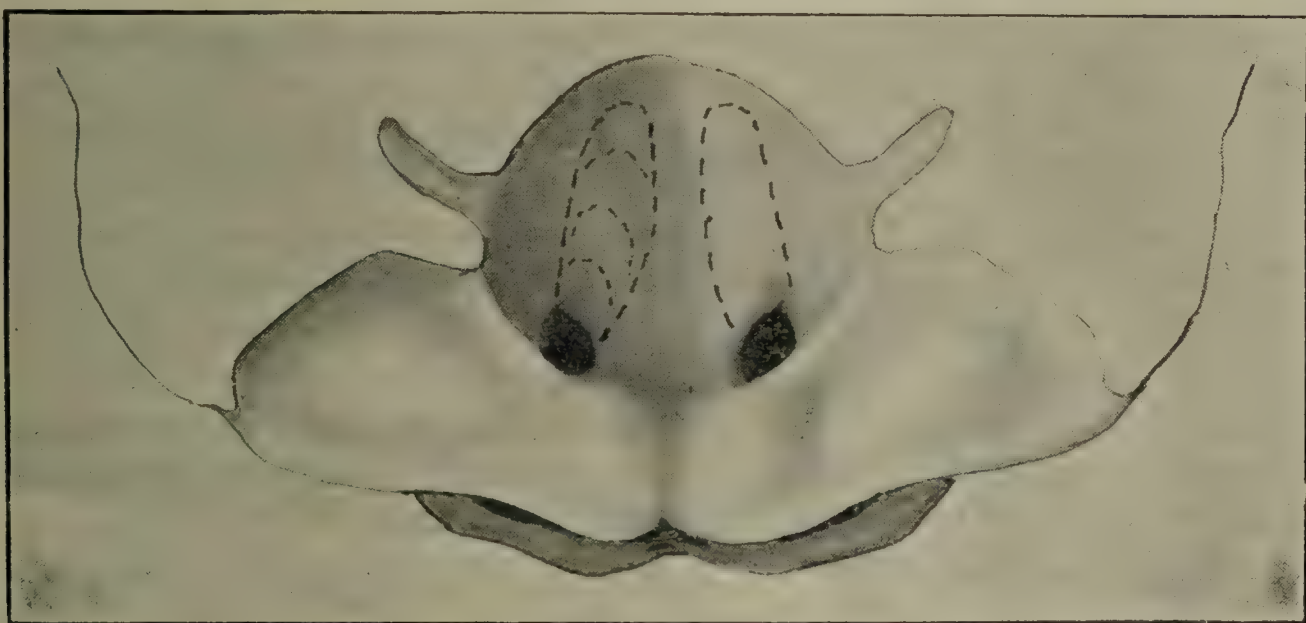


FIG. 56.—VIEW, FROM BELOW AND BEHIND, OF THE ROOF OF THE MOUTH OF AN EMBRYO OF 16 MM. (SIXTH WEEK).

Showing the palate folds reaching the fronto-nasal process, the evident shape of this process, though covered by a layer of maxillary mesoderm, and the growth of the labial extension of the mesoderm only just meeting its fellow in the middle line. This will become much thicker and vertically deeper, hiding the fronto-nasal form altogether. The interrupted lines indicate the extension upward of the upper level of the posterior nasal openings.

of the septum form in this wall as it is 'discovered' by the extension of the fossæ. The nasal fossæ, however, extend *backwards as well as upwards.* This must be associated with the upward movement of the upper edges of the posterior nares, which are the extreme ends of the roof of the pits or primitive fossæ. The primitive posterior nares therefore *enlarge in an upward and backward direction* with the growth of the fossæ, thus increasing the height of their openings into the cavity of the mouth. This is represented by the interrupted lines in Fig. 56. The broad strip of mouth-roof which lies between the openings is evidently the free 'edge' of the septum between the fossæ; this is continuous, like it, with the fronto-nasal process below, and growing in height with the increasing height of the openings. The upper limits of the openings finally reach the level of the highest part of the

pharyngeal or mouth roof (Fig. 56); at the same time the nasal fossæ have attained their final situation, and the capsule enclosing them is in position in the front part of the base of the skull.

Nasal Capsule.—A cartilaginous capsule is formed round the growing fossæ. It extends into the septum, but is deficient in the floor. As the fossæ extend upwards and backwards, the lower and front portion of the cartilaginous capsule is made first, the rest being added as the fossæ grow. When they reach their final position, the cartilaginous capsule is completed by junction between its outer walls and the septal formation, and by the fusion of the upper part of the whole structure with the cartilaginous ala orbitalis, which lies behind it (see Fig. 59).

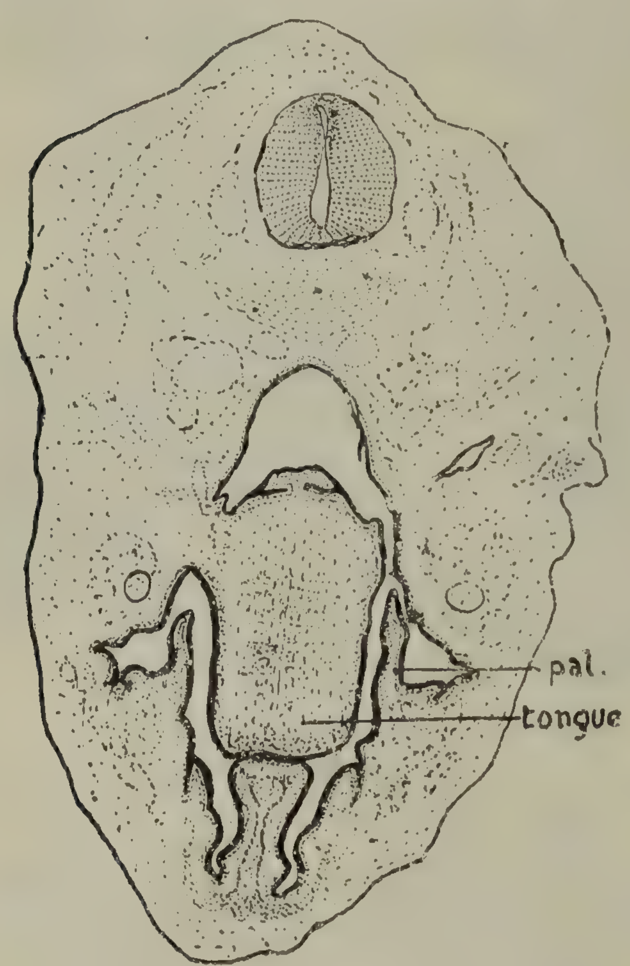


FIG. 57.—SECTION THROUGH EMBRYO OF 28 MM., SHOWING THE PALATE FOLDS BESIDE THE TONGUE, WHICH IS OCCUPYING THE CAVITY OF THE MOUTH, AND IN CONTACT WITH THE SEPTUM AND NASAL MARGINS.

Roof of Cavity of Mouth.—The roof of the mouth, at first somewhat flattened, becomes arched. The concavity from behind forward is due to the mesodermal growth—in which the nasal fossæ are situated—above and in front of it; the transverse concavity is due to the growth of the maxillary processes. The posterior nares open on this roof, and the 'free edge' of the septum is a part of the roof.

At the beginning of the third month the posterior nasal openings reach their full height, extending on the roof of the mouth as far up as the level of the highest part of its curve. The cavity of the mouth is occupied by the tongue, which is *in contact with the roof*, the *back of the septum*, and *the margins of the posterior nares*. The palate folds lie beside the tongue, directed downwards (Fig. 57).

Formation of Palate and Definitive Posterior Nares.

The base of the tongue is attached to the mandible, which is comparatively short up to the ninth week, so that the tip of the tongue has not reached the fronto-nasal process. At this time, however, the elongation of the jaw *carries the front part of the tongue below the process*, and the front parts of the palate folds, being attached to the process, are necessarily brought above the tongue. The remaining parts of the folds, which were beside the tongue, soon follow the change of position initiated by the front portions.

The palate folds thus find themselves *above the tongue*, which is now in less close contact with the septum and mouth-roof, and can broaden out to some extent in the wider space below the folds (Fig. 57). The folds, therefore, have better opportunities for growth. They get thicker, and in their growth insinuate themselves *between the tongue and the posterior border of the septum*. They become *attached to* this aspect of *the septum*, and *to one another*. The connection with the septum only occurs along its *lower* three-fourths or so, and to this extent the *corresponding* portions of the posterior *openings are closed* by the folds passing across them. The openings are *not* closed in this way for their *upper fourths*, more or less, and these unclosed parts constitute the **definitive posterior choanæ.** The posterior parts of the palate folds, which lie below and behind the upper fourth of the septum, but do not get attached to it, form the *soft palate*.

Rathke's Pouch and Formation of Pituitary.

The angle between the bucco-pharyngeal membrane and the early overhanging fore-brain forms a transversely disposed cleft (Fig. 33). This is quickly changed by the formation of the maxillary processes on either side; the central part now remains as a depression, **Rathke's pouch,** the front wall of which is made by ectoderm covering the rounded surface (Fig. 54) of the fore-brain. After the bucco-pharyngeal membrane disappears, the back wall of the pouch is formed by the roof of the pharynx, depressed by mesodermal thickening. Increasing thickness of the mesoderm round it causes the pouch to become deeper, and at the same time its buccal portion is constricted to form a neck or stalk. This opens (Fig. 55) on the roof of the mouth. The upper part is a dilated sac, adherent by its front wall to the fore-brain prominence, as before; the **pituitary body** is developed from this part of the pouch.

Slow ingrowth of mesoderm separates the pouch from the brain at the beginning of the second month. The *antero-lateral lobes* of the *pituitary* body are formed by *ectodermal outgrowths* from the *front wall of the pouch* into this mesoderm. The *posterior lobe* is formed from the blunt end of a median club-shaped *growth from the fore-brain*, projecting just above the pouch. The stalk of this growth forms the *infundibulum*. The antero-lateral parts grow up over this stalk, and meet above it, and the upper parts of this, in contact with the stalk, form the *pars tuberalis*.

The original neck or stem of Rathke's pouch is broken and destroyed by the formation of the skull-base, thus leaving the body only attached by the infundibulum. The buccal part of the stalk remains, however, below the base, and is drawn out into a long cell-strand as the mouth forms. The ultimate position of the attachment of this strand to the lining layer is near the lower part of that portion of the *nasal septum* which is not attached to the palate folds.

Formation of Region of Face.

The diagrams in Fig. 58 show how the face is built up, mainly by the great growth of the brain and of the maxillary process. The *maxillary* growth leads to the nasal region, originally more lateral, being brought into the centre of the face, to the great depth of the

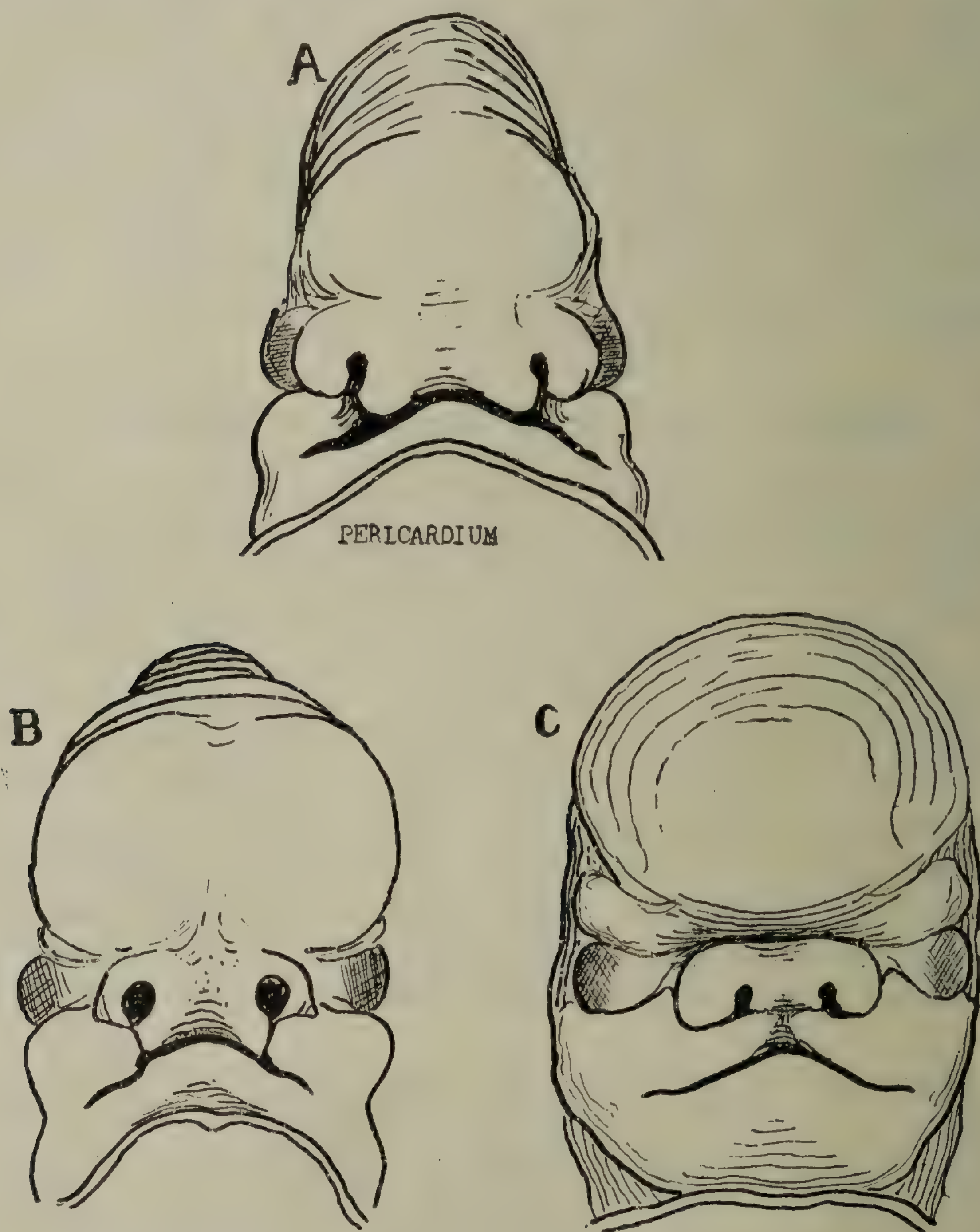


Fig. 58.—Three Figures to show the Formation of the Face.

Though diagrammatized, the figures practically illustrate the conditions in embryos of about 10, 12, and 16 mm. respectively. The maxillary mesoderm is invading the fronto-nasal process in the last figure, but this does not give an idea of the depth of the formation in later stages. The eyes are still rather lateral in position; they do not come right in front before the third month.

upper jaw, and, by its invasion and covering of the fronto-nasal process, to the formation of an upper lip; the lip is being formed in diagram C, but the two maxillary growths have not yet met to make the vertical depth of the lip. The greatest thickness of the maxillary process, however, is behind the eye, where its height and breadth exceed its

measurements elsewhere. This leads to broadening of this part of the head, and one of its effects is seen in the eyes, for these, originally placed *laterally*, are swung *forwards* and inwards, and thus come to *look forwards from the face.* This movement is not completed before the third month.

Cartilaginous Base of Skull.

This is developed in *paraxial mesoderm.* It can be divided, according to its place of origin, into (*a*) a posterior part, behind the pituitary and below the hind-brain; and (*b*) a front part, underlying the projection of the fore-brain.

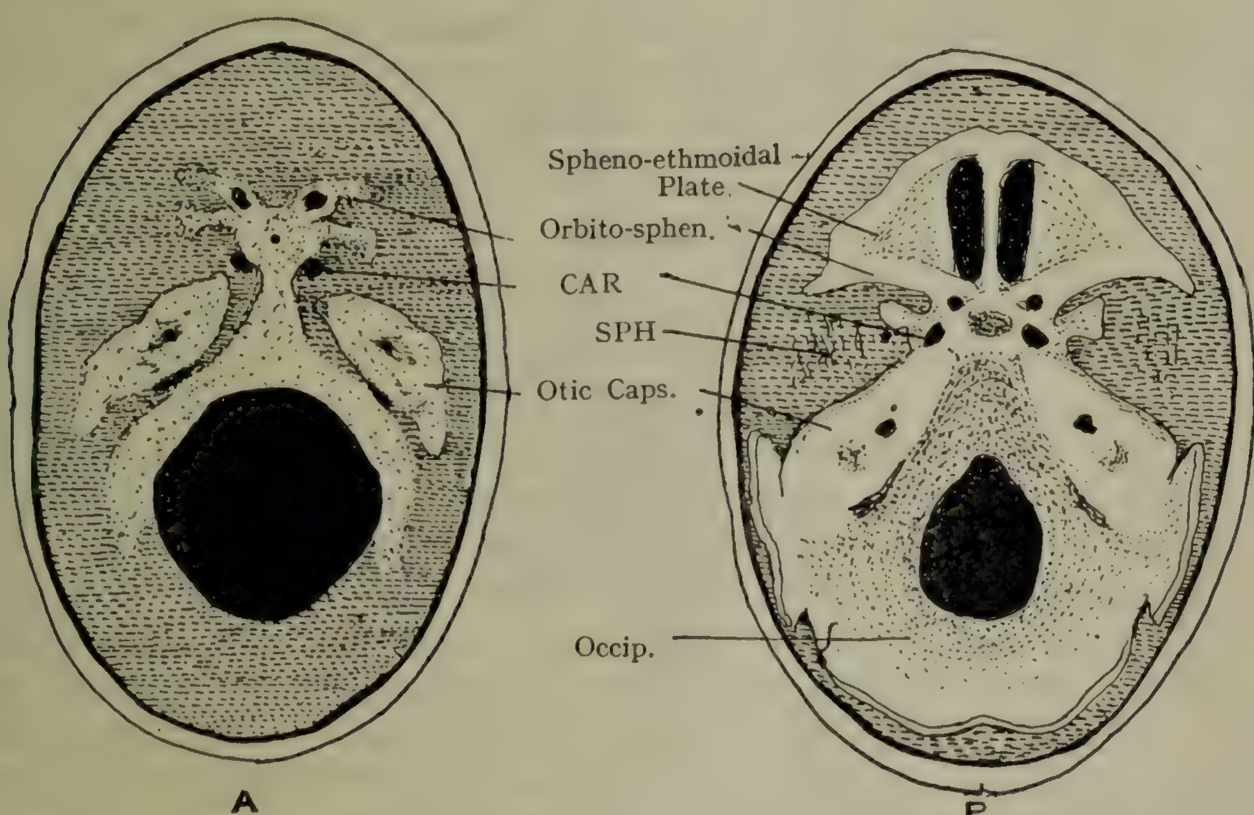


FIG. 59.—TWO SCHEMATIC FIGURES TO SHOW THE PARTS OF THE CARTILAGINOUS BASE.

The nasal capsule has come into position in the base of the second figure. SPH, area where the membranous great wing will come up into the base; CAR, carotid artery through paraxial mesoderm.

(*a*) The *most anterior* somites (four) lie behind the hind-brain, and coalescing here, form a *basal plate* of cartilage; this is situated between the cartilaginous ear-capsules (Fig. 59, A). This part of the base may be termed ' parachordal,' although the notochord lies *below* it, in relation with the roof of the pharynx. The plate extends as far as the pituitary formation, where it becomes continuous with the more anterior chondrifications; it blends secondarily with the otic capsules on each side, and later it gives extensions backwards round the neural tube, to make the cartilaginous part of the occipital (Fig. 59, B).

Only four somites are apparent in the embryo, but it is possible that a number have been concerned in forming the mesodermal condensation that lies just behind the pituitary. The number of somites taken into the skull in other types is very variable, but more than four in number.

(*b*) Two small 'bars' of cartilage form beside the pituitary stalk in early stages, but these soon fuse with each other and with neighbouring areas of chondrification, to form a short but wide plate (Fig. 59, A) from which extend, on each side, a long *orbito-sphenoid*, pierced at its base by the optic nerve, and a short *alisphenoidal process*, which becomes attached to the otic capsule behind it.

The front part of the cartilaginous base is completed by the *nasal capsule*, when it comes into position, and by (Fig. 59, B) the *spheno-ethmoidal plate*, which connects this with the orbito-sphenoidal process.

The area of paraxial mesoderm seen in the diagram between the orbito-sphenoid and the otic capsule does not chondrify later, but forms *dura mater*, including the *tentorium cerebelli*, and the hiatus in the base of the skull is filled by the movement upward from below of a 'visceral' bone, the *membranous alisphenoid*, which is formed in the thickest part of the maxillary process.

Heart.

The details of the formation and division of the heart are given in full in the section dealing with the description of the organ; it is enough here to point out that it has, at a fairly early stage, the form of a single and relatively simple tube, formed by the rather irregular coalescence of two vascular channels lying in the approximating edges of mesoderm near the anterior margin of the embryonic plate, and its final form is gained by modifications of this single tube. The tube is supported at first by a *dorsal mesocardium* from the pericardial roof. It elongates and becomes twisted, and the dorsal mesocardium gives way in the middle, thus leaving a venous and an arterial mesocardium at the corresponding ends. The perforation of the mesocardium, between arterial and venous reflections, becomes the *great transverse sinus*. The *sinus venosus*, in the septum transversum, opens into the venous end of the cardiac tube, and the arterial end passes out of the pericardium as the *common arterial stem*; this divides into two *ventral divisions* below the floor of the pharynx. The heart-tube itself shows three dilatations: primitive (single) *auricle*, *ventricle*, and *bulbus cordis*. The common ventricle is the largest division, and hangs down below and between the other two, which thus become relatively approximated. As the heart grows, its cavities become divided into right and left by the formation of a complicated system of septa, which are described later; its enlargement also *draws the sinus venosus into the pericardial confines* from the transverse septum, and this venous cavity becomes part of the heart when completely formed.

Arterial System.

Aortic Arches.—The aortic arches, passing from the *ventral* side to the *dorsal* aortæ, are numbered like the visceral arches in which they lie. The first two, formed early, break up and disappear very soon.

The others, formed rapidly in order from before backwards, are modified to make the permanent vessels. Distinct ventral aortæ do not occur in human embryos, but a good idea of the changes in the aortic arches may be obtained, nevertheless, by studying the general vertebrate plan of these arches, as given by Rathke. This is shown in Fig. 60, and gives the nature of the alterations. The *third* aortic arch becomes, with the *dorsal aorta in front of it*, the **internal carotid**, and the *fourth* arch forms the **aortic arch** on the left, and the *first part of the* **subclavian** on the right. The **pulmonary arteries** are formed as side-branches from the *sixth* vessel, which remains itself as the *ductus arteriosus* on

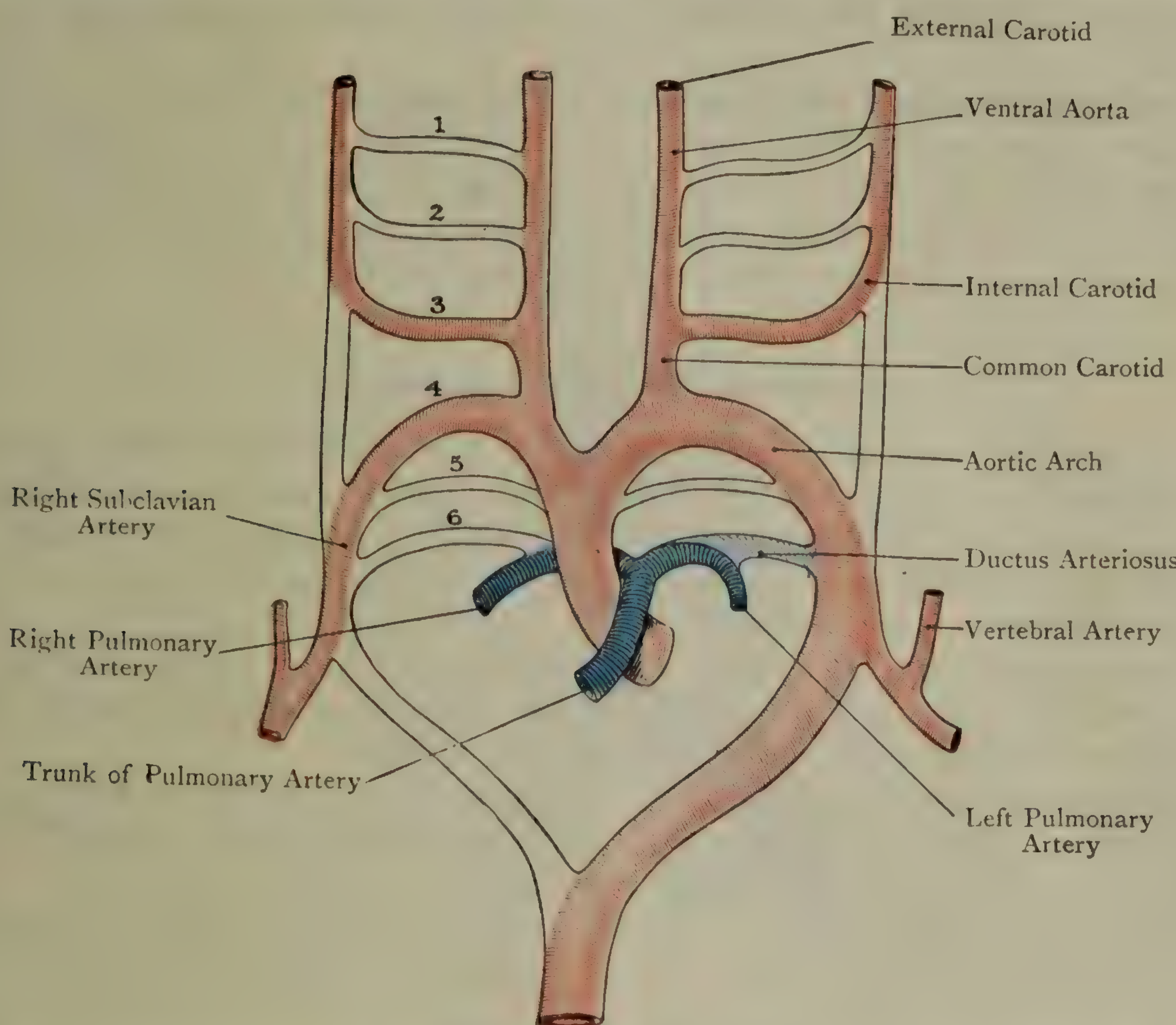


FIG. 60.—SCHEME OF THE AORTIC ARCHES, SHOWING WHAT BECOMES OF THE DIFFERENT VESSELS.

The fifth aortic arches disappear very soon after formation.

the left, disappearing on the other side. The dorsal aortæ join opposite the end of the pharynx, forming a single **aorta,** which divides again into the *umbilical arteries*, and the vessels of the lower limb arise as branches from these. Intersegmental arteries come off the dorsal vessels, running to the body-wall, and *visceral* branches go to the visceral structures. The anterior ends of the dorsal aortæ are prolonged to the fore-brain as **internal carotids,** piercing the paraxial mesoderm beside the pituitary rudiment.

The **veins** are for the most part as in the earlier stages (p. 51 and Fig. 37). The *vitelline* veins are broken up into a network in the

septum transversum by the growing liver. The *left umbilical vein* forms a connection with the left vitelline vein on the visceral aspect of the liver, so the blood from the placenta is *diverted into the liver vessels*, the rest of the left umbilical vein, like the right one, disappearing. The *posterior cardinal vein*, joining with the *primitive jugular*, forms the **duct of Cuvier.** This passes in the body-wall round the outer side of the lateral cœlomic recess to reach the sinus venosus in the septum transversum. When the pleural dilatation of the recess spreads into the body-wall, it goes *outside* the duct, which thus runs in front of the root of the lung to reach the heart. It becomes the *intrapericardial* part of the **superior vena cava** on the right, and degenerates on the left side.

The **inferior vena cava** is formed above the renal veins by a secondarily developed *subcardinal* vein, and in its upper or anterior portion by the junction of this with the veins leaving the liver to reach the sinus venosus. Below the renal veins it is formed from a ' supracardinal ' or ' periganglionic ' system: details are given later.

Genito-Urinary System.

The *excretory* organs are developed in association with the region of the *intermediate cell mass* (p. 42). The *genital* glands are formed in relation with part of the excretory system. The products of the two systems are carried to the cloacal region by ducts; there are, on each side of the body, two ducts.

As the result of interdevelopment it comes about that the duct of the *permanent* kidney is a *new formation* altogether, and the older ducts become connected only with the genital system.

The genito-urinary system as a whole, then, can be considered as composed of glands, ducts, and modifications in the cloacal region connected with the differentiation of the two systems.

The urinary or excretory glands and ducts are the first to form.

Excretory System.

The development of this system is characterized by the appearance of three successive glandular formations, of which the first is merely vestigial, the second is functional during a part of intra-uterine life, and the third becomes the definitive kidney. The three formations are known respectively as the **pronephros, mesonephros,** and **metanephros.** But the structure of these is essentially the same; each is composed of groups of excretory ' units,' of a very simple type, found throughout the animal kingdom in general.

The basic structure of such a nephric ' unit,' which is developed in connection with the body-cavity, can be understood from Fig. 61, which represents a section through a (hypothetical) simple animal of the vertebrate type. The cavity in the somite (myocœle) is connected with the splanchnocœle by a narrow channel in its ' stalk.'

This channel is the part from which the nephric 'unit' is made. The inner or splanchnic wall is pushed in as a covering for a vascular *glomerulus*. The lateral or somatic wall develops an outgrowth which becomes a convoluted *nephric tubule*. The tubule ends in a longitudinally running *excretory duct*, which carries the excretion caudally to the cloaca. The cœlomic channel or cavity into which the glomerulus projects is termed the *nephrocœle*, and the *nephrostome* is the opening into the tubule from the nephrocœle. Fluid exuded from the glomerulus would 'flush' the nephrocœle into the tubule, and thus carry any waste products in the cœlom into the excretory duct.

In the actual animal or embryo itself, the connection between *myocœle* and nephrocœle is always obliterated. That between nephrocœle and *splanchnocœle* may be (*a*) so widely open that the glomerulus

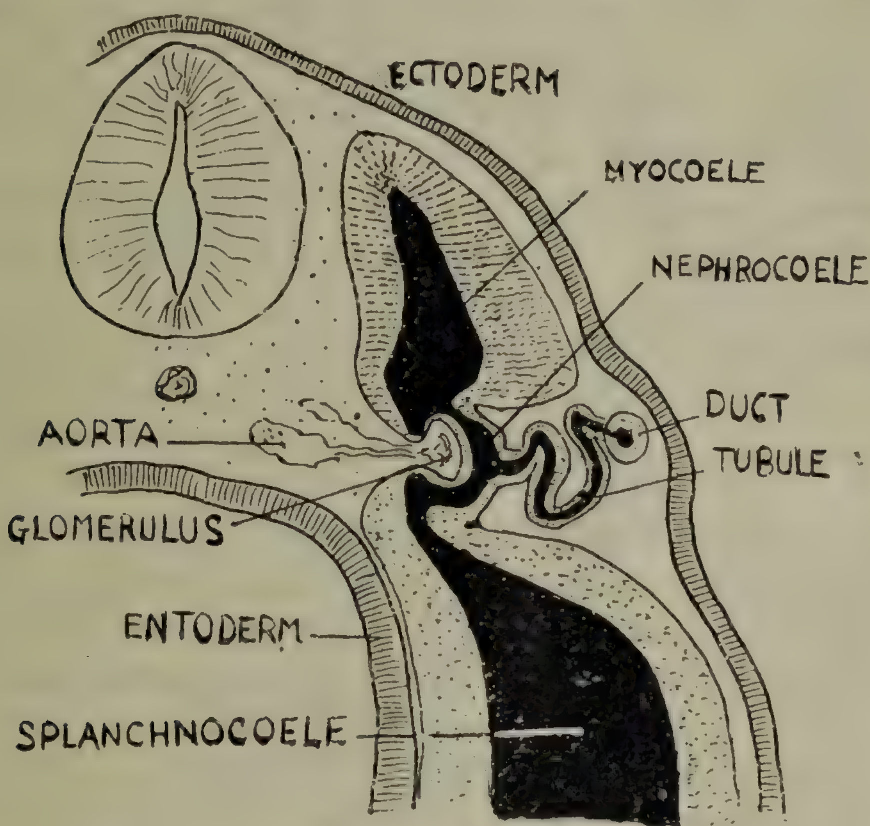


FIG. 61.—TRANSVERSE DIAGRAMMATIC SECTION TO SHOW SITUATION AND COMPONENT PARTS OF A NEPHRIC 'UNIT' IN A VERTEBRATE EMBRYO.

and nephrostome may be really in the dorsal part of the splanchnocœle, the glomerulus being then said to be *external*; (*b*) a persistent minute aperture; or (*c*), most usually, completely closed secondarily, the glomerulus being then enclosed and described as *internal*.

The myotome and its stalk are in segmental series, but the splanchnocœle shows no segmentation. Thus the nephric units are *in segmental series*, developing from the myotome stalk. In the human embryo the stalks have no cavities and are more or less fused together, making a solid *intermediate cell mass* (Fig. 31) in which segmentation is not very apparent; but the nephric units develop secondarily in this mass, and show its primitive segmental value by forming in segmental series—at any rate at first.

If the opening (*peritoneal opening*) into the splanchnocœle is narrowed or closed, it is apparent that a large development of the nephric

structures from the intermediate cell mass would lead to a projection or bulging of the *roof* of the splanchnocœle into that cavity.

The primitive connection of the nephric system with the cœlom suggests that that cavity may have come into being originally as a drainage cavity in the thickness of the mesoderm. This would imply that the splanchnocœle was originally segmented, but such segmentation would quickly disappear to allow of the further unhampered development of the visceral structures.

In the human embryo the three successive sets of excretory organs develop in connection with the solid intermediate cell mass, and are thus related to the dorsal wall of the body-cavity.

Pronephros.—Segmental tubules are formed very early from the intermediate cell mass below the cervical myotomes. The nephrostomes reach the roof of the lateral recess of the pericardium on each side. The glomeruli, badly formed, are in part external. The outer ends of the more posterior tubules join together to form an *excretory duct,* known usually as the **Wolffian duct.** Lumina are not present, or are badly formed, in the system of tubules. The whole structure is evidently merely vestigial; it begins to disappear at its anterior end before it has fully appeared farther back, and it has disappeared by the time the embryo reaches the length of 5 mm.

The **Wolffian duct** extends backwards, keeping pace with the differentiation of the mesoderm from before backwards, and ultimately reaches the cloaca at about the time when the pronephric tubules disappear.

Mesonephros.—This begins to develop on each side as the pronephros is disappearing. It forms in the intermediate cell mass caudal to the pronephric area, although its cranial end somewhat overlaps this. Its glomeruli are *internal* from the beginning. Its tubules are much coiled, and they open at their outer ends into the Wolffian duct, which is, of course, already *in situ* as the result of its rapid backward growth from the pronephric region. The tubules and glomeruli are at first segmental, but subsequently secondary tubules and tufts form between them, so that a large mass of dilated tubules and glomeruli is built up and projects into the abdominal cavity at each side of the *mesentery.* The mass is frequently termed the **Wolffian body.** It reaches its greatest development about the sixth week.

Metanephros.—The caudal end of the nephrogenic area, immediately caudal to the mesonephros, is dorsal to the cloaca. Mesonephric formation does not extend to this part, and it is only represented by a condensed mesodermal mass. When the ' ureteric outgrowth ' of the Wolffian duct (see later) comes into relation with it, it forms a *metanephric cap* on the dilated end of this. It is carried forwards on this outgrowth, *passing dorsal to the caudal part of the mesonephros.* Glomeruli and tubules subsequently develop in the metanephric blastema, and join with collecting tubules which grow out from the ureteric bud. The *permanent* **kidney** is formed in this way.

The Wolffian duct, the proper excretory duct, lies beside the growing mesonephros as it runs back to the cloaca. The tubules of the meso-

nephros come to open into it secondarily. Its anterior or pronephric end degenerates with the degeneration of the pronephric tubules from which it is formed, so that it comes to correspond with the extent of the mesonephros at its anterior end. It opens caudally into the cloaca.

The **ureteric bud** arises from it close to the wall of the cloaca (see Fig. 66), and grows dorsally and cranially, coming into relation with the metanephric mesoderm, and carrying this with it on the dorsal side of the mesonephros. The hollow bud has a club-shaped end, which soon shows a tendency to a bilobed condition; these two 'lobes' ultimately make the *major calyces* or *infundibula* of the pelvis of the

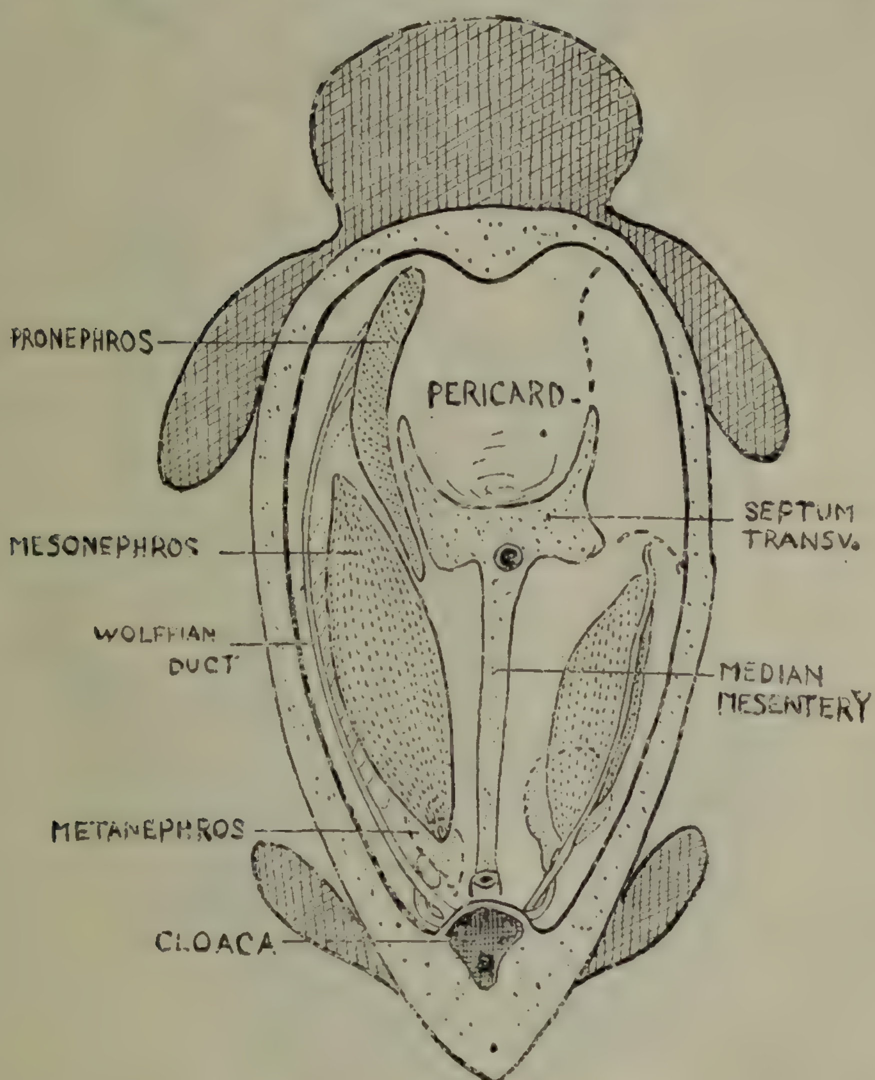


FIG. 62.—SCHEMATIC VIEW OF DORSAL WALL OF BODY AND ITS CAVITY, SEEN FROM BELOW, TO SHOW THE RELATIVE SITUATIONS OF THE THREE SUCCESSIVE FORMATIONS.

Interrupted lines indicate the shutting-off of the pleural cavity.

kidney. The bud, with its metanephric mesodermal cap, pushes gradually forward on the dorsal wall of the abdomen, and comes into relation with the large suprarenal gland, which is formed just below the diaphragm. Outgrowths take place from the infundibula into the mesodermal cap, forming *minor calyces* and *collecting tubules*, and these form secondary junctions with tubules which are formed, in the cap, with glomeruli.

Sometimes there is failure of junction, with the result that the secreting tubules become distended, and a *congenital cystic* kidney is formed.

The general relations of all these structures to one another, and to the body-cavity and regions, are shown schematically in Fig. 62.

The *pronephros,* on each side, is associated with the dorsal wall of the lateral recess of the pericardium, and extends to the upper abdominal region; the *mesonephros,* overlapping this on its outer side, lies in the abdomen, and extends about as far as, or just beyond, the middle of the lumbar region; the *metanephros,* the temporarily undeveloped hinder portion of the nephric ridge (intermediate cell mass region), lies immedi-

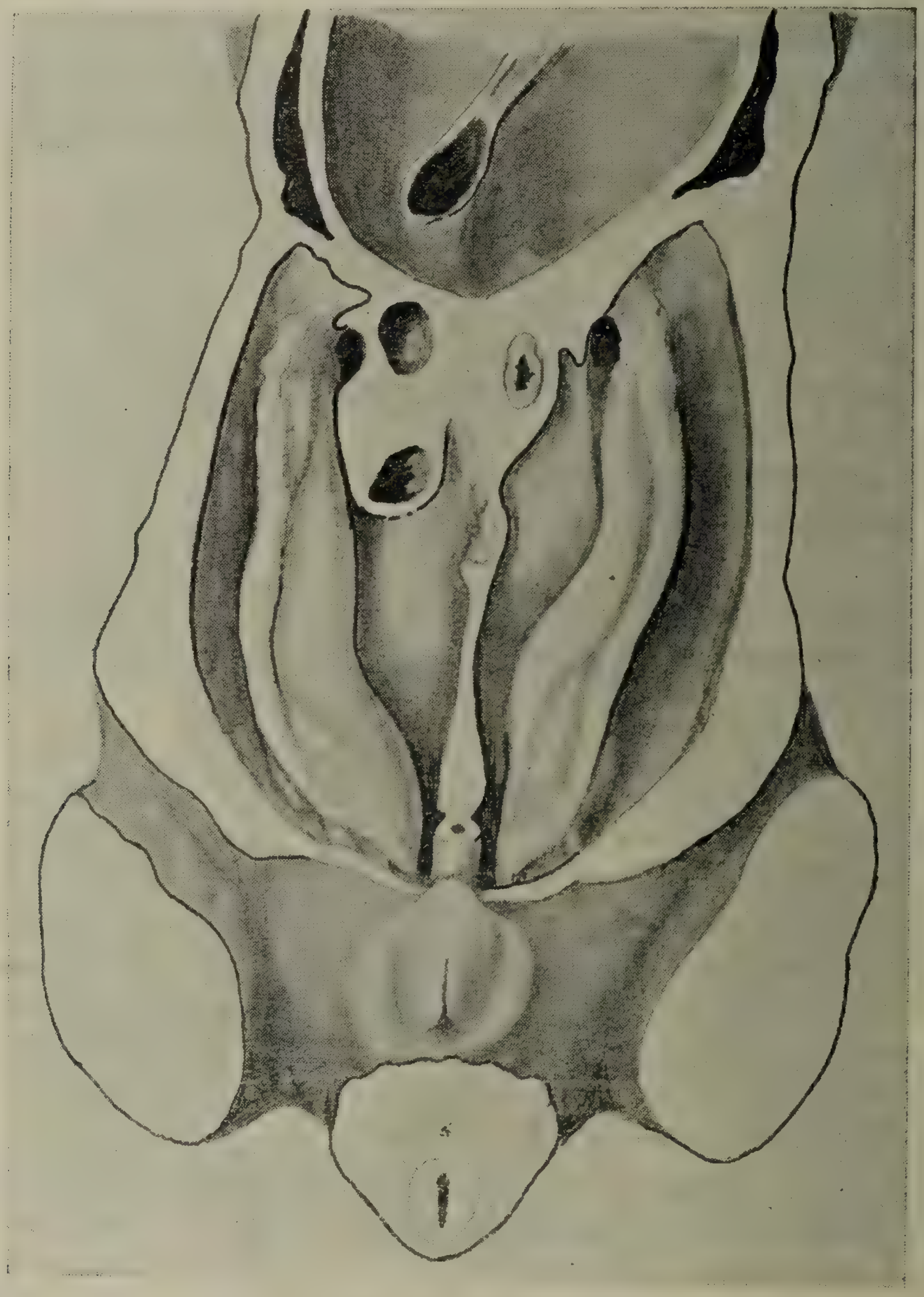


FIG. 63.—BACK WALL OF ABDOMEN OF EMBRYO OF 15 MM.

Shows Wolffian ridges, with tubal ridge ventro-laterally, and gonad internally Mesonephros is behind and between these, but shows at one or two places· Suprarenal swellings appear between the ridges and the mesentery.

ately caudal to the mesonephros. The *Wolffian duct,* lying beside these structures, extends caudally to reach the cloaca, and is giving off a secondary *ureteric bud.*

The fact that the mesonephros overlaps the pronephros is an indication that it cannot be looked on simply as a prolongation backwards of the pronephric formation. It is apparently a replacing structure, more specialized than the pronephros, as is indicated by the enclosed glomeruli, etc.

On the other side of the figure is shown a subsequent state. The pronephros disappears, the lateral recess becoming the pleural cavity, as indicated by the interrupted lines; the mesonephros is now separated from the pleura by the diaphragm, and extends caudally from this; the upper end of the Wolffian duct has disappeared with the pronephros, and its ureteric outgrowth has reached the metanephric condensation and has dislocated it cranially on the dorsal aspect of the mesonephros.

The two mesonephric masses, or Wolffian bodies, thus form *elongated prominences lying beside the attachment of the median mesentery* to the dorsal wall of the abdomen. The actual condition in the sixth week, the other abdominal viscera being removed, is shown in Fig. 63, and

FIG. 64.—SECTION THROUGH UPPER ABDOMEN OF 15 MM. EMBRYO.

Fig. 64 is a drawing of a section through the upper abdominal region of the same embryo. The two Wolffian bodies are separated from the mesenteric line above by the masses of the *suprarenal* formations, but they approach the mesentery below; here the permanent kidneys can be seen, just apparent on the dorsal side of the more salient ridges.

The structure of the Wolffian body, as seen on transverse section, is illustrated in Fig. 65, where tracings of such sections in embryos of the second month are shown.

In the embryo of 8 mm. the body forms a well-marked ridge, with the Wolffian duct (WD) in its lateral part, and the future gonad already indicated by thickening of the cœlomic lining on its ventro-medial

aspect. The posterior cardinal vein (V) lies dorsally. At 12 mm. the tubular structures in the body have increased considerably, the gonad is very apparent, and the Wolffian duct is now projecting somewhat ventro-laterally. The next specimen shows these changes accentuated, and a second duct (D) is seen ventral to the Wolffian duct in what is now a definite duct ridge or fold: the second duct is the Müllerian duct. At 26 mm. the gonad is well formed, and attached to the main mass by a narrow pedicle, and the plane of section cuts the ducts somewhat along their length. A key to the different parts of this compound 'urogenital fold' is given in the last figure, where M is the main (meso-

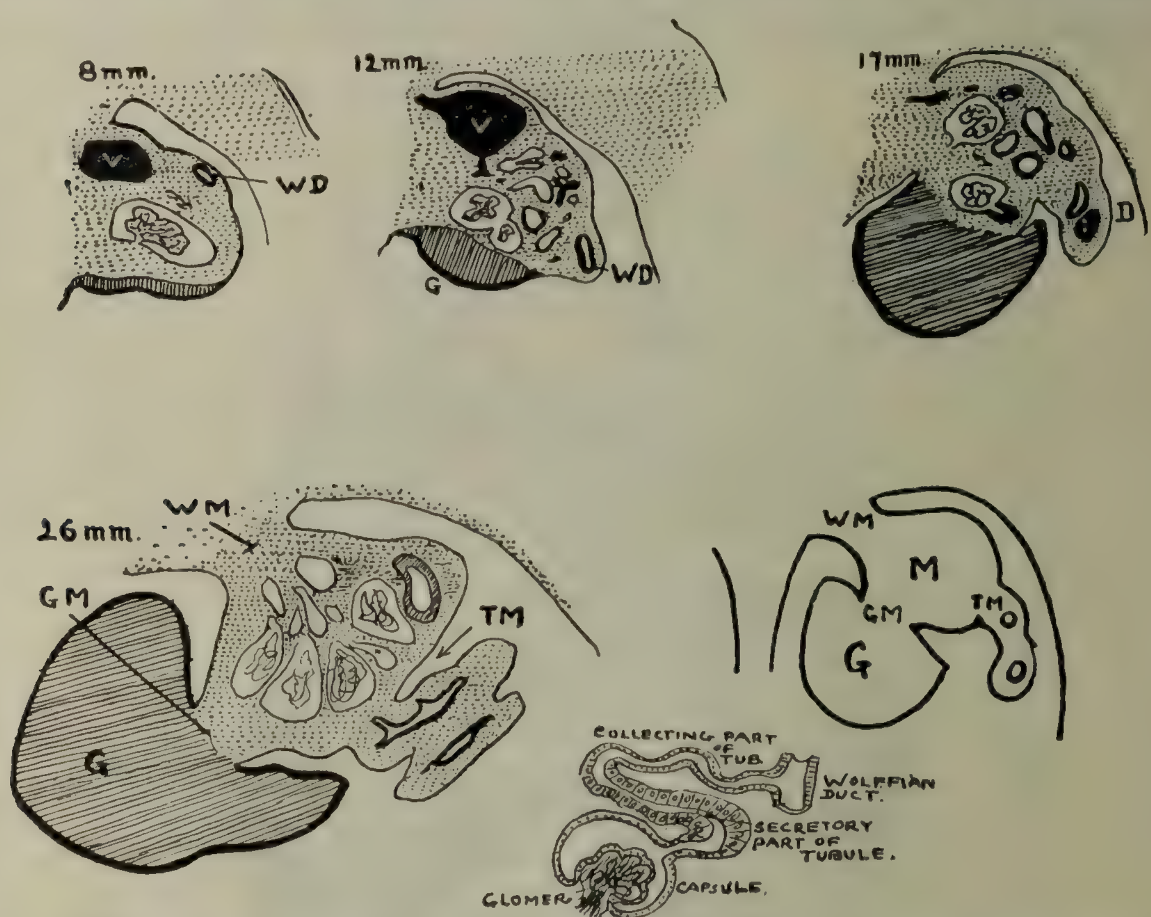


Fig. 65.—Tracings of Sections through the Region of the Wolffian Body at Different Times in the Second Month.

The lowest figure is a scheme of a mesonephric tubule, showing its convoluted course, with a secretory part near the glomerulus, and a collecting part leading to the duct.

nephric) body, WM the Wolffian or urogenital mesentery, G the gonad, GM the genital mesentery, and TM the tubal mesentery supporting the tubal ridge and ducts.

Division of Cloaca.

The cloaca has been seen to be a cavity into which open the *hind-gut* and the *allantois*. The first figure in Fig. 66 gives the position of the cloaca in the tail end of an embryo of less than 5 mm. A prolongation towards the tail process is known as the *post-anal gut* (PG). The cloacal membrane (*m*) looks cranio-dorsally. The *Wolffian duct* (W) reaches the cloaca, but has not yet given its ureteric outgrowth. BS is the body-stalk.

The cloaca is *divided* by the **cloacal septum** into *ventral* and *dorsal* parts. The septum, deepening from above downwards, is seen to be bringing about this division in the other figures; it is completed in the last. The *dorsal* division of the cloaca is now the **rectum,** and its ventral moiety is known as the **urogenital sinus,** because the genital ducts and the ureter open into it. The *ureter* is shown, arising from the Wolffian duct, in the second figure, while, in the others, its opening has been transferred to the sinus, and is assuming a *higher position here than that taken by the Wolffian duct.* The other duct (Müllerian) is not shown.

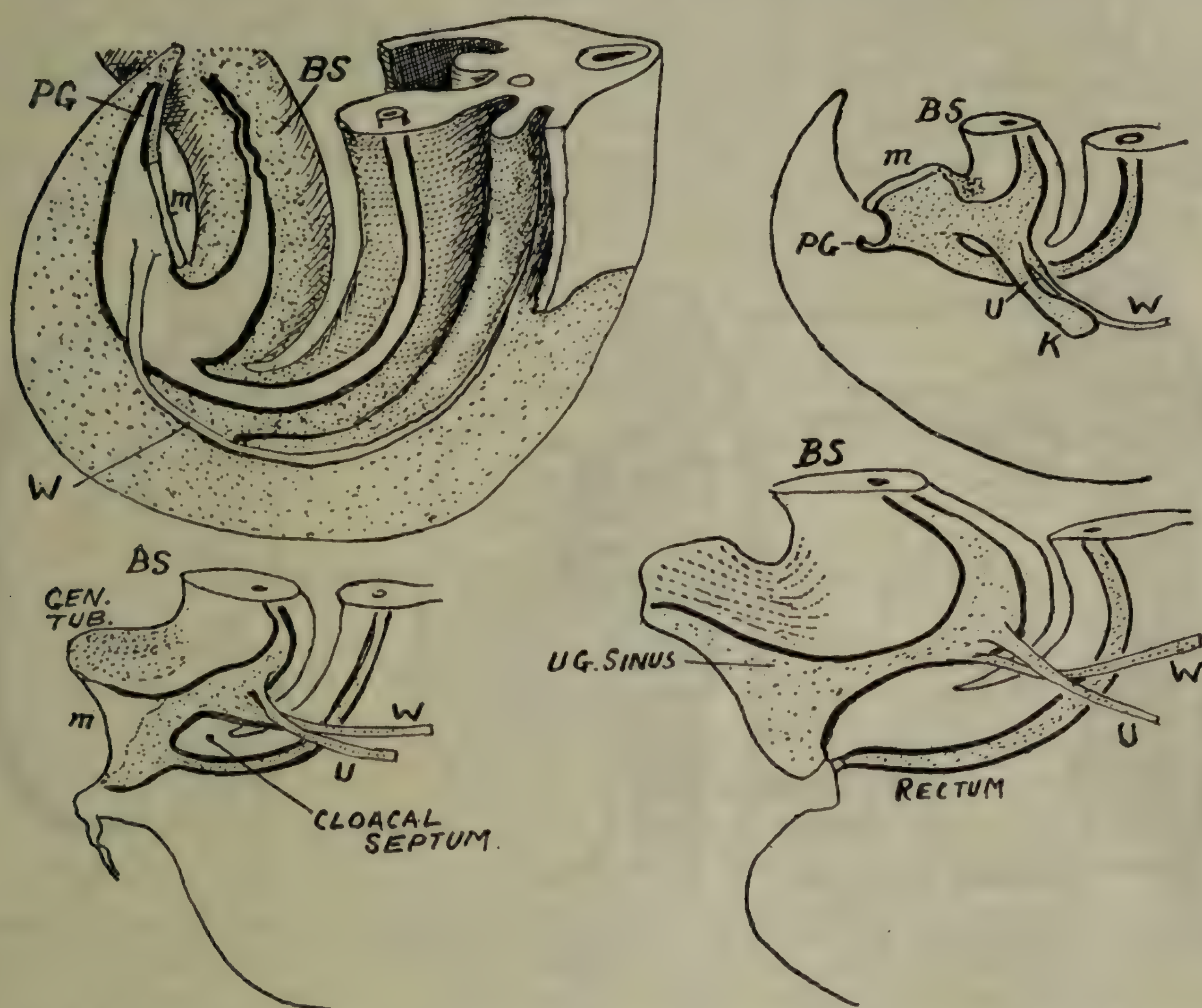


FIG. 66.—OUTLINE RECONSTRUCTIONS OF CLOACAL REGIONS IN EMBRYOS OF 4·5 MM., 8 MM., 13 MM., AND 18 MM., TO SHOW THE DIVISION OF THIS CAVITY.

Description in text. Also shows the atrophy of the 'caudal filament,' which drops off after the 13 mm. stage.

It should also be noticed that the direction in which the cloacal membrane looks is almost completely reversed, this result being attained by rapid mesodermal growth between the membrane and the body-stalk, with lessening of growth in the caudal region. Associated with this is the formation of a prominent *genital tubercle* at the ventral end of the membrane. When the membrane gives way, the urogenital sinus opens on the surface, but the rectum remains plugged by an epithelial formation for some time afterwards.

Genital Glands or Gonads.

A genital gland develops on each side of the body, on the *medial aspect of the Wolffian body.* The lining cells of the cœlom which cover this region begin to proliferate about the end of the first month. A growing mass of mesoderm cells is formed in this way on each side, making a projection (see Fig. 64) which extends nearly along the whole length of the mesonephros. The mesonephric structures lie behind and between the gonad and the tubal ridge.

Towards the middle of the second month the gland in the male embryo begins to show an arrangement of its contained cells into columns (*medullary cords,* Fig. 67). At this stage there is no indication of similar arrangement in the female gonad.

Male Gonad or Testis.—In addition to the *medullary cords,* which are visible in the body of the testis, *rete cords* are formed near the

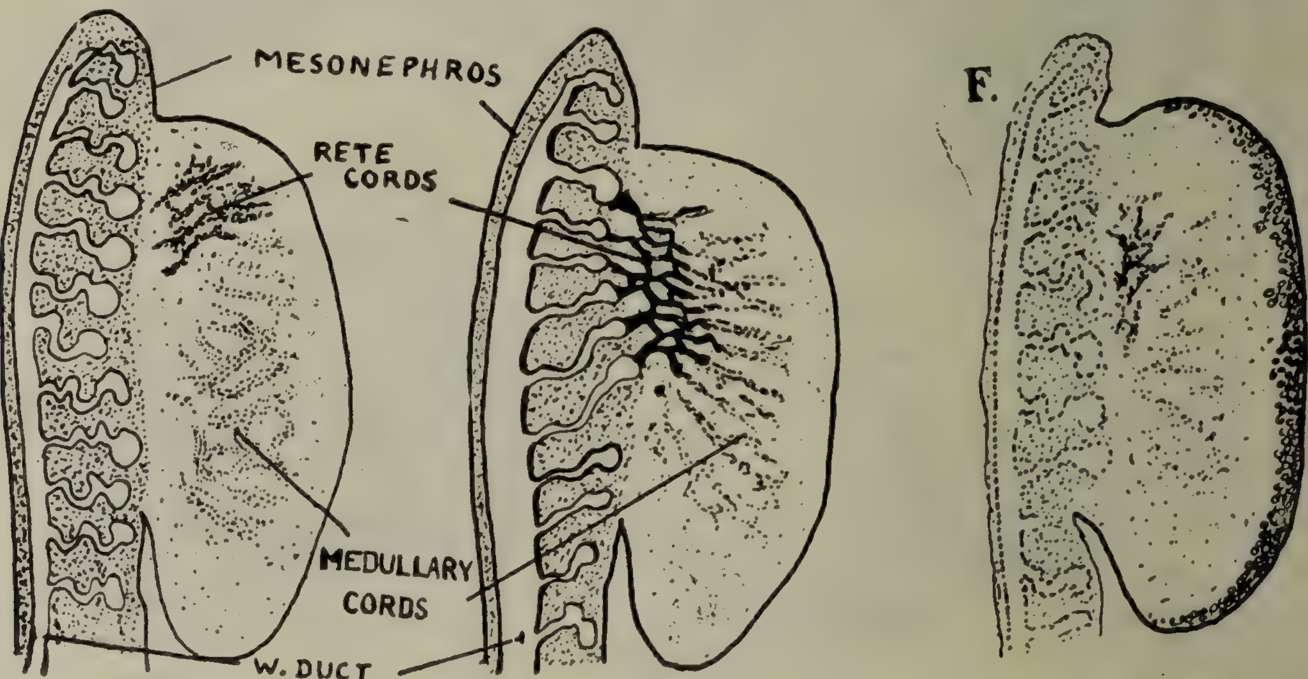


FIG. 67.—DIAGRAMS TO ILLUSTRATE DEVELOPMENT OF MALE AND FEMALE GONADS.

attached border or hilum of the gland. These are derived from the *upper part of the gland.* They develop lumina. Later there are found secondary connections of the rete cords with the *medullary cords,* on the one hand, and on the other hand with a number of *tubules* in the neighbouring part *of the mesonephros.* In this way the potential tubules of the testis (medullary cords) are brought into continuity with the Wolffian duct, which therefore *becomes the vas deferens.*

In the **female gland** or **ovary,** at a much later stage, there is some indefinite indication of attempted formation of medullary cords; definite rete cords are developed, somewhat as in the male. But a late ingrowth of epithelioid cells from the surface *displaces these earlier formations,* which subsequently disappear. The new cells from the surface ultimately form the sex-cells and nutritive cells. There is no attempt at junction with mesonephric tubules, as in the male; consequently *these tubules and the Wolffian duct degenerate* and become vestigial.

Müllerian Duct.

This is the *oviduct,* which only functions in the female, although it forms in both sexes. It begins to develop about or just after the time that the gonads make their appearance. An ingrowth of lining cells takes place into the diaphragmatic end of the *tubal ridge,* close to the Wolffian duct. This ingrowth extends in a caudal direction by growth of its solid free extremity; it lies beside the Wolffian duct, and thus *reaches the cloaca.* The cloaca has divided by this time (see Fig. 66), and the Müllerian duct, with the other duct, joins the *dorsal wall* of its *ventral subdivision.* The duct fuses with its fellow of the other side before reaching its termination, so that an *unpaired and median structure* is implanted into the ventral division of the cloaca. Each Müllerian duct has thus, from its earliest stage, an opening into the cœlom at its proximal or diaphragmatic end, and it has no connection with the nephric tubules which open into the Wolffian duct.

The extension backwards of the blind end of the duct, which lies close to the Wolffian duct, is only a secondary modification of its original mode of formation, which seems to have been by a process of splitting off from the Wolffian duct from before backwards.

Transverse Pelvic Ridge and Genital Cord.

The Müllerian duct lies, in the tubal ridge, on the *ventral* side of the Wolffian duct; the mesonephric tubules open into the *dorsal* side of the Wolffian duct. As the duct approaches the pelvis, however, beyond the mesonephric area, it changes its relation to the Wolffian duct, crossing it ventrally to lie on its inner side. Thus (Fig. 68) entering the pelvis, the two Müllerian tubes lie *between the other two ducts.* The four ducts lie in the pelvis in a mesodermal ridge which extends across the pelvis, and is continuous, at the pelvic margin, with the Wolffian ridge. The two Müllerian ducts fuse together in this ' transverse ridge '; it is immediately dorsal to the allantoic bladder; it is separated from this by a peritoneal depression in *female* embryos, and becomes the broad ligament, but in *male* embryos it is smaller and attached to the back of the bladder without an intervening depression.

The central part of this mesodermal ridge is thickened round the contained ducts, and this condensation surrounds them as they pass to the urogenital sinus, constituting the **genital cord.**

Terminal Portions of Ducts.

The **Müllerian ducts** are well formed in *female* embryos, and have a large lumen where they are fused together; this fused part makes the **uterus and** (a large part of) **vagina,** the muscular and fibrous walls of these being developed from the mesoderm of the genital cord. In the *male* they are smaller, and the fused part has an irregular lumen; this forms the small **uterus masculinus,** or sinus pocularis.

The terminal parts of the **Wolffian ducts** lie beside the fused Müllerian ducts in the genital cord. In the *female* they form the vestigial *ducts of Gaertner*, lying beside the uterus in the broad ligament. In the *male* the Wolffian ducts remain functional as the **vasa deferentia,** and the terminal parts form the **common ejaculatory ducts,** which lie beside the uterus masculinus.

The various conditions and changes that have been described are shown in schematic fashion in Fig. 68. The scheme on the left illustrates the original arrangement. The change in position of the ducts entering the pelvis is seen. The upper figure on the right

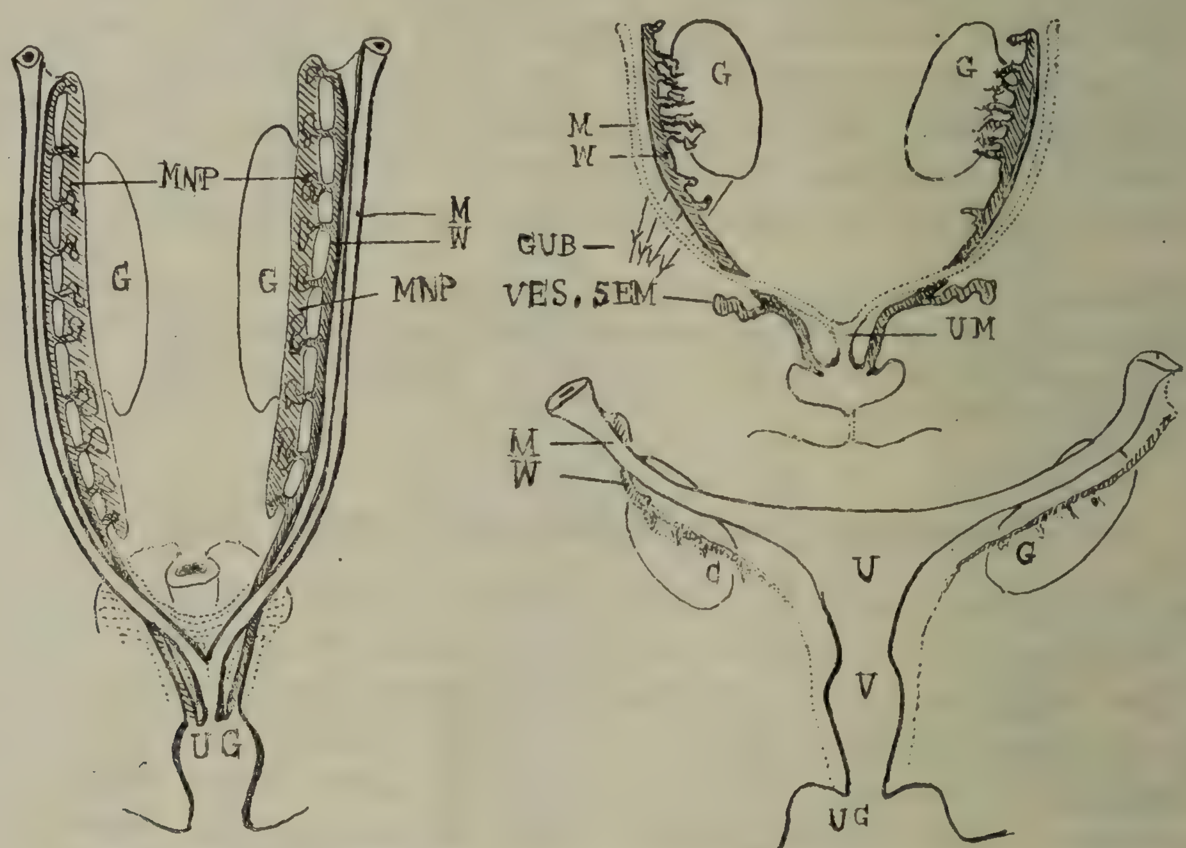


FIG. 68.—DIAGRAMS OF MALE AND FEMALE DEVELOPMENTAL CHANGES.

Mnp, mesonephros; M, W, Müllerian and Wolffian ducts; G, gonad; UM, fused Müllerian ducts; UG, urogenital sinus; U, uterus; V, vagina; VES. SEM., seminal vesicle. The direction of the fibres of the gubernaculum is shown at GUB.

shows *male* modifications, the connection between mesonephric tubules and those of the testis, and the consequent persistence of the Wolffian, and degeneration of the Müllerian duct. The **vesiculæ seminales** are formed as secondary outgrowths from the vasa deferentia. The lower figure, representing the *female*, shows the degeneration of the Wolffian ducts, their remnants, with those of the mesonephric tubules, lying between the ovary (G) and the Müllerian ducts, which remain as oviducts.

Changes in Position of Urogenital Structures.

The original position of the structures on the dorsal wall of the abdomen is quickly modified. The conditions present *in the female*

at the end of the second month are shown in Fig. 69. The great extension of the liver attachment and the growth of the suprarenals are associated with marked downward displacement of the structures of the Wolffian ridge. At the same time there has been degeneration of the upper part of each mesonephros. Thus the gonad and tube, with the Wolffian remnants, are approaching their ultimate pelvic

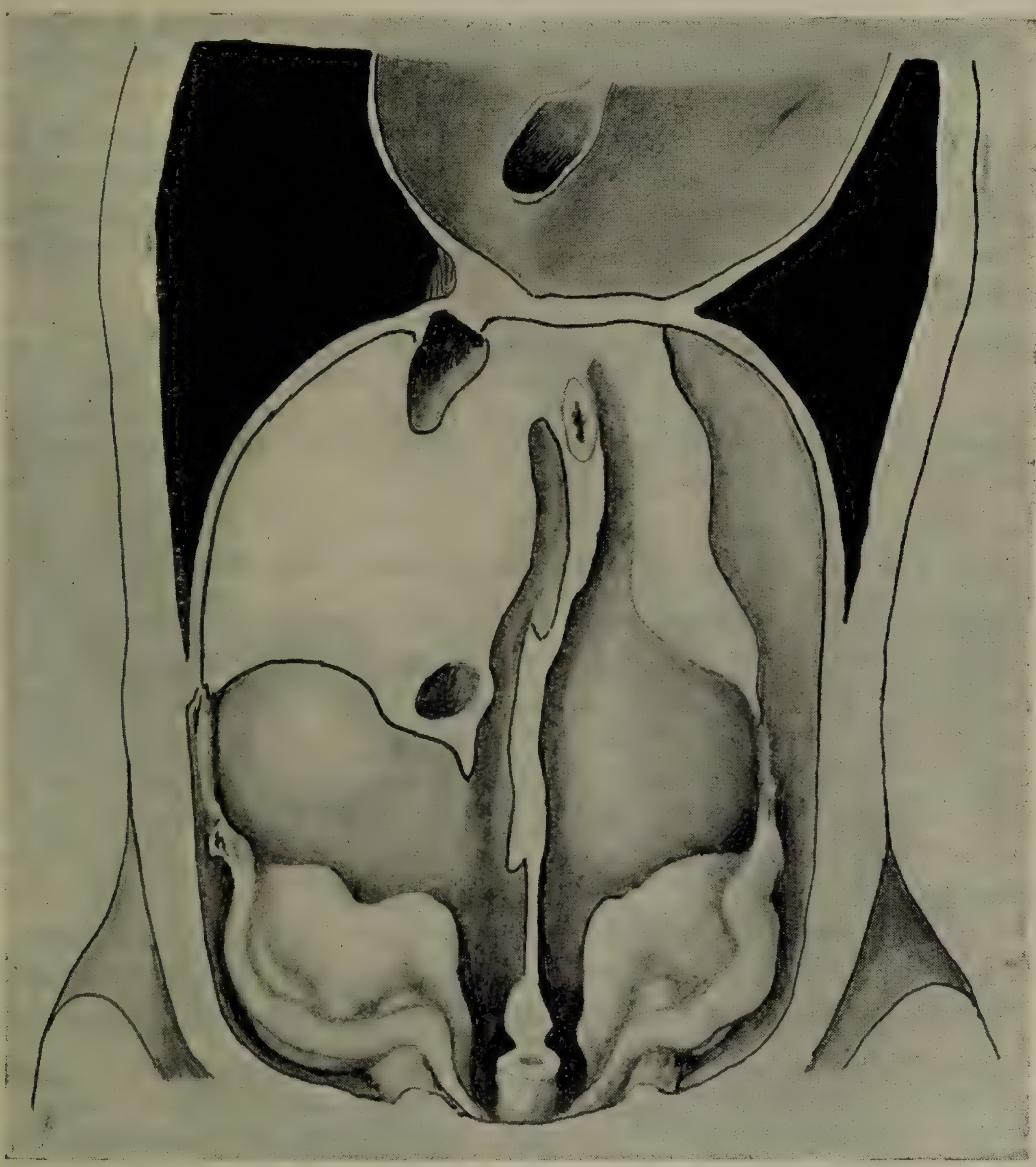


FIG. 69.—DORSAL WALL OF ABDOMEN IN 28 MM. EMBRYO.
For comparison with Fig. 63.

position, which they will attain at a much later period as a result of difference in growth-rates.

In the male there is the same kind of general descent that is seen in Fig. 69, but an additional factor becomes operative in the shape of the **gubernaculum testis.** This is seen in its early stage in Fig. 63. It is a band passing between the inguinal abdominal wall and the testis and the two ducts, and develops muscular fibres in its thickness.

As the band *does not grow in length pari passû* with the wall, the structures to which it is attached necessarily come to a lower level near this wall and out of the pelvis. No doubt a certain amount of muscular contraction occurs also, and aids in this movement of the testis along the pelvic brim. The other end of the gubernaculum passes through the wall and into the genital swelling, which forms that half of the scrotum. Thus the gland is brought down towards the scrotum, but it is not known by what mechanism or factors the actual passage outside the body is brought about. The testis is just outside the outer ring at birth.

A similar but weaker gubernacular fold is present in the female, but the persistence and thickening of the Müllerian tubes, to which it is attached on each side, limits its power of downward traction, and the ovary moves into the pelvis with the tube to which it is attached.

Failure of the factors causing descent may lead to the condition of retained testis, when the gland is usually found on the pelvic brim, or just within the abdomen; if partially retained it is in the inguinal canal. On the other hand, an ovary may be drawn down into this situation by failure of gubernacular attachment.

Further Intra-Uterine Conditions: the Decidua.

The embedding of the ovum has been described shortly on p. 28: the conditions were brought up to the stage in which the ovum, covered by chorionic villi, lies in the intervillous space in the stratum compactum of the decidua. The intervillous space is filled with blood and necrotic detritus, results of the action of the trophoblast on the decidua. The cavity containing the ovum is separated from the uterine cavity by a thin layer of mucous membrane, the **decidua capsularis.**

The first diagram in Fig. 70 represents these conditions. The growing embryo and ovum cause a projection of the capsular decidua into the uterine cavity; the capsular decidua is stretched and thinned.

The decidua capsularis is that part of the stratum compactum immediately surrounding the aperture of entry and stretched out by the growing ovum. The aperture is closed just after the entry of the ovum by a fibrinous plug, and its position is possibly indicated by a thin scar (Reichert's scar) on the most prominent part of the capsular decidua.

The mucosa between the intervillous space and the muscular wall of the uterus, composed of the *deeper parts of the compact and the whole thickness of the spongy layer* in this part, is called the **decidua basalis.** The remaining decidua, lining the rest of the cavity of the uterus, is the **decidua parietalis.**

The *cervical canal* is *closed* by a plug consisting of epithelial and mucous débris.

Within the chorion the embryo is surrounded by the *amnion,* which does not fill the ovum; thus an extensive extra-embryonic

cœlom is present. The chorionic villi are smaller (*chorion læve*) over the capsular aspect of the chorion, but are well developed and rapidly growing (*chorion frondosum*) over its basal aspect. The body-stalk is *attached to this basal region* of the chorion.

It is evident that the ovum can undergo rapid growth in this position out of proportion to the more slowly enlarging uterus, for it can expand in the direction of the uterine cavity, which will ultimately be obliterated by its expansion.

The second diagram in Fig. 70 gives schematically the condition in the fourth month. The ovum has enlarged considerably, and by its enlargement has brought the *decidua capsularis* into contact with the *parietal* layer over the rest of the uterine wall, thus *obliterating the uterine cavity*; the cavity is shown in the figure as on the point

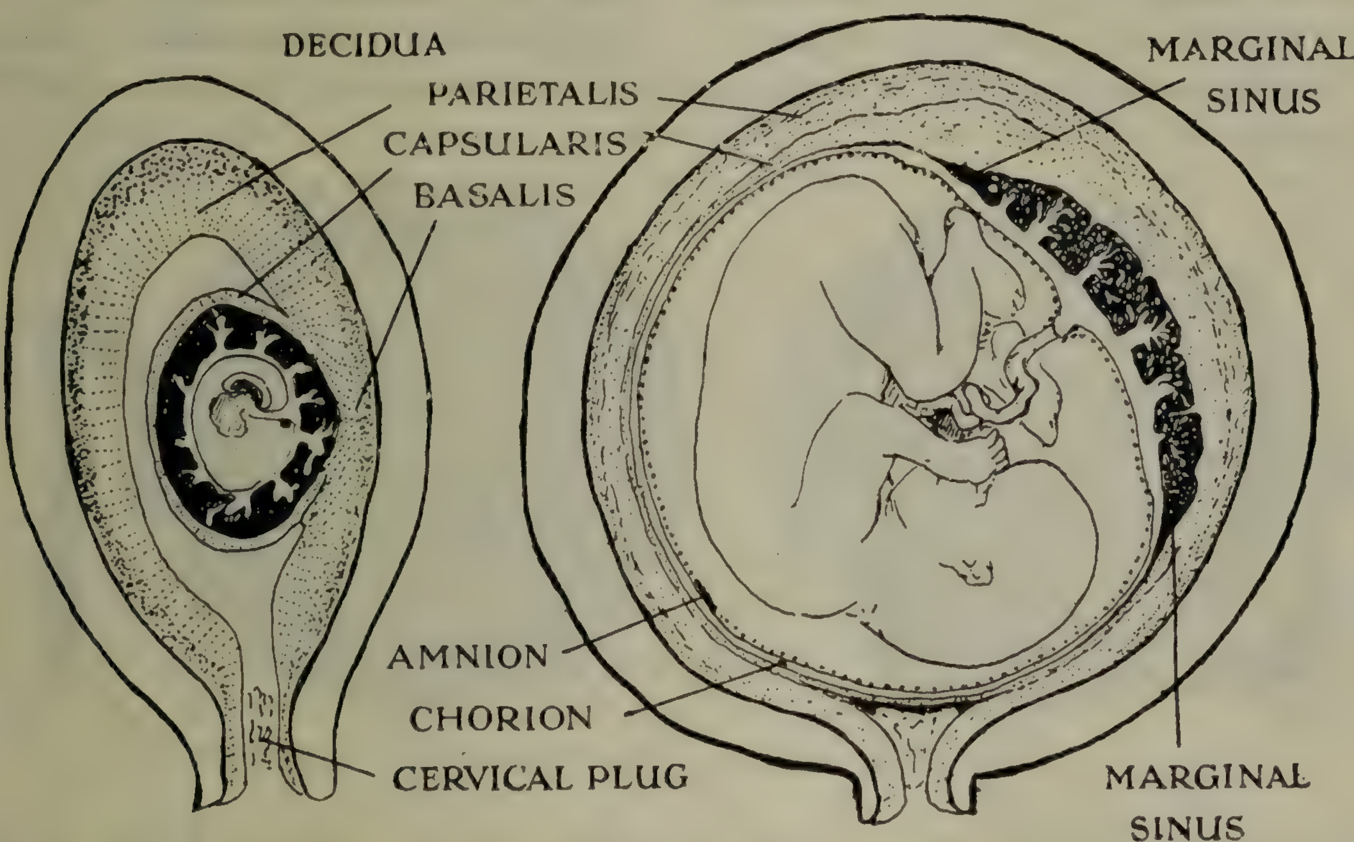


Fig. 70.—Two Diagrammatic Sections of the Gravid Uterus, to illustrate the Conditions at the End of the First and in the Fourth Months.

of obliteration. A certain amount of fusion then takes place between the parietal and capsular layers. The villi on the greatly stretched capsular part of the chorion have practically disappeared, and the chorion and decidua capsularis have come into close contact, with the disappearance of the intervillous space which originally intervened. Within the ovum the amnion has enlarged with the growing fœtus, and has come into contact with the whole extent of the inner surface of the chorion, obliterating the extra-embryonic cœlom. The body-stalk has elongated, and is now a definite *umbilical cord* covered by amnion and connecting the fœtus with the basal part of the chorion. This basal chorion is thickened, and has growing from it enormously enlarged and arborescent villi; these are the villi of the chorion frondosum. These large villi lie in the intervillous space which is

filled with maternal blood, and the 'floor' of the space is made by the superficial part of the *decidua basalis*. The basal chorion with its villi, and the superficial layer of the basal decidua, form together the **placenta,** which is the organ on which the fœtus depends for its nutrition and respiratory exchanges.

The *extra-embryonic cœlom* is *obliterated* towards the end of the second month.

The *uterine cavity* is *obliterated* in the fourth month.

The *placenta* is considered to be functional from the third month onward, but it can be recognized definitely before the third month.

The *amnion and chorion,* with their immediate decidual covering, constitute what are known, in the lying-in room, as *the membranes.*

The **amnion** is a thin transparent membrane, composed of a very fine *outer* layer of areolar mesoderm, lined on its *inner side* by a layer of cells, the amniotic ectoderm. It encloses the *amniotic cavity,* filled with *amniotic fluid,* a thin clear liquid containing a small amount of albumin.

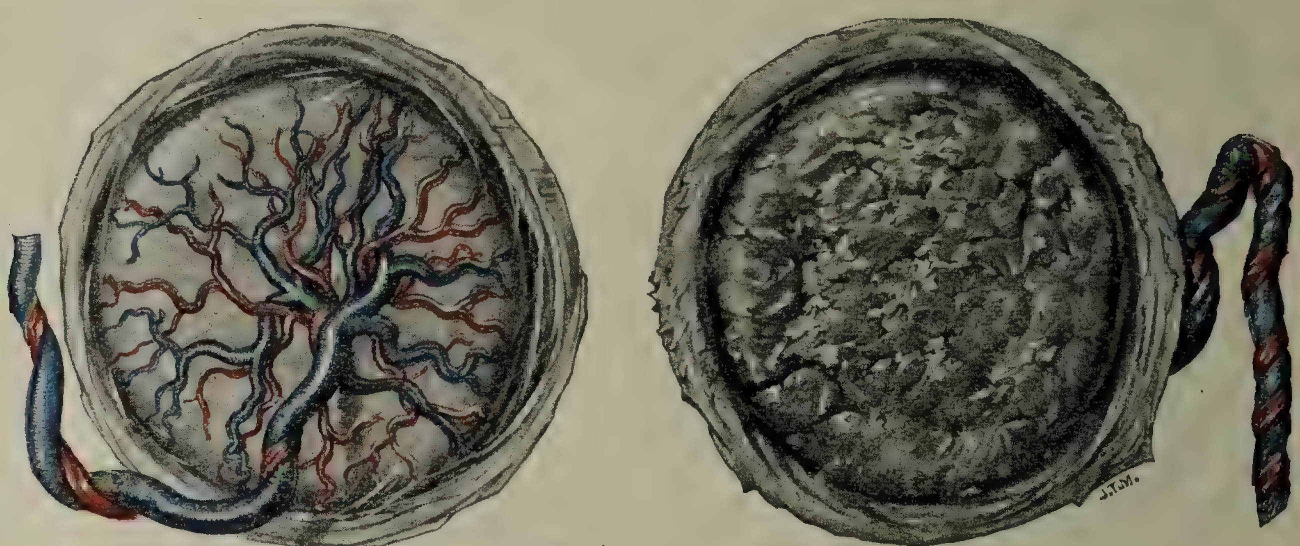


FIG. 71.—PLACENTA: FŒTAL AND MATERNAL SURFACES.

The **chorion,** although shown in the diagram as a fairly thick wall, is really only thick and opaque where it forms the chorionic basis of the placenta. In the rest of its extent it undergoes much stretching and thinning, so that it becomes almost transparent.

The **capsular decidua** is also stretched to such an extent that it almost becomes transparent. It is considered to become more or less attached to the chorion, but remnants of the villi of the chorion læve can always be found, here and there, pressed between the two layers.

The **placenta** can be seen to be composed essentially of a 'floor-plate' of decidua (maternal part) and 'roof-plate' of chorion from which the villi spring (fœtal part). Between these two plates is the area of villi, bathed in the blood of the intervillous space. The peripheral part of this space, surrounding the area of large villi, makes an open sinus or channel round the placental margin, hence termed the *marginal sinus.*

The placenta, from its mode of construction, must necessarily

be continuous at its edge with the ‘ membranes’ (chorion and decidua) enclosing the ovum; it is lined on its fœtal aspect by the amnion. Further details of its structure will be given later.

It is evident that, as a result of the fusion of the capsular and parietal decidual layers, the cavity of the ovum has replaced the cavity of the uterus. The fœtus, lying in the amniotic fluid, is separated from the mouth of the uterus (which is still closed by a mucous plug) by the thin ‘membranes,’ consisting from within outwards of *amnion*, *chorion*, and *decidua capsularis*.

From the fourth month to the time of birth the conditions remain essentially as figured. The enlargement of the fœtus and ovum can now only take place *pari passu* with that of the uterus. At full term the fœtus, attached by an umbilical cord of considerable length to the placenta, is separated from the vaginal cavity by the ‘ membranes ’ already described, which bulge through the dilated cervix uteri. When these membranes are ruptured, the amniotic fluid escapes, and the uterus contracts down on the fœtus, which is expelled, partly by the contraction of the uterus, and partly by that of the abdominal walls.

After the fœtus has left the uterus, this contracts down on the placenta and membranes. The placenta separates from the deeper layers of the decidua, and is expelled, with its associated membranes, by further uterine contraction.

The line of separation of the placenta lies in the stratum spongiosum of the basal decidua. The growth of the uterus leads to stretching of this decidua, and the large gland-cavities of the spongy stratum are drawn out into long cleft-like spaces; it is in the plane of these clefts that the separation occurs between the ‘ maternal part ’ of the placenta and the rest of the basal decidua. The line of clefts is shown in Fig. 70.

Histological Changes in the Decidua.

In addition to the macroscopic changes which have just been considered, certain histological effects of pregnancy are found in the decidua at an early stage. The lining epithelium is destroyed before implantation in the neighbourhood of the site of this process, and subsequently elsewhere.

The decidua becomes very vascular. Its glands enlarge, and their lining cells become enormously swollen and show a tendency to break down. The stroma is much swollen, and is everywhere infiltrated with *decidual cells*; these are large spherical or angular cells (Fig. 73) with well-marked nuclei of considerable size, and when present are diagnostic of pregnancy. Their origin is not definitely known; probably it is from the stroma cells. The decidua also shows a considerable infiltration with leucocytes, a fact which is of use in distinguishing decidual structures from neighbouring fœtal formations.

Placenta.

The placenta is mainly composed of masses of villi, but its *fœtal* surface is made by the **placenta chorion** from which the villi spring, and its *maternal* surface is covered by a layer, more or less complete, of *decidua basalis*, torn away from the uterine lining when the placenta and its ' membranes ' are expelled.

The whole structure usually resembles a thick disc, nearly circular in outline, some 6 to 8 inches across, and 1 or 2 inches thick. It is covered by the *amnion* on its fœtal surface, and has the **umbilical cord** implanted on this surface, as a rule near its centre.

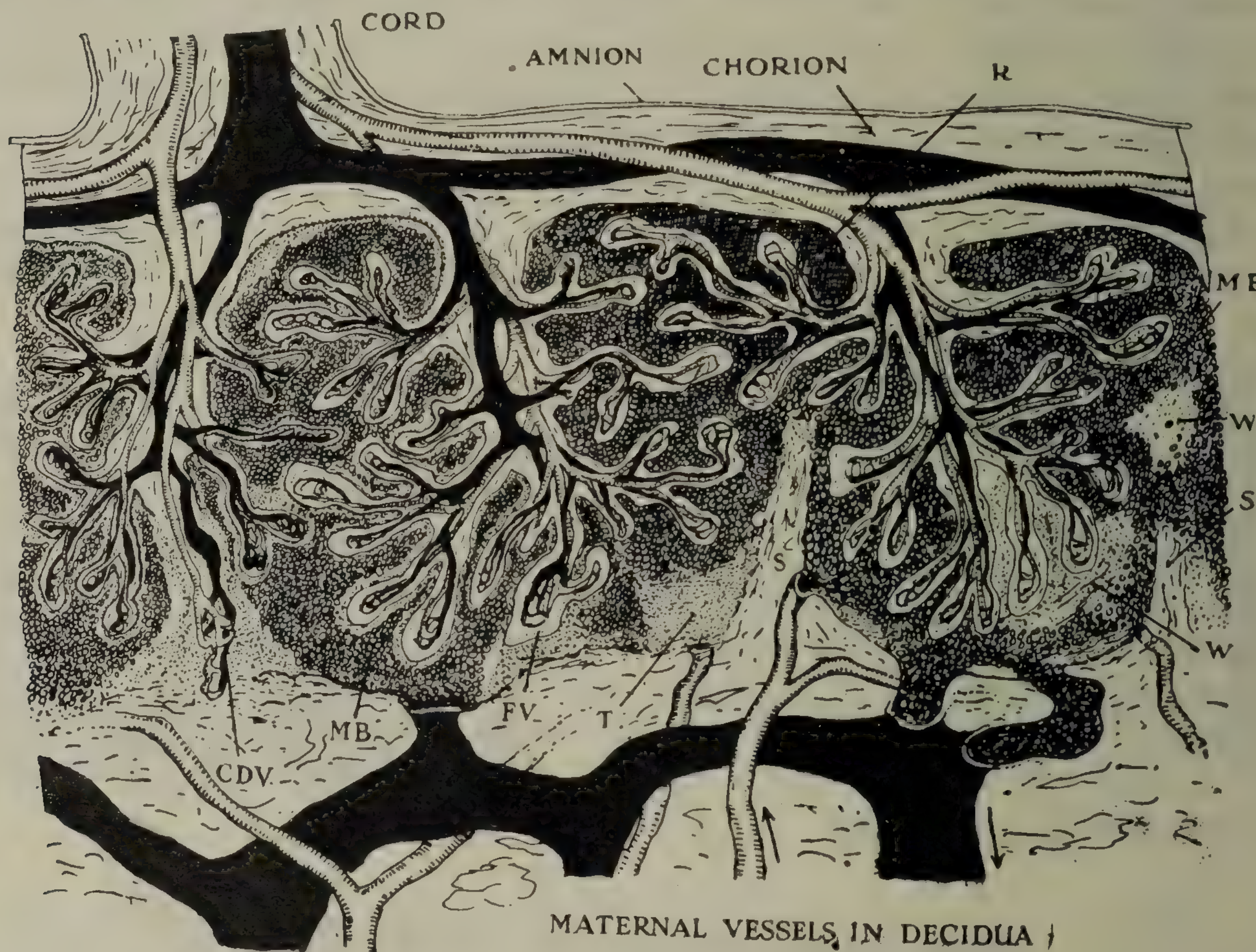


FIG. 72.—PLACENTAL SECTION (SCHEMATIC).
Explanation in text.

The structure of this organ is shown in the diagrammatic section in Fig. 72. Villi project from the placental chorion into the large **intervillous space,** which holds the arborizations produced by their enormous development. They lie, in this space, bathed in *maternal* blood (MB). This blood enters the space by maternal arteries, and leaves by maternal veins; these vessels have been opened up by the destruction of decidua by the trophoblast of the advancing villi. Some form of circulation is thus present in all probability in the intervillous space, providing for the interchange between this blood and that in the villi. The decidual wall closing the space has masses of plasmodi-trophoblast here and there in contact with it (T); this may be degenerated, forming one of the varieties of ' fibrin ' or ' fibrinoid,'

of which other sorts are derived from necrosed decidua. Some masses of fibrinoid make what are termed *white infarcts* (W) in the intervillous space, and clotted blood, usually round some necrotic tissue as a centre, may make (R) *red infarcts*. Some villous processes show attachment to the decidual wall through their trophoblastic covering, as at FV; these are known as **fixation villi.** Fixation villi occasionally degenerate, leaving their contained vessels, however, enlarged into dilated sinuses, which thus seem to run from the chorion (CDV) to the decidua, and are called *chorio-decidual vessels*; it must not be forgotten, however, that there is *never any direct connection between fœtal and maternal*

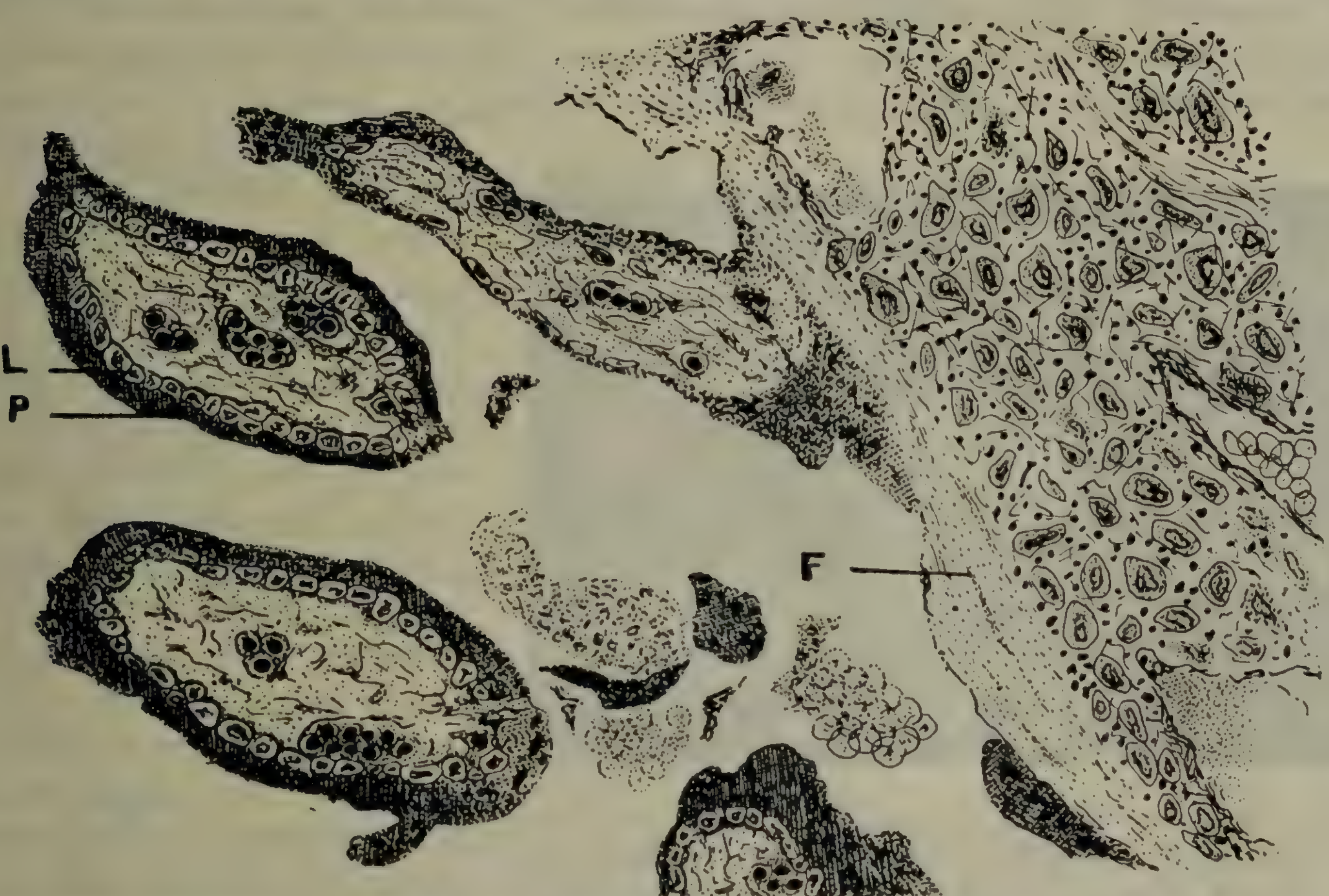


FIG. 73.—PART OF A SECTION THROUGH THE INTERVILLOUS SPACE IN THE FOURTH WEEK.

Villi are seen cut, covered by trophoblast. L, cyto-trophoblast or Langhans' layer; P, plasmodi-trophoblast. One fixation-villus is in position. Masses of plasmodium and degenerated and necrosed tissues lie in the space. F is a deposit of 'fibrinoid' lying against the decidua. The decidua shows the large nucleated cells of the 'decidual change' in the stroma, and is infiltrated with leucocytes.

vessels, and the chorio-decidual vessels *end* in or on the decidua, and have no connection of any sort with the vessels of this layer.

The destruction of the decidua which results from the activity of the villi is naturally most marked opposite each main villous stem, so that these areas are partially separated from each other by incomplete **septa** projecting (S) into the intervillous space. The maternal arteries tend to open on or near these septa, the venous apertures lying rather between them. The placenta, when viewed from the maternal side, exhibits indefinite prominences corresponding with these main villous areas, separated by badly marked depressions along

the lines of the septa; the prominences make the *cotyledons*, of which there are generally from twenty to twenty-five.

Where the villi are sparse or absent, in the peripheral part of the intervillous space, this space, containing only blood, is known as the *marginal sinus*; it is shown in Fig. 70.

General Growth of Fœtus.

Fig. 74 shows embryos in various stages of development during the first three months, drawn of natural size. The human appearance is definitely attained in this month. Limbs begin as 'limb-buds,' which grow larger, form 'hand-plates' with marginal irregularities that indicate the early form of digits, and later develop a bend nearer the proximal end, which, as the nearer segments grow, become the elbow and knee respectively. Limb-buds are at first condensations of mesoderm or mesenchyme, in which the central parts form the skeleton, and joints appear in these central parts secondarily. Muscles and tendons develop *in situ*, and not as ingrowths from somites.

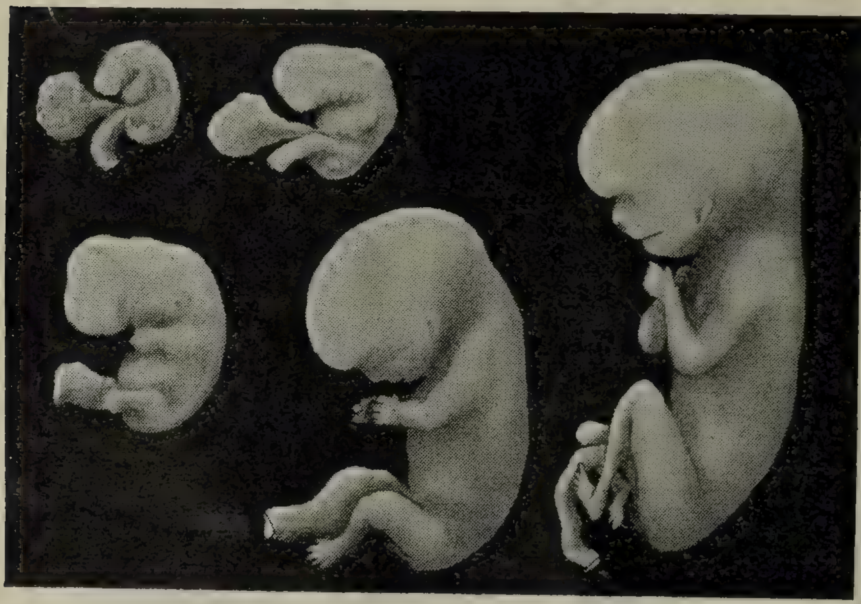


Fig. 74.—Drawings, Natural Size, of Embryos of the End of the First Month, Fifth Week, Sixth Week, End of Second Month, and Middle of Third Month Respectively.

After this time the fœtus increases in 'sitting height' at about the rate of $1\frac{1}{2}$ inches a month.

After the third month the growth of the fœtus goes on with fairly regular progress at about the rate of 10 mm. a week, more or less. During the *third month* the nails appear on the hands and feet, the eyelids close, and the umbilical gut enters the abdomen. During the *fourth month* minute hairs can be found on the surface, and the hair begins to show on the head during the *fifth month*; movements of the fœtus are apparent in this month. In the *sixth month* the nails begin to project on the digits, and the fœtus is covered with fine hairs, and with a fatty, sebaceous-like material, the *vernix caseosa*. The eyes, which have been closed since the third month, open during the *seventh month*, and subcutaneous fat begins to be deposited. In the *eighth month* the fine hairs (*lanugo*) begin to disappear from the skin, subcutaneous fat is well developed, and the testes appear at the internal ring. In the *ninth month* the testes reach the scrotum, and the fœtus approximates to the appearance of the new-born child.

Umbilical Cord.—This is the name given to the later representative

of the body-stalk, of which it is practically only a modification. It connects the fœtus with the placenta, carrying the placental or umbilical vessels. Its length (usually less than 2 feet) is considerable, though variable, and it exhibits a twisted appearance, due to the movements of the embryo—at any rate in part. Its structure shows a semi-transparent substance, *Wharton's jelly*, formed by changes in the mesoderm of the body-stalk, and carrying the *vessels* and *allantoic remnants*; this is *surrounded by an amniotic covering*, which is said to include a portion of the original body-wall proximally. Remains of the *vitello-intestinal duct* may exist between amnion and the rest of the cord, the *umbilical vesicle* (yolk-sac) itself being usually between the amnion and the placenta.

Summary of Structures derived from the Germinal Layers.

Ectoderm.

1. The nervous system—that is to say, the spinal cord and encephalon, the peripheral nerves, and the sympathetic system.
2. The epithelial elements of the organs of sense, except the tongue—*e.g.*, the epithelial elements of the olfactory region, internal ear, optic nerve, and retina.
3. The epithelial elements of the posterior lobe of the pituitary body, and those of the pineal body.

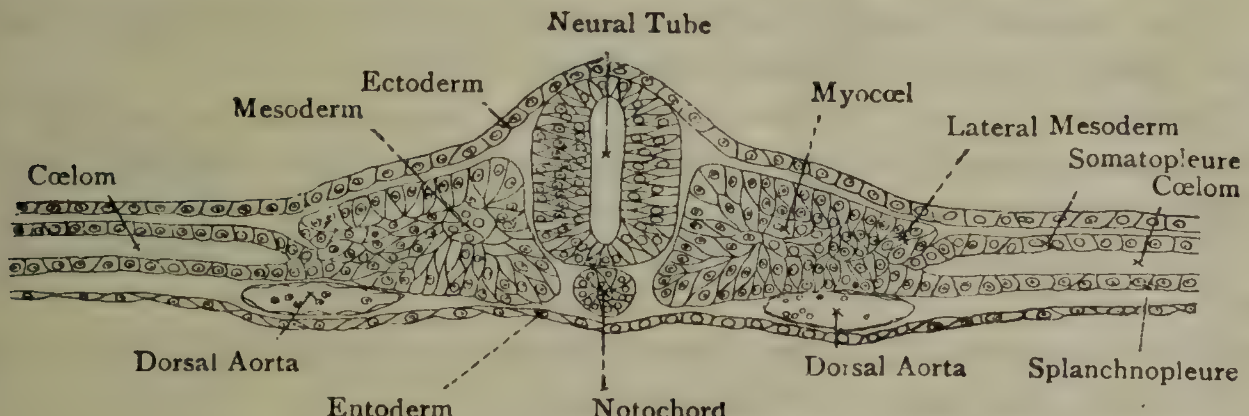


FIG. 74A.—THE GERMINAL LAYERS.

4. The crystalline lens.
5. The epidermis and its appendages—*e.g.*, the hairs and nails.
6. The epithelial elements of the sebaceous glands, sweat-glands, and mammary glands.
7. The plain muscular tissue connected with the hair-follicles, and arranged as the *musculi arrectores pilorum*, as well as the plain muscular tissue of the sweat-glands; muscles of iris.
8. The epithelium of the roof and sides of the mouth, but not that which covers the tongue and back part of the floor of the mouth; the epithelium of the parotid glands; the enamel of the teeth; and the anterior lobe of the pituitary body.
9. The epithelium of the nasal fossæ and of the air-sinuses which communicate with them.

10. The epithelium of the external auditory meatus and outer layer of the membrana tympani.

11. The epithelium of the conjunctiva and front part of the cornea.

12. The epithelium (modified epidermis) of the anal canal *below* the anal valves.

13. The epithelium of the spongy part of the male urethra.

Entoderm.

1. The epithelium of the alimentary canal, except the following parts: (*a*) The roof and sides of the mouth; and (*b*) the anal canal below the anal valves.

2. The epithelium of the tongue (including that of the taste-buds) and of the floor of the mouth.

3. The epithelium of the glands which open into the alimentary canal (except the parotid glands)—*e.g.*, the liver and pancreas. The epithelium of the gall-bladder is included.

4. The epithelium of the Eustachian tube and tympanum.

5. The epithelium of the thyroid and thymus bodies.

6. The epithelium of the respiratory tract—*e.g.*, the larynx, trachea, bronchial tubes, and air-cells of the lungs.

7. The epithelium of the urinary bladder, of the prostatic and membranous parts of the male urethra, and of the whole of the female urethra.

Mesoderm.

1. The various connective tissues—*e.g.*, bone, cartilage, dentine, cement, areolar tissue, fibrous tissue, and blood.

2. Muscular tissue, striated and plain, except the muscular tissue of the sweat-glands, that which constitutes the *musculi arrectores pilorum* in connection with the hair-follicles, and that of the iris.

3. The vascular and lymphatic systems, together with their endothelial linings.

4. The serous and synovial membranes, together with their endothelial linings, including all bursal sacs.

5. The kidneys and ureters.

6. The testes, and their complicated excretory equipments.

7. The ovaries, Fallopian tubes, uterus, and vagina.

8. The spleen.

The mesoderm exists under two forms, called mesothelium and mesenchyme.

Mesothelium is that form of mesoderm in which the cells are flattened and form a definite epithelial membrane or layer, known as **endothelium,** there being only a very small amount of intercellular substance. It lines serous membranes, as well as the chambers of the heart, the bloodvessels, and the lymphatic vessels.

Mesenchyme is that form of mesoderm in which the cells are more or less scattered in a homogeneous ground-substance or matrix, as occurs, say, in the various connective tissues. The cells are stellate and non-epithelial.

CHAPTER III

OSTEOLOGY

THE skeleton is named from a Greek word which means dry, and is that part of the body which, being richly impregnated with lime salts, persists in a dry condition long after the soft parts have disappeared in the process of decomposition. In the invertebrate animals the skeleton is, for the most part, on the outside, and acts as a protective covering as well as maintaining the shape of the body and serving as a fixed surface from which the muscles may act. In this position it is known as an exoskeleton, and may be calcified, as in the lobster, or composed of chitin, as in the beetle; but in any case it is derived from the outer layer or ectoderm of the embryo.

In the vertebrate animals, of which man is an example, the exoskeleton persists as the horny layer of the epidermis with the so-called epidermal appendages, such as the hair, nails, and teeth; but the shape of the body is maintained, the muscular attachments provided, and protection to delicate internal organs, like the brain and heart, afforded by an endoskeleton derived from the middle layer or mesoderm of the embryo.

To the medical man, a knowledge of the exact position of the bones is of the first importance, since many parts of them can be felt through the skin, and provide landmarks by means of which the soft structures can be found. It is for this reason that the student begins his anatomical course with a study of the bones, and the writer feels that he cannot too early or too often impress upon his reader that it is only from Nature that the skeleton can be learnt. The book can act as a friendly guide, calling attention to the points most worthy of notice, and supplying the conventional names of the parts; but the student must gain for himself the mental picture of the bones as they are, and must find out on his own body what parts can be felt through the skin and how they change their position in different movements. He must learn, too, to visualize those parts of the bones which cannot be felt, and to acquire the anatomist's sense of how far from the surface they are likely to be.

Remember that the anatomist's sense is a study of three dimensions, and will never be gained from looking at pictures, however beautifully drawn; indeed, the paradox is not without a good deal of truth that the better illustrated a textbook of anatomy is, the less likely is it to produce a good anatomist, since the temptation to use the clean picture instead of the possibly unattractive ' part ' is so great.

If the student will take as an ideal the power to recognize every

bone in the body with his eyes shut, by the feeling alone, and to tell the side to which it belongs, he will find that it will not be so very long before that ideal is attained, that the work gets pleasanter with each attempt, and, when he has reached his goal, he will be surprised to find that he has educated his power of observation and acquired a sense of touch which will help him far in his profession.

Recent development of X rays has made a knowledge of the skeleton more essential than ever to the surgeon and physician, and normal radiograms should be studied whenever possible, otherwise very laughable mistakes in diagnosis may be made later on.

There is another point of view which the student should keep before him—that of forensic medicine; at any time a medical man may be asked whether a particular bone is human, whether it belonged to a man or a woman, and what can be said of the age, the stature, and physique of the individual to whom it belonged. The answer to many of these questions is often ridiculously easy if an interest has been taken in them, and may raise the answerer's reputation materially.

But apart from the mere technical advantage of a sound knowledge of the skeleton as the foundation of topographical anatomy and surgery, osteology has a wide range of philosophical interest, and brings its followers into touch with many sides of science and art. The study of the evolution and comparative anatomy of the skull and of the limb girdles opens the way to endless discussion on the later phases of life on this planet, while the different proportions of various parts of the skeleton form the basis of physical anthropology, and enable us to understand, year by year, a little more of the interminable wanderings and intermixtures of the different races of mankind before written history began, and to check and criticize the assertions of historians. To take only one small though homely example: the early history of Britain has quite changed its outlook since we have been able to realize the part which the people of the Stone, Bronze, and Iron Ages have played in building up the modern Englishman.

These branches of the subject have to be omitted or merely touched lightly in a treatise on medical osteology, but they are there in the background, and many a zoologist, anthropologist, and artist envies the expert knowledge and training which most medical men have received in the laborious task of 'learning their bones.'

Descriptive Terms.

Apophysis : any projection on a bone not ossified from a separate centre.

Capitellum : a small head.

Condyle ('knuckle'): a round eminence covered by articular cartilage.

Epicondyle : a prominent point, non-articular, on a condyle.

Diaphysis : the shaft of a bone, or the part other than the epiphysis.

Epiphysis : a process of bone ossifying independently, and attached

for a time to the principal part of the bone by cartilage, but subsequently becomes united by bone.

Facet : a small smooth surface.

Foramen : a hole.

Fossa : a depression.

Glenoid : like a shallow socket.

Hiatus : a gap.

Meatus (pl. *meatûs*): a passage or canal.

Neural : pertaining to the nervous system.

Sinus or *antrum :* a cavity, usually in the interior of a bone.

Spine : a pointed process.

Styloid : pencil-like; applied to an elongated pointed process.

Trochanter : a term applied to certain muscular levers on the thigh-bone.

Trochlea : a pulley.

Tubercle : a small rounded prominence.

Tuberosity : a larger prominence.

Chemical Composition of Bone.—Osseous tissue belongs to the connective tissues, and it consists of an organic matrix or ground substance, impregnated with mineral matter. The mineral matter is composed chiefly of calcium salts, and so it petrifies the ground substance. The organic matrix is usually spoken of as the animal matter, and it forms about 33 per cent. (or more) of the entire bone. The mineral matter is spoken of as the earthy matter, and it forms about 67 per cent. (or less) of the bone.

The **animal matter** imparts flexibility and elasticity to the bone, and is composed of very delicate fibres, which are collected into bundles, held together by cement substance. The fibres consist of *collagen*, which is converted into gelatin by boiling. The animal matter can be separated from the earthy matter by steeping a bone for some time in dilute hydrochloric acid, the effect of the acid being to dissolve out the earthy matter. When bone is so treated it is said to be *decalcified*. There is left a tough, flexible, elastic substance, which can be bent and twisted in various directions, and even tied into a knot, but no amount of force applied to it, or pressure laid upon it, would cause it to break. A bone when so treated retains its original shape, but it loses weight to the extent of about two-thirds, and it also loses its property of hardness, so that it is incapable of bearing weight.

The **earthy matter** imparts hardness and rigidity to the bone, and is composed principally of calcium salts, of which the most abundant is *calcium phosphate*, there being about 57 per cent. of this salt present. Besides this there are *calcium carbonate* in the proportion of about 7 per cent., and *calcium fluoride* in the proportion of about 1 per cent. In addition to the calcium salts there are about 1 per cent. of *magnesium phosphate*, and about $\frac{1}{2}$ per cent. of *sodium chloride*. The earthy matter may be separated from the animal matter by burning a bone. The first effect of the heat is to char the animal matter, which is subsequently consumed. When so treated a bone is

said to be *calcined,* and the process is spoken of as combustion or *calcination.* There is left a white, chalk-like, very brittle substance, which, if of small size and carefully handled, retains its original shape. The slightest rough handling, however, will cause it to break, or crumble into a coarse powder. Calcined bone undergoes no change in shape, but it loses weight to the extent of about one-third. It also loses its flexibility and elasticity. The only property it now possesses is hardness. As stated, it is also very brittle, and, by reason of this, it cannot be bent nor twisted in the slightest degree. The animal and earthy matter, as they form bone, are intimately combined.

Fig. 75.—Longitudinal Section through the Upper End of the Femur, showing Compact and Cancellated Osseous Tissues.

The proportion of about one-third of animal matter to about two-thirds of earthy matter applies to the healthy adult. In young children the relative amount of animal matter is much greater, so that in them the bones are very tough and elastic, but not very hard, and therefore not capable of bearing much weight. In old age there is a relatively large amount of earthy matter present. The bones of old persons, therefore, are very hard and brittle, but not very tough and elastic; hence the frequency of fractures in old persons from slight causes.

Structure of Bone.—There are two varieties of osseous tissue—namely, compact, and spongy or cancellated. Compact osseous tissue is so named because its constituents are so closely packed together that the bone appears to the naked eye (*macroscopic*) to be dense and close like ivory. Spongy or cancellated osseous tissue, on the other hand, presents an open porous appearance like a sponge. It is called cancellated because it resembles lattice-work. These two varieties of osseous tissue merge very gradually into one another.

When **compact bone** is viewed under the microscope in thin transverse section it presents a number of small round or oval openings, and when viewed in thin vertical section it presents short longitudinal tubes, called **Haversian canals.** These pervade every part of compact bone, and the innermost open into the marrow canal of long bones, whilst the outermost open by minute orifices on the external surface. They range in diameter from $\frac{1}{1000}$ to $\frac{1}{200}$ inch, the average being $\frac{1}{500}$ inch. The smallest lie nearest the external surface, and

the largest are nearest the marrow canal. They are very short and longitudinal in direction, and they communicate freely with one another by connecting canals, some of which are oblique and others transverse. These connecting canals are very small, having a diameter of only $\frac{1}{2000}$ inch. The Haversian canals thus form a freely intercommunicating system of tubes throughout compact bone. The largest canals contain each an arteriole, a minute vein, one or two lymphatics, and a small amount of marrow tissue. The smallest canals contain only one bloodvessel, which is of the nature of a capillary. Those nearest the external surface also contain very delicate thread-like processes of the periosteum. Nerve fibrils have been demonstrated in bone, which is extremely sensitive.

The bone around the Haversian canals is arranged in the form of concentric plates, called *Haversian* or *concentric bone lamellæ.* In transverse section these appear as concentric rings, and in longitudinal section as parallel lines. In the interspaces between the systems of Haversian or concentric lamellæ there are *interstitial,* and, near the external surface, *circumferential* or *peripheral lamellæ,* which are parallel with the surface. Some of the canals which pierce the circumferential lamellæ are devoid of concentric lamellæ, and are known as **Volkmann's canals.**

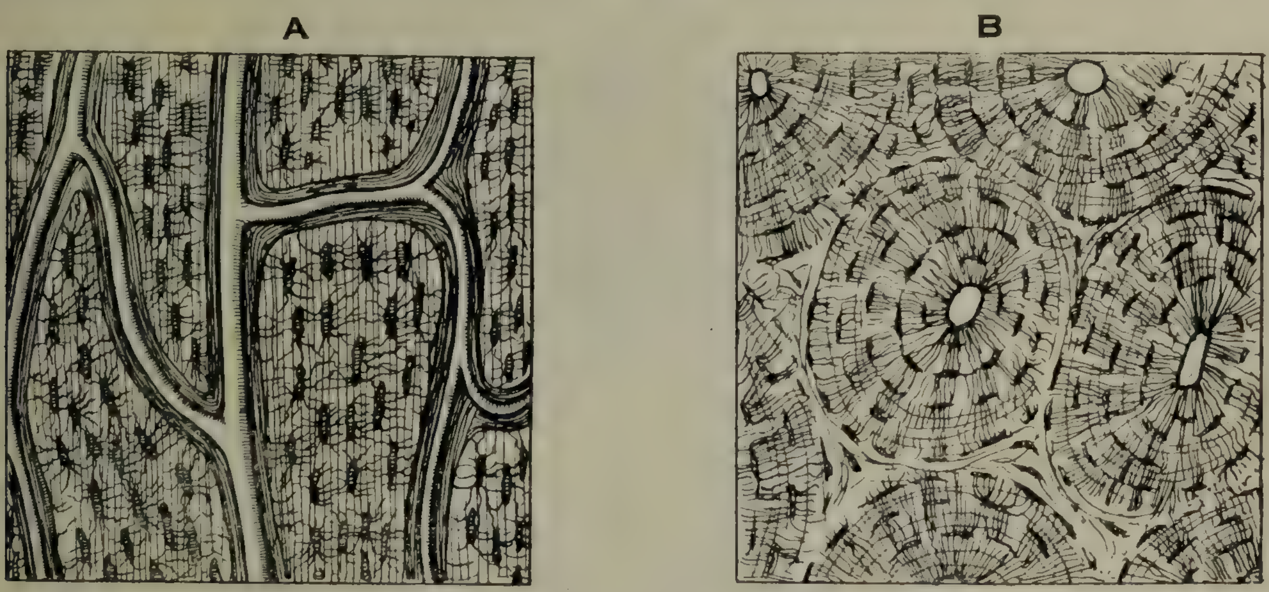


FIG. 76.—STRUCTURE OF COMPACT BONE.

A, longitudinal section, showing Haversian canals; B, transverse section, showing Haversian systems.

In the interspaces between the Haversian or concentric lamellæ there are small fusiform cavities, known as the *bone lacunæ.* These are about $\frac{1}{2000}$ inch in length, and, like the lamellæ, they are arranged concentrically round the Haversian canals. Radiating from these lacunæ there are minute channels, called *bone canaliculi,* which pass through perforations in the lamellæ, and so serve to connect the various lacunæ with one another. Some of those radiating from the innermost ring of lacunæ communicate directly with the Haversian canal. The canaliculi thus constitute a system of intercommunicating channels which maintain a connection directly and indirectly between a given Haversian canal and the lacunæ arranged concentrically around it, and traverse the lamellæ in their course. Each lacuna contains a protoplasmic nucleated cell, called the *bone cell,* which almost completely fills it, and sends off processes into the canaliculi communicating with it. The canaliculi contain nutritive fluid derived from the arteriole. A given Haversian canal, with its concentric bone lamellæ, concentric bone lacunæ, and canaliculi, constitutes a **Haversian system,** and compact bone is simply an aggregation of such systems, with, in addition, the intermediate and circumferential lamellæ. Certain lamellæ are perforated perpendicularly by fibres, which thus bind them together. These fibres are known as the *perforating fibres* of Sharpey. Some of them are com-

posed of white fibrous tissue, and others of elastic tissue, and those nearest the periphery are connected with the periosteum from which they are derived. Others, however, more deeply placed, have no apparent direct connection with the periosteum. The perforating fibres are absent from the lamellæ of the Haversian systems.

Cancellated bone is composed of very slender trabeculæ, which are arranged in a reticular manner so as to enclose spaces, known as the *medullary spaces.* These spaces, in the recent state, are filled with marrow. The trabeculæ consist of superimposed lamellæ of compact bone. The strongest lamellæ are disposed in the direction in which the greatest pressure has to be borne, and serve to transmit the stress from the cartilage-covered bone end to the thick compact tissue of the shaft. These are known as pressure lamellæ. Other lamellæ, known as traction lamellæ, transmit the strain of the chief muscles from their insertions to the compact bone; while a third kind, known as bolting lamellæ, join the others more or less at right angles, keep them from buckling.

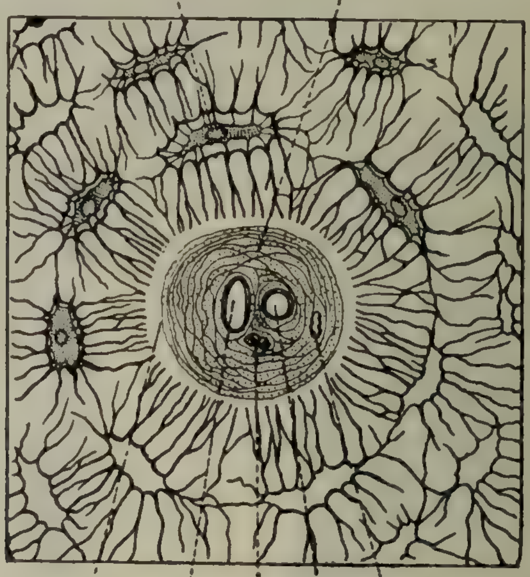


FIG. 77.—DIAGRAM OF A HAVERSIAN SYSTEM, MINUS THE CONCENTRIC BONE LAMELLÆ.

and distribute traction or pressure from one lamella to the next. The use of cancellated bone is to impart sufficient strength without adding unduly to weight.

Classification of Bones.—Bones are arranged in four classes, as follows: Long; short; tabular; and irregular.

A **long bone** consists of a shaft and two articular extremities. The shaft is either cylindrical or prismatic, and contains a medullary cavity, which is surrounded principally by compact bone. The articular extremities are composed of cancellated tissue, except at the surface, where there is a thin shell of compact bone. Long bones are found in the appendicular skeleton.

A **short bone** consists mainly of cancellated tissue, except at the surface, where there is a thin covering of compact bone. Short bones are more or less oblong in shape, and are found in the carpus and tarsus.

A **tabular bone** is composed of two plates or tables of compact bone,

which enclose between them cancellated tissue. The scapula, ilium, and bones of the skull vault belong to this class. In the case of the latter the cancellated tissue is called *diploë*.

An **irregular bone** is one which is so irregular in form and in the relative distribution of the compact and cancellated tissues as to be excluded from any of the preceding classes. The vertebræ belong to this class.

Ossification.—All bones are originally membranous. Some of them—for example, the tegmental bones of the cranium and most of the bones of the face—ossify in membrane, but the majority pass

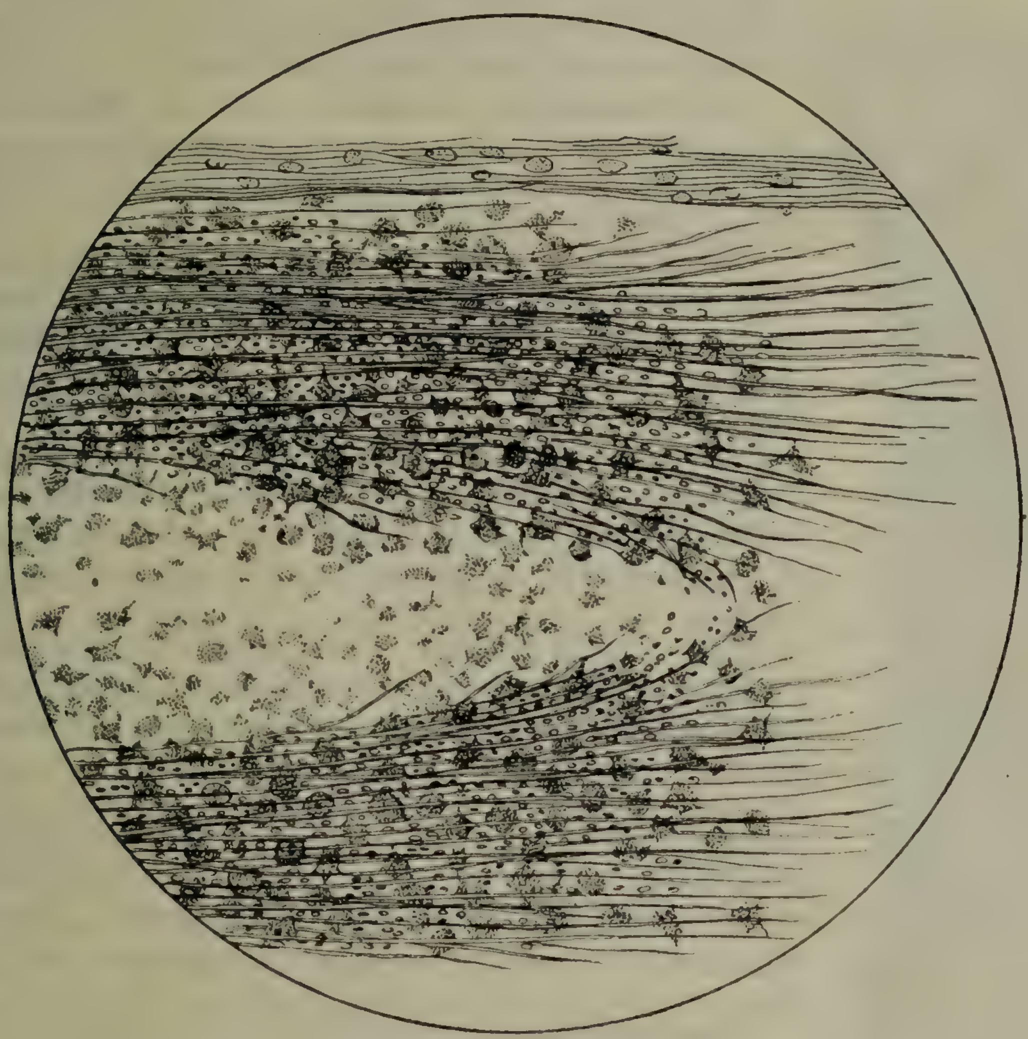


FIG. 78.—OSSIFICATION IN MEMBRANE.

through a cartilaginous stage before becoming ossified. There are, therefore, two modes of ossification—namely, **intramembranous** and **intracartilaginous**—and bones are consequently spoken of as *membrane-* and *cartilage-bones.*

Centres of Ossification.—These are primary and secondary. The *primary centre*, which as a rule appears about the end of the second month of intra-uterine life, is that from which the ossification of the principal part of the bone proceeds. This, in the case of a long bone, is the *shaft* or *diaphysis*. The *secondary centres*, which for the most part do not appear until after birth, are those from which the ossification of outgrowths of a bone proceeds, these forming what are known as the *epiphyses*.

Ossification in Membrane.—In this mode of ossification the bone is preceded by fibrous tissue. The fibres of this tissue are known as **osteogenetic fibres,** and they are arranged in small bundles. The tissue is very vascular, and contains many nucleated cells, called **osteoblasts.** At the centre of ossification the osteogenetic fibres, which have a covering of osteoblasts, become calcified, and bony spicula are thus formed, which radiate towards the circumference of the bone. These radiating spicula are connected at frequent intervals, and so build up a bony reticulum. As the osteogenetic fibres grow and shoot out they carry with them coatings of osteoblasts, and the process of calcareous incrustation goes on, so that the bony spicula increase in length, and gradually approach the periphery. During this process of spicular bony formation many of the osteoblasts are left behind, and become imprisoned in the lacunar spaces of the forming bone, where they represent the future bone cells. The ossification of a membrane bone is thus effected by means of osteogenetic fibres plus osteoblasts, the fibres acting as outrunners and becoming calcified.

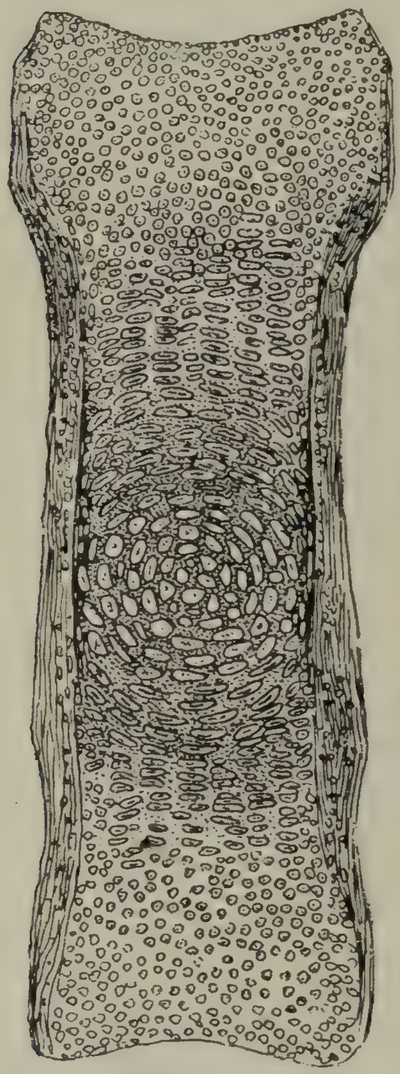


FIG. 79.—OSSIFICATION IN CARTILAGE.

Ossification in Cartilage.—The cartilage is covered by a membrane, called the *perichondrium,* which corresponds to the periosteum, and the process of ossification takes place in three stages.

First Stage.—In this stage the ossification is partly *endochondral,* and partly *ectochondral,* or on the surface beneath the perichondrium. In the **endochondral form** the cartilage cells at the centre become enlarged, and the intervening matrix becomes calcified. Above and below the centre the cartilage cells are arranged *in long columns,* directed towards each extremity. The matrix between these columns becomes calcified by an extension of the calcareous matter at the centre, which now surrounds the cell-columns. The spaces in the calcified matrix, which contain these columns, are known as the *primary areolæ.* At the same time, **ectochondral** or **subperichondral ossification** is proceeding in a manner similar to what takes place in membranous ossification—that is to say, by osteogenetic fibres, osteoblasts, and calcareous impregnation. In this way several layers of bone are laid down at the surface beneath the perichondrium, and these constitute the circumferential lamellæ. During this process some of the osteoblasts are detained in lacunar spaces, and form the *bone cells.*

Second Stage.—This is known as *the stage of irruption.* The inner or osteogenetic layer of the perichondrium bursts in through openings in the circumferential lamellæ in the form of osteogenetic fibres, osteoblasts, and osteoclasts or bone destroyers. These incursions reach the calcified matrix, and the osteoclasts now commence their destructive work. The cartilage cells of the primary areolæ, as well as the walls of these areolæ, are absorbed, and larger spaces, called *secondary areolæ,* or medullary spaces, are formed in the original calcified matrix. These spaces contain osteogenetic fibres and osteoblasts, and the latter now build up lamellæ of bone.

Third Stage.—This is a repetition of the preceding two stages. The cartilage cells arrange themselves in rows; the intervening matrix becomes calcified and invests them; the enclosed cartilage cells atrophy and give rise to primary areolæ; the osteoclasts produce partial absorption of the calcified cartilage, giving rise to medullary spaces; and the osteogenetic fibres and osteoblasts build up lamellæ of bone. Simultaneously with these processes, subperiosteal ossification is going on. The medullary cavity is due to absorption by the osteoclasts of the osseous tissue in the centre of the shaft.

The ossification of the epiphyses of a bone is *endochondral.*

Periosteum.—The periosteum is a fibrous, vascular membrane, which closely invests bones, except where there is articular cartilage, at the margin of which it ceases. It consists of **two layers**—outer and inner. The fibres of the *outer layer* are arranged closely, and it is therefore dense. The *inner layer* consists chiefly of ramifying elastic fibres. Between the inner layer and the surface of the shaft of a long bone there is, especially during the development and growth of the bone, a layer of *subperiosteal areolar tissue.* Within its meshes cells, called **osteoblasts,** accumulate during the period of growth. These cells emerge from the outermost Haversian canals along the course of the entering arteries, and they represent the *bone cells* of the bone lacunæ of compact bone which have migrated outwards. The osteoblasts take an important part in the formation of bone during its growth.

The periosteum is richly supplied with arteries which, after ramifying, enter the outermost Haversian canals, along with fine processes of the inner periosteal layer. The periosteum serves (1) as a bed in which the arteries subdivide before entering the bone, and (2) to give a firm hold to tendons and ligaments. It also takes part in ossification and regeneration of bone. When the periosteum is stripped from a bone, the uncovered portion is liable to necrosis and exfoliation.

Marrow or Medulla Ossium.—The marrow fills the marrow canals of long bones and the medullary spaces of cancellated bone, and it also sends processes into the innermost Haversian canals. It is composed of a reticular fibrous matrix, which is pervaded by many bloodvessels and cells, the latter being called *myelocytes* (marrow cells). There are two kinds of marrow, yellow and red, which differ as to the character of the cells. In **yellow marrow** most of the cells have become transformed into fat cells, so that the marrow resembles adipose tissue. **Red marrow** contains very few fat cells. Many of its cells are colourless, protoplasmic, nucleated cells, which resemble the leucocytes of the blood, though of larger size, and like them are capable of amœboid movement. Other reddish cells, called *erythroblasts,* are present, which are the sources from which large numbers of red blood-corpuscles are formed. In addition to these two sets of cells, there are large multinucleated, protoplasmic cells, called the *megakaryocytes* (myeloplaxes of Robin), which play an important part in the absorption of bone.

Yellow marrow is found in the marrow canals of long bones, whilst red marrow occurs in (1) articular ends of long bones; (2) medullary spaces of cancellated bone; (3) bodies of the vertebræ; (4) sternum; (5) ribs; and (6) the *diploê* of the cranial bones. Marrow serves the following uses: (1) it (red marrow) is an important *blood-forming organ* (red corpuscles); (2) it contributes to the nourishment of bone; and (3) it serves as a light packing material for all hollow spaces within bones, with the exception of the air-sinuses in the bones of the head.

The wall of the marrow canal of all long bones and that of the medullary spaces of all cancellated bone are lined with a very delicate

layer of areolar tissue, which is richly provided with bloodvessels. This is known as the *endosteum* or *medullary membrane.*

Osseous tissue is richly supplied with bloodvessels, which are derived from the periosteum and marrow.

General Principles of the Skeleton.

Before beginning a detailed description of the bones, it will be well to impress upon the reader a few general principles in order to avoid misunderstandings later on.

In the first place, it must be very clearly understood that all parts of the human body are described by the anatomist as if the body were in the upright position, with the arms by the sides, and the palms of the hands turned forwards. The commonest cause of misunderstanding is in careless use of the terms ' over ' and ' under.' There are certain terms, however, which free the describer from any thought of the position of the body. Among these are **dorsal,** towards the back; **ventral,** towards the front; **cephalic** or *cephalad,* towards the head; and **caudal** or *caudad,* towards the tail or its site. A structure nearer the middle line is *internal* or **medial,** but if it is actually in the middle line it is **median,** while one farther from the middle line is *external* or **lateral.**

Superficial and *deep* are used in relation to the nearest skin, but they are only useful when there is no doubt as to where the nearest skin really is. *Proximal* and *distal,* too, are very useful terms, and are used relatively to the centre of the body, which, for practical purposes, may be taken as the heart.

Homologous and *analogous* are terms which are liable to be confounded one with the other. Homology suggests structure, and means that the parts compared are derived from the same embryological structures, though they may be used for very different purposes. Analogy, on the other hand, suggests function, and implies that the parts are used for the same purpose, though they may be derived from totally different parts of the embryo. The wing of a bird, for example, is homologous with the fore-limb of a horse and the upper extremity of a man, though they are not analogous; while the wing of a beetle is analogous, though not homologous, with the wing of a bird. When similar structures are repeated in the body, they are said to be *serially homologous* or *homodynamous,* as in the successive legs of a centipede. The human arm is, therefore, serially homologous with the thigh, the forearm with the leg, and the hand with the foot.

Structures which in the early embryonic position, in which the extremities project at right angles to the central axis of the trunk, lie nearer the head are said to be *preaxial,* whatever position they may occupy in the adult, and those farther away from the head are *postaxial.* The radius and tibia, therefore, are preaxial, and the ulna and fibula postaxial bones of the forearm and leg respectively.

From the foregoing it will have been noticed incidentally that,

to the anatomist, the arm is only that region between the shoulder and elbow, while the leg lies only between the knee and the ankle.

It is well to think, when studying the details of any particular bone, what that bone has to do, and, having settled that, whether it is not wonderfully well adapted for the work it has to perform; whether any part of it seems useless at first sight; and whether, as one's knowledge increases, a use does not appear for the seemingly useless part.

At first we marvel at the wonderful way in which bones are designed for the work they have to do, but after more patient observation we realize that much that we regarded as design is really adaptation, that bones are moulded by the surrounding muscles to suit the needs of those muscles, and that the muscles again increase or diminish according to the work which they are called on to do in the particular animal or individual.

Sometimes, it is true, no mechanical advantage is to be found for certain marks or projections, and, if these were parts of a machine, they would be scrapped and the machine made lighter and less cumbrous thereby; but it must be realized that Nature's method of scrapping is very slow, and that structures which have ceased to be useful take ages to disappear, and, even then, are liable to reappear in individual cases as abnormalities without any advantage, it may be with positive disadvantage, to the individual.

In the case of the vertebral column, which is the part of the skeleton to be described immediately, there is a jointed rod which in man's case supports the weight of the head by means of the bodies of the vertebræ; it is sometimes said that these are wonderfully designed for this purpose, but all the teaching of comparative anatomy shows rather that they are wonderfully adapted, for we are enabled to follow the evolution of an invertebrate, sea-living animal, whose young could only find food enough by dispersal, developing an unjointed elastic rod in its tail, the effect of which is to bring the tail back to the mid-line after each lash produced by the muscles, thus enabling the creature to swim away.

This is the notochord, around which a fibrous sheath is developed, and, as the creature becomes larger and more complex, the sheath requires stiffening, for muscular attachments, by conversion into cartilage and finally bone. The stiffening would mean loss of mobility were the now cartilaginous rod not segmented into the bodies of vertebræ. At the same time the nerve cord, which runs along the dorsal side of the notochord, becomes protected, and made to follow the movements of the backbone, by a series of cartilaginous and, later on, bony rings which join the bodies of the vertebræ.

This is the condition of things in the fish, but, up to now, the head has derived little or no benefit from the backbone, save that it is propelled through the water with the rest of the creature.

The pectoral and pelvic fins, which are the primitive vertebrate limbs, are borne on limb girdles which at this stage are unconnected with the backbone. On leaving the water for a terrestrial existence

the hind-limb girdle becomes connected with one or more vertebræ, and so the hind fin is converted into an organ for propulsion of the body on land, through its central axis or backbone. The pectoral limb girdle, on the other hand, does not join the vertebral column, but fastens itself on to the ventral ends of the ribs, which fuse to form a breast-bone, or sternum. In this way the fore-limbs are specialized for the support of the front part of the body and, should the possessor take to the air, become gradually modified to form wings; or, should he take to an arboreal life, are useful organs for climbing.

When the aquatic life is relinquished the tail, which in the fish forms the greater part of the body, is no longer needed as an organ of propulsion, and is modified into a balancing or prehensile organ, or may merely serve as a wisp to keep off flies. Finally, in man and his nearest relations it ceases to project at all, and is only represented by a few rudimentary vertebræ, fused together to form the coccyx.

Finally, with the gradual assumption of the erect position, the union of the pelvis with the vertebral column is most advantageous for transmitting the whole weight of the trunk to the thighs, and only slight adaptation is needed here, though it is quite obvious that the arrangement was not one of design, and now, at last, the bodies of the vertebræ support the weight of the head, a work for which they already happen to be almost completely adapted, though not designed.

CHAPTER IV

THE BONES OF THE TRUNK

A. The Vertebral Column.

THE vertebral column is composed of thirty-three vertebræ in the young subject, and these in the adult are divided into two classes—namely, movable and immovable, or fixed. The vertebræ are subdivided into five groups—cervical, thoracic, lumbar, sacral, and coccygeal.

Component Parts of a Complete Vertebra.—A complete vertebra is composed of a body, ~~or centrum~~; a **vertebral arch** (*neural arch*); a spinous process, or neural spine (*neurapophysis*); two transverse processes; four articular processes (*zygapophyses*), two superior and two inferior; and a **vertebral foramen.** The centrum forms the anterior or ventral part of the bone, and is somewhat disc-shaped. The *neural arch* consists of two halves, the anterior portion of each being the *pedicle*, and the posterior portion the *lamina*. The pedicles present, above and below, the *superior* and *inferior vertebral notches*. The *spinous process* is formed by the fusion of the two laminæ in the median line posteriorly. The *transverse processes* project outwards, one at either side, from the neural arch at the junction of the pedicle and lamina. The *articular processes*, two superior and two inferior, project upwards and downwards from the junction of the pedicle and lamina at either side, and they are covered by cartilage. The vertebral foramen is enclosed by the body and neural arch. It is bounded in front by the posterior surface of the body, on either side by a pedicle and lamina, and behind by the fusion of the laminæ to form the spinous process.

Structure of a Vertebra.—The body is composed of cancellous tissue, covered by a thin layer of compact bone. The chief lamellæ are disposed in almost vertical curves, the convexities of which are directed towards the periphery. Crossing these there are horizontal lamellæ which are nearly parallel with the superior and inferior surfaces. The cancellous tissue is permeated by venous channels which converge to the two large foramina on the posterior surface of the body. The neural arch and its processes are chiefly composed of compact bone, the amount of cancellous tissue being for the most part small.

In the above description the terms 'body' and 'centrum' have been used as synonymous, but this is not strictly true. By 'body' is meant all that part of the vertebra which does not in the adult appear to belong to the neural arch. By 'centrum' only that part of the

body is indicated which develops from its own centre of ossification. Later on it will be seen that a small part of the side of the body belongs morphologically to the neural arch.

The Cervical Vertebræ.

The **cervical vertebræ** are seven in number, and they occupy the region of the cervix or neck. The distinctive character of all cervical vertebræ is the presence of an aperture at either side of the body, called the *foramen transversarium.* The **first** or **atlas,** the **second** or **axis,** and the **seventh** or **vertebra prominens** have such pronounced characters that they require a special description.

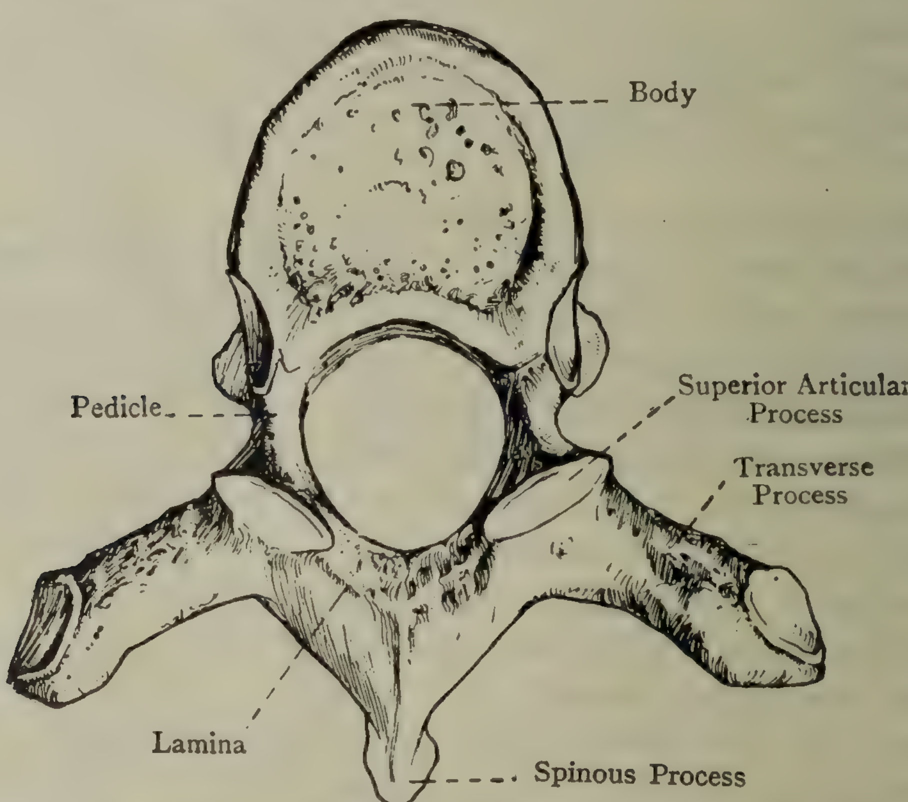


FIG. 80.—THE SIXTH THORACIC VERTEBRA (SUPERIOR VIEW).

A Typical Cervical Vertebra.—The body is small and box-shaped; wider sideways than from before backward. On its upper surface there is a *neuro-central lip* on either side, which embraces the bevelled lateral border of the lower surface of the body above. The whole surface is thus concave from side to side, and the posterior lip is on a slightly higher level than the anterior. The *inferior surface* is bevelled laterally, and its anterior lip is on a lower level than the posterior. The inferior surface is convex from side to side, and concave from before backwards. The superior and inferior surfaces give attachment to the intervertebral discs. The *anterior* surface is convex from side to side, and concave from above downwards. It is covered by the anterior longitudinal ligament, and it presents a number of nutrient foramina. The *posterior surface* is flat, and presents several nutrient foramina, two of which, one at either side of the middle line, are large, for the escape of the basivertebral veins. The *posterior surface* is related to the posterior longitudinal ligament. Each *lateral surface* forms the inner boundary of the foramen transversarium.

The **pedicles** spring at either side from the posterior part of the lateral surface of the body, where each encroaches rather nearer the upper than the lower surface. They are smooth and almost cylindrical, and their direction is outwards and backwards. Above and below each pedicle there is a well-marked *vertebral notch*, the *superior* being narrower and slightly shallower than the *inferior*. The superior notch lodges a spinal nerve. When two vertebræ are in position the contiguous vertebral notches, at either side, complete an intervertebral foramen through which emerges the cervical nerve, and it will be noticed that, in its exit, the nerve must pass behind the foramen transversarium.

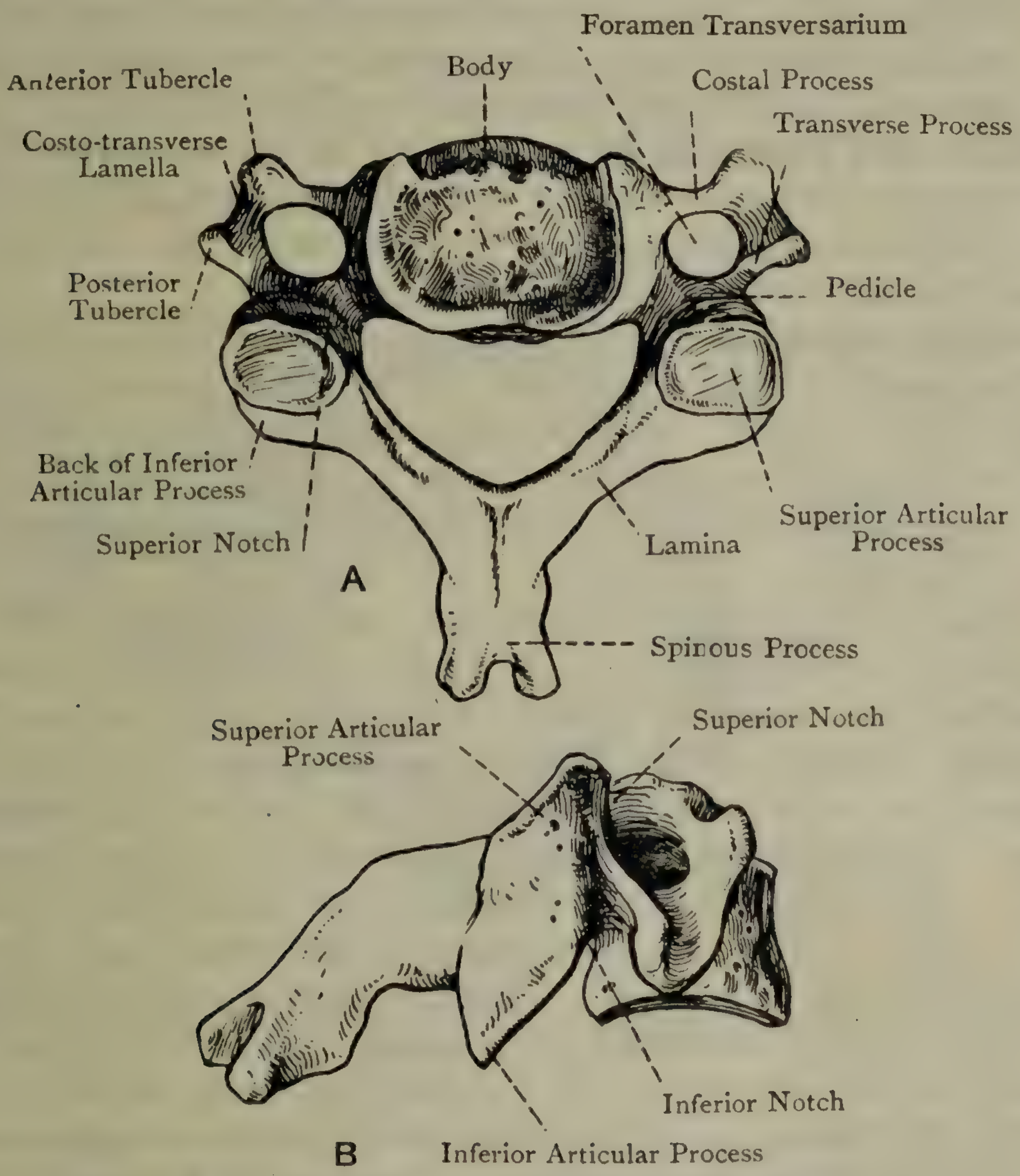


FIG. 81.—THE FIFTH CERVICAL VERTEBRA.
A, superior view; B, lateral view.

The **laminæ** spring each from a pedicle. They are compressed from before backwards, and their direction is backwards and inwards to the middle line, where they fuse, and so give rise to the spinous process. The upper border and adjacent portion of the posterior surface of each lamina give attachment to the ligamentum flavum connecting it to the lamina above, whilst the lower part of the anterior surface near the lower border gives attachment to the ligamentum flavum connecting it to the lamina below.

The **spinous process** is formed by the fusion of the two laminæ. It is triangular, and its direction is backwards and slightly down-

wards. Superiorly it presents an antero-posterior ridge for an interspinous ligament, and inferiorly a grooved surface, also for an interspinous ligament. It terminates behind in a bifid extremity, which, in the case of the third, fourth, and fifth vertebræ, presents a distinct triangular notch. The bifurcated extremity gives attachment to the deep fibres of the ligamentum nuchæ. The cervical spinous processes are very short, except those of the sixth and seventh, especially the latter, and in this way backward flexion or over-extension of the neck is not interfered with.

The **articular processes** spring from the junction of the pedicle and lamina at either side. Each is nearly circular, the plane being oblique, and the surface almost flat. The *superior pair* look backwards and upwards, and the *inferior pair* forwards and downwards.

The **transverse processes** (*diapophyses*) spring at either side from the junction between the pedicle and lamina, and are serially homologous with the transverse processes of a thoracic vertebra. Each terminates in a projection, known as the posterior tubercle.

The **costal processes** (*parapophyses*) project outwards from either side of the body anteriorly, and are serially homologous with the vertebral part of a rib. Each terminates in a projection, known as the anterior tubercle, which, with the posterior tubercle of the corresponding transverse process, gives attachment to the intertransverse muscles.

The transverse and costal processes are connected, at a short distance from the body, by a plate of bone, called the *costo-transverse lamella*, which is deeply grooved superiorly for a spinal nerve, this groove being continuous with the superior vertebral notch. There is thus formed, at either side, an aperture, called the **foramen transversarium.** This foramen is circular, vertical in direction (except in the case of the axis), and it transmits the following structures: the vertebral artery; the vertebral plexus of veins; and the vertebral sympathetic plexus of nerves. Though the foramen is present in each transverse process, it does not give passage to the foregoing structures in the case of the seventh. The vertebral vein, however, may pass through it. In many cases an additional foramen of small size is present on one or both sides, lying behind the main foramen, and, when this is so, it transmits a small vein. The foramina transversaria of either side, when in position, build up a canal, which is open in each intertransverse space.

The **vertebral foramen** is situated behind the body, and is triangular, with the angles rounded off. It contains the spinal cord and its membranes, and is larger than in the other regions to allow for the mobility of the neck.

The Atlas.—The atlas is the first cervical vertebra, and is so named because it supports the head. Its distinctive characters are the absence of a body and spinous process. It has the form of a ring, narrow in front and wide behind, and its component parts are as follows: an anterior arch; a posterior arch; two lateral masses; and a ring.

The **anterior arch** is a curved plate of bone which connects the antero-internal parts of the lateral masses. It is compressed from before backwards, convex in front and concave behind. The *anterior surface* presents at its centre a conical prominence, called the *anterior tubercle.* This gives attachment at either side to a portion of the longus cervicis muscle, and its central part receives the accessory ligament. The *posterior surface* presents at its centre a circular concave facet, called the *odontoid facet,* for articulation with the anterior surface of the odontoid process of the axis. The upper border gives attachment to the anterior atlanto-occipital membrane, and the lower to the anterior atlanto-axial ligament.

The **posterior arch** is serially homologous with the laminæ of other vertebræ. It springs at either side from the back part of a lateral

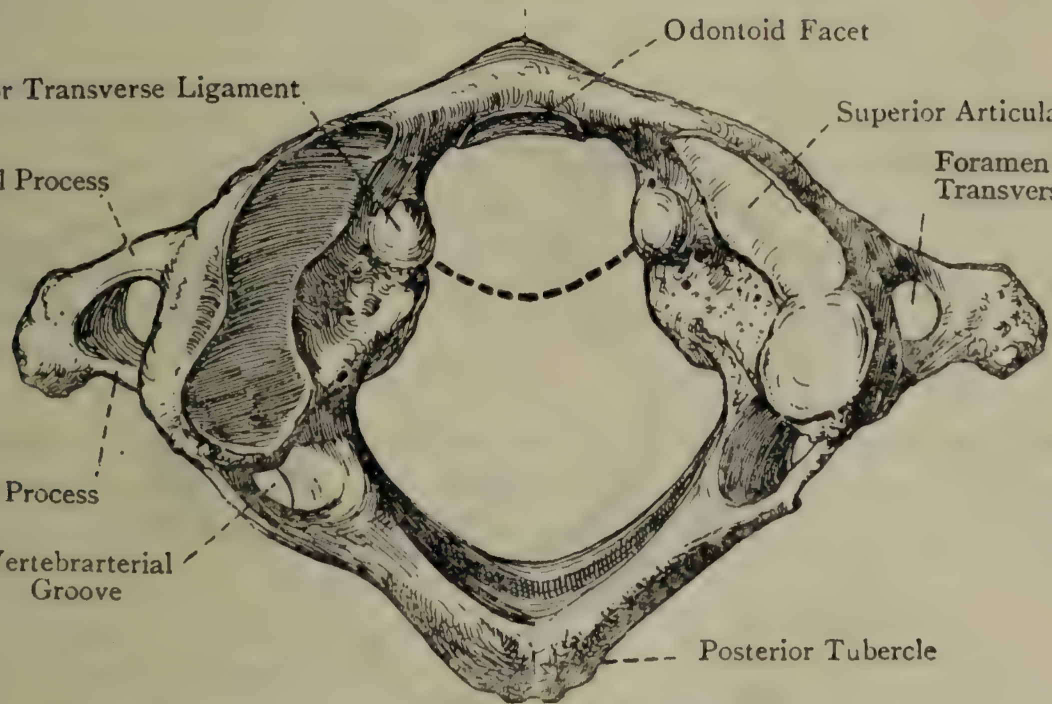


FIG. 82.—THE ATLAS (SUPERIOR VIEW).

The vertebrarterial groove on this bone was converted into a foramen on both sides.

mass, from which it sweeps backwards and inwards. The part close to the lateral mass at either side is flattened from above downwards. It presents on its upper surface a shallow depression, called the *vertebrarterial groove,* which lodges the vertebral artery and suboccipital nerve. This groove is sometimes converted into a foramen on one or both sides by a spiculum of bone extending from the back part of the superior articular process to the posterior arch behind the groove. The vertebrarterial groove is serially homologous with the superior vertebral notch of other vertebræ, but, unlike them, it lies *behind* the superior articular process. The inferior surface of the posterior arch, behind each lateral mass, presents a shallow vertebral notch, which lies *behind* the inferior articular process. The centre of the posterior arch presents the *posterior tubercle,* which is the only representative of a spinous process. At either side of this tubercle the rectus capitis

posterior minor arises. The upper aspect of the posterior arch give
attachment to the posterior atlanto-occipital membrane, and the lowe
aspect of the posterior atlanto-axial ligament.

The **lateral masses** support the superior and inferior articula
processes, and laterally the transverse and costal processes sprin
from them. The anterior surface of each gives partial origin to th
rectus capitis anterior. The medial surface of each presents anteriorl
a tubercle for the transverse ligament. The *superior articular processe*
are oval and deeply concave, to articulate with the condyles of the
occipital bone. Their long axes are directed backwards and outwards
so that they converge in front and diverge behind. Anteriorly they
reach as far as the anterior arch, and posteriorly they overhang the
vertebrarterial grooves on the posterior arch to a slight extent, but they
do not extend farther back than about the centre of the ring. The plane

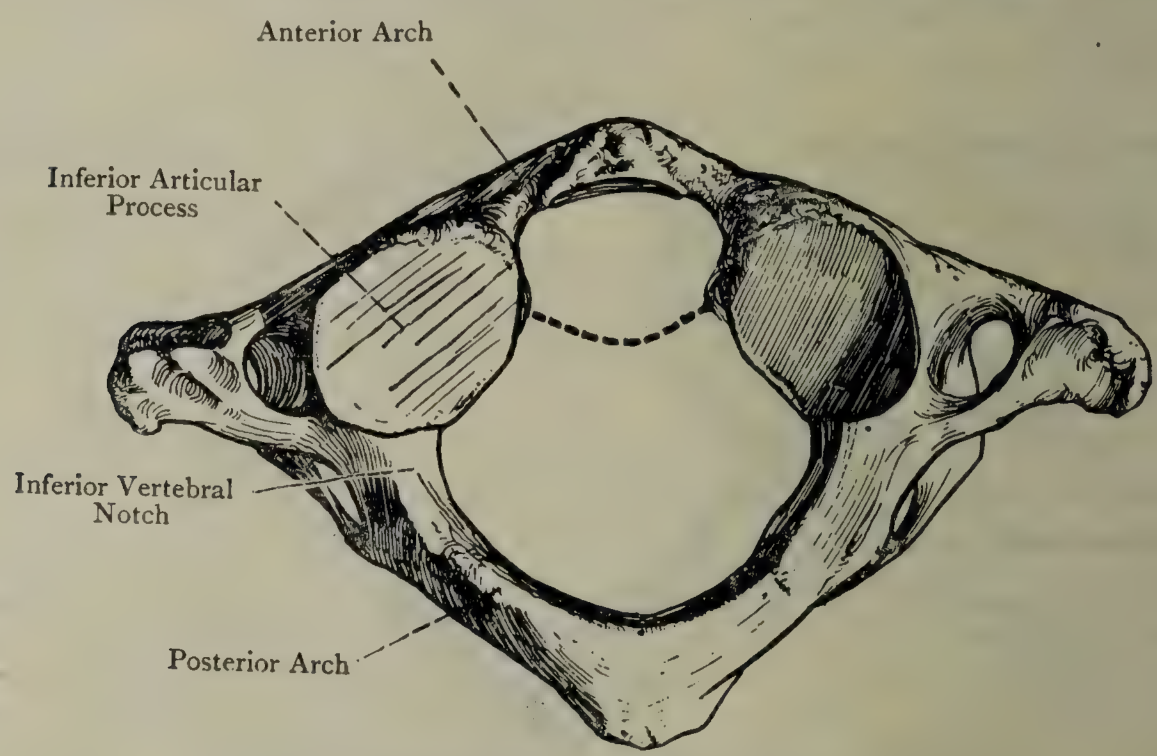


FIG. 83.—THE ATLAS (INFERIOR VIEW).

of each is sloped downwards and inwards, and the direction of the surface is upwards and inwards. The movement between them and the occipital condyles is one of flexion and extension, or nodding. Sometimes one or both of them may be divided by a groove into two circular facets. The *inferior articular processes* are circular and almost flat. The plane of each is sloped upwards and inwards, and the direction of the surface is downwards and inwards. They articulate with the superior articular processes of the axis, and the movement allowed is rotation. The articular processes of the atlas, being placed in front of the points of exit of the spinal nerves, do not correspond in position with the articular processes of succeeding vertebræ (with the exception of the superior pair of the axis). They occupy a position corresponding with the pedicular portions of the bodies of vertebræ, and in this way the superincumbent weight is transmitted to the vertebral bodies.

The **transverse** and **costal processes** spring from the side of each

lateral mass, and, lateral to the costo-transverse foramen, the costo-transverse lamella and the anterior and posterior tubercles are more or less fused into one long irregular mass, though the posterior tubercle usually remains conspicuous. The upper surface of this mass at its front part gives origin to the rectus capitis lateralis, and at its back part to the obliquus capitis superior, whilst the lower surface at its back part gives insertion to the obliquus capitis inferior. The foramen transversarium is of large size in order to guard against the vertebral artery being compressed during the rotatory movements of the bone upon the axis.

The **ring** of the atlas, in the recent state, is divided into two compartments by the transverse ligament. The anterior small division is called the *odontoid compartment*, and it lodges the odontoid process of the axis. The posterior large division represents the vertebral foramen of other vertebræ, and it lodges the spinal cord with its membranes.

Varieties.—(1) The posterior arch may be incomplete at the centre, the deficiency being bridged over by fibrous tissue. (2) The costal process may be incomplete, the deficiency in the foramen transversarium being filled by fibrous tissue. (3) There is sometimes an additional small foramen on either side, a little behind the foramen transversarium, for the passage of the sub-occipital radicles of the vertebral plexus of veins. (4) The groove for the vertebral artery may be converted into a foramen by a bridge of bone, as in the specimen from which Fig. 82 was drawn.

The Axis.—The axis is the second cervical vertebra, and is so named because its odontoid process, which is the distinctive character of the bone, forms a pivot on which the atlas, supporting the head, rotates. From the presence of this process the axis is sometimes called the vertebra dentata.

The **odontoid process** (*processus dentatus*) springs from the superior surface of the body, and represents the body of the atlas. It is constricted and somewhat circular close to the body, this part being called the *neck*. Above this it expands into a *head*, which tapers off at either side by two sloping surfaces, forming by their convergence an antero-posterior ridge, known as the summit. The anterior surface presents a circular convex facet, called the *atlantal facet*, for articulation with the odontoid facet on the posterior surface of the anterior arch of the atlas. The posterior surface presents a shallow transverse groove,

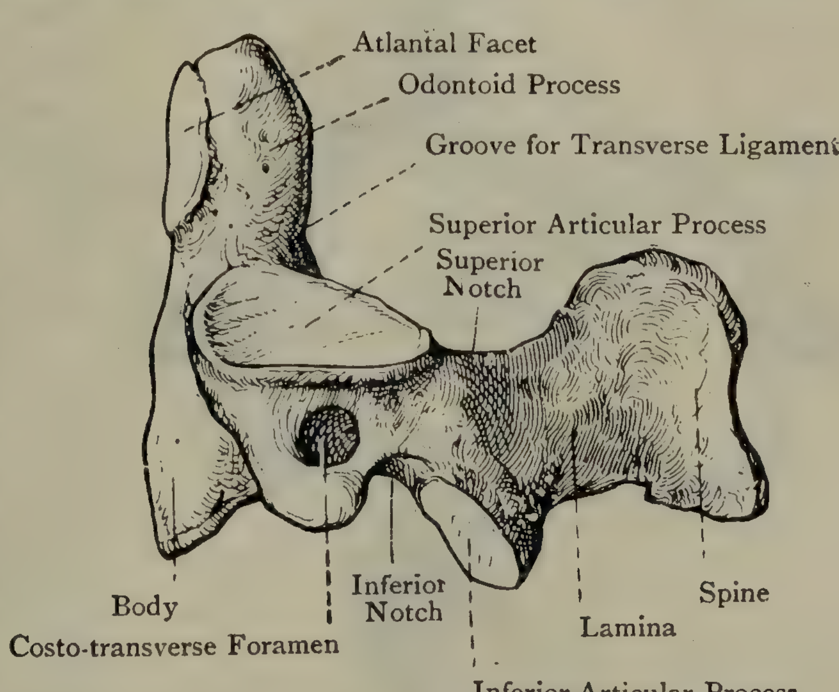


Fig. 84.—The Axis (Lateral View).

for the play of the transverse ligament of the atlas. The lateral sloping surfaces on either side of the summit give attachment to the lateral odontoid ligaments, whilst the summit itself gives attachment to the middle odontoid ligament.

The *superior surface* of the **body** is occupied by the odontoid process and portions of the superior articular processes. The *inferior surface* differs from that of other cervical vertebræ only in the greater downward projection of its anterior lip. The *anterior surface* presents a median vertical ridge which bifurcates inferiorly into diverging lips, enclosing a small triangular surface. On either side of the median ridge the surface is depressed, and gives attachment to a portion of the longus cervicis muscle. The other surfaces of the body present nothing peculiar.

The **pedicles** are concealed above by the superior articular processes. Each, on its inferior aspect, presents a wide and deep *inferior vertebral notch,* which is placed in front of an inferior articular process. The *superior vertebral notches,* which are very shallow, are situated on the upper borders of the laminæ, and, like those of the atlas, are placed *behind* the superior articular processes.

The **laminæ** are massive, and give attachment by their upper borders to the posterior atlanto-axial ligaments, whilst their anterior surfaces, near the lower borders, give attachment to ligamenta flava, as in other vertebræ.

The **spinous process** is massive. Its direction is backwards, and it terminates in two strong tubercles, separated inferiorly by a triangular cleft. Each of these tubercles gives attachment to some of the deep fibres of the ligamentum nuchæ, and to the following muscles from above downwards: the rectus capitis posterior major; the obliquus capitis inferior; and the highest portion of the semispinalis cervicis.

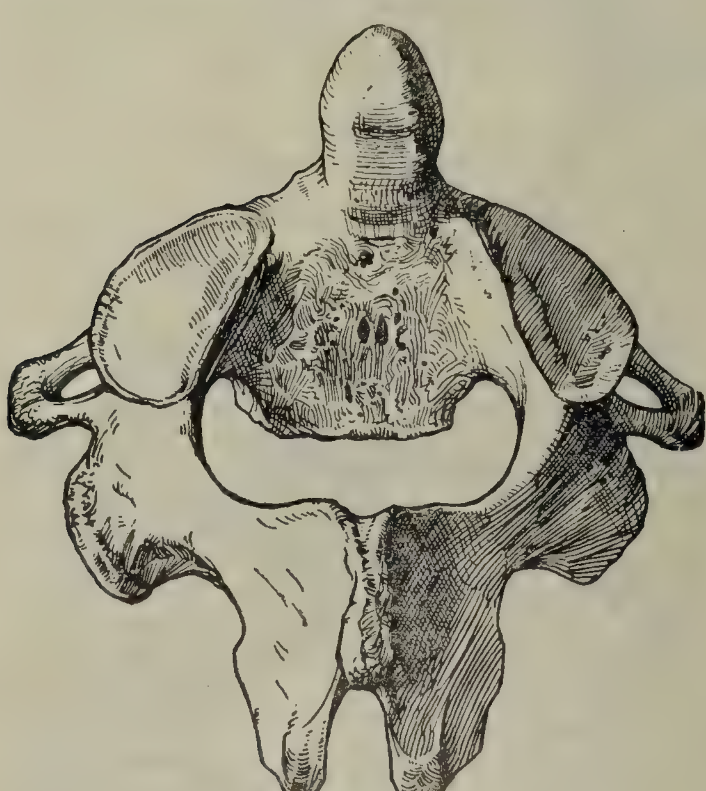


FIG. 85.—THE AXIS (SUPERIOR VIEW).

The *superior articular processes* are situated on the upper surface of the pedicle at either side, the upper surface of the costal process, and a portion of the superior surface of the body, upon which latter it encroaches very near to the odontoid process. The plane of each is sloped outwards and downwards. The surface is slightly convex from before backwards and circular, its direction being upwards and outwards. They articulate with the inferior articular processes of the atlas, and the movement allowed is rotation. The *inferior articular processes* differ

from those of most vertebræ only in being situated principally upon the lower borders of the laminæ. The superior pair, like all four articular processes of the atlas, being placed in front of the points of exit of the spinal nerves, do not correspond in position with the superior articular processes of succeeding vertebræ, but occupy a position corresponding with the pedicular portions of the bodies of vertebræ.

The **transverse processes** are very short, and are directed outwards and downwards. Each terminates in a single tubercle.

The **costal processes** also terminate in tubercles, and the costo-transverse lamellæ are not grooved superiorly.

The foramen transversarium is directed upwards and outwards, the reason of this obliquity being as follows: when the atlas and axis are in position, each foramen transversarium in the atlas lies farther out than that in the axis. In order, therefore, to obviate any sudden and undue bend in the vertebral artery, the foramen in the axis is directed obliquely upwards and outwards so as to guide the vertebral artery gradually to the foramen in the atlas.

There is nothing peculiar about the vertebral foramen.

Varieties.—(1) The summit of the odontoid process may present a facet, indicating an articulation with the anterior margin of the foramen magnum of the occipital bone, which in such cases presents a prominence known as the middle occipital condyle. (2) The odontoid process may, in very rare cases, remain separate from the body, thus forming the *os dentatum*. (3) An odontoid process in two halves has been recorded.

The Seventh Cervical Vertebra.—The distinctive character of this vertebra is the great length of its spinous process, which is the only cervical spine that can readily be felt beneath the integument of the neck. On account of this outstanding prominence the seventh cervical is known as the **vertebra prominens.** The spinous process is directed straight backwards, and terminates in a single large tubercular eminence. The other characters of this vertebra to be noted are as follows: the antero-posterior measurement of the body exceeds that of other cervical vertebræ; the transverse process is massive and comparatively long; the posterior tubercle is very distinct, but the anterior is rudimentary, or wanting; the foramen transversarium is of small size, and does not

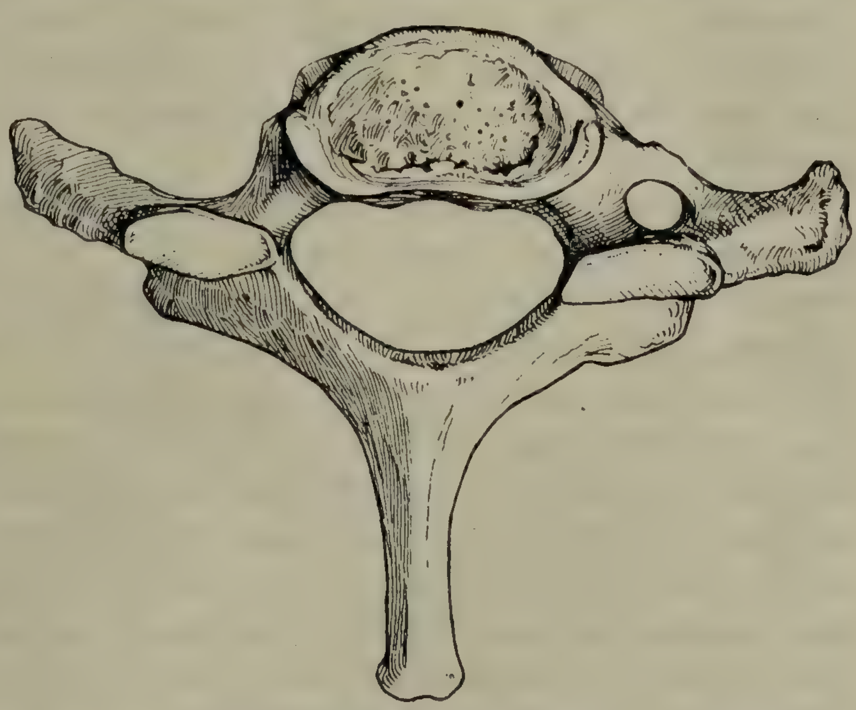


FIG. 86.—THE SEVENTH CERVICAL VERTEBRA (SUPERIOR VIEW).

The costal process of the left side was undeveloped in this vertebra.

transmit the vertebral vessels and vertebral sympathetic plexus. The vertebral vein, however, may pass through it.

Varieties.—(1) The costal process may remain separate from the transverse process, thus giving rise to a cervical rib. (2) The costal process may be wanting on one or both sides, in which cases there is no foramen transversarium.

It is to be noted that the **sixth cervical vertebra** is peculiar in the following respects: the spinous process, like that of the vertebra prominens, terminates in a single large tubercular eminence; and the tubercle of each costal process, known as the anterior tubercle, is of large size, and is called the **carotid tubercle (of Chassaignac).**

The difference in the arrangement of the articular processes of the atlas and axis to those of the other vertebræ will probably have fixed the reader's attention, and he may have wondered how they managed to shift their position from the dorsal to the ventral aspect of the nerve-roots. To show the advantage of such a change in transmitting the weight of the head directly on to the bodies of the lower vertebræ is no explanation of how it was brought about; but a little examination of the bones will convince him that these so-called articular processes of the atlas and upper surface of the axis are not the buffer-like articular processes or zygapophyses of the lower vertebræ, but modified and enlarged neuro-central lips, and that the true zygapophyses are suppressed, since there is no further need for them.

The Thoracic Vertebræ.

The **thoracic vertebræ** are twelve in number, and their distinctive character is the presence of one or more facets on either side of the bodies for articulation with the heads of ribs. The **first, tenth, eleventh,** and **twelfth** (sometimes also the **ninth**) are peculiar, and require separate descriptions.

A Typical Thoracic Vertebra.—The **body** is larger than that of a cervical vertebra, but smaller than that of a lumbar. When viewed from above or below it is heart-shaped, being broad and hollowed out behind, and narrow and rounded off in front. The posterior depth of the body exceeds the anterior in adaptation to the backward curve of the vertebral column in the thoracic region. The *superior* and *inferior surfaces* present a raised rim round the circumference, due to the original epiphysial plate, and this renders the whole of each surface slightly concave from the periphery towards the centre. The *anterior* and *lateral surfaces* merge gradually into each other, and are concave from above downwards, the entire antero-lateral surface being convex from side to side and pierced by numerous nutrient foramina. Each lateral surface, close to the vertebral arch, presents two articular demi-facets, superior and inferior, of which the superior is the larger, and is situated upon the pedicular portion of the body, the inferior smaller one being just in front of the lower part of the inferior vertebral notch. These demi-facets are for articulation with the heads of the ribs, and are called the *costo-capitular facets*. When two vertebræ

are in position, the superior demi-facet of the lower vertebra and the inferior demi-facet of the upper form an articular cavity for the head of a rib. The *posterior surface* of the body is concave from side to

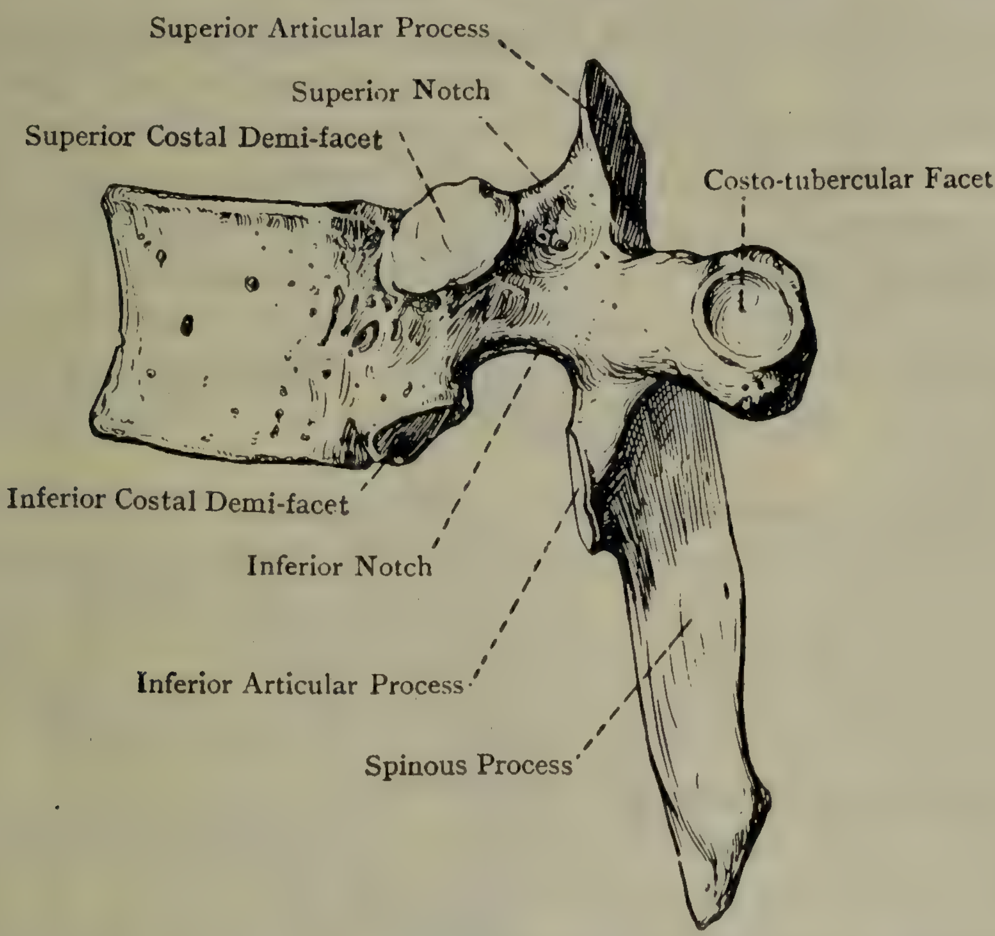


FIG. 87.—THE SIXTH THORACIC VERTEBRA (LATERAL VIEW).

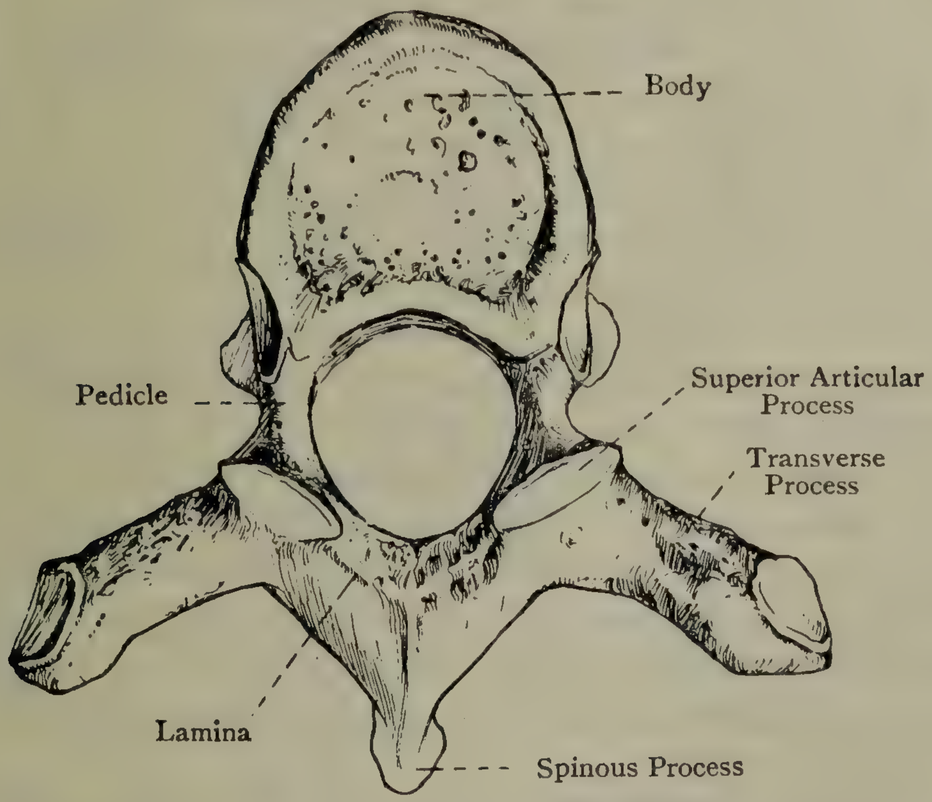


FIG. 88.—THE SIXTH THORACIC VERTEBRA (SUPERIOR VIEW).

side, and presents nutrient foramina, as in the cervical vertebræ. The superior and inferior surfaces are related to the intervertebral discs, and the anterior and posterior surfaces are related to the anterior and posterior longitudinal ligaments.

The **pedicles** spring from either lateral extremity of the posterior surface of the body, and their upper borders are very nearly on a level with its superior surface. Each pedicle is laterally compressed, and is directed backwards and slightly outwards. The *superior vertebral notches* are shallow, and each is usually bounded in front by a transverse neuro-central lip. The *inferior vertebral notches* are deep and wide.

The **laminæ** are short, deep, and compressed from before backwards, their planes being sloped downwards and backwards. The markings for the ligamenta flava are the same as in cervical vertebræ.

The **spinous process** is elongated and three-sided. Its direction is downwards and slightly backwards, and it terminates in a sloping border ending below in a sharp point. The spinous processes of the middle thoracic vertebræ are imbricated or overlapping, and therefore very vertical.

The **articular processes** are nearly circular, their surfaces are flat, and their planes are almost vertical. The *superior pair* project upwards from the junction between the pedicles and laminæ, and they look backwards and slightly upwards and outwards. The *inferior pair* are placed on the anterior surfaces of the laminæ, and they look forwards and slightly downwards and inwards.

The **transverse processes** spring from the junction of the pedicles and laminæ, and each is directed outwards and backwards. They are long and club-shaped, being somewhat constricted at their bases, but expanding into knob-like enlargements at their extremities. The anterior surface of the extremity of each presents a circular facet, called the *costo-tubercular facet*, for articulation with the tubercle of a rib. These facets are often useful in determining the position of the vertebræ in the series, because, in the higher ones, they are concave and in front of the transverse process; while, in the lower, they become flat and rise to the upper surface, so that the processes support the lower ribs from below. The posterior surface of the extremity gives attachment to the posterior costo-transverse ligament. The anterior surface of the transverse process faces the posterior surface of the neck of a rib, and gives attachment to the ligament of the neck of the rib. This region corresponds with the costo-transverse foramen in a cervical vertebra. The lower border of the transverse process gives attachment to the superior costo-transverse ligament, which connects it with the crest, or upper border of the neck, of the rib below. The transverse process is serially homologous with a cervical transverse process.

The **vertebral foramen** is almost circular, and is of smaller size than in the cervical or lumbar vertebræ, since this is the least movable region of the whole column.

Peculiar Thoracic Vertebræ.—These are the first, tenth, eleventh, and twelfth (sometimes also the ninth).

The First Thoracic Vertebra.—The bodies of this and the next vertebra closely resemble those of the cervical region in shape, and on that of the first the neuro-central lips are evident. No mistake should be possible, however, as the characteristic points of all thoracic

vertebræ, the facets for the ribs, are present on the sides of the bodies, and in the case of the first there is a whole facet above instead of part of one, since the seventh cervical takes no share in supporting the first rib.

In other respects the first thoracic vertebra is typical.

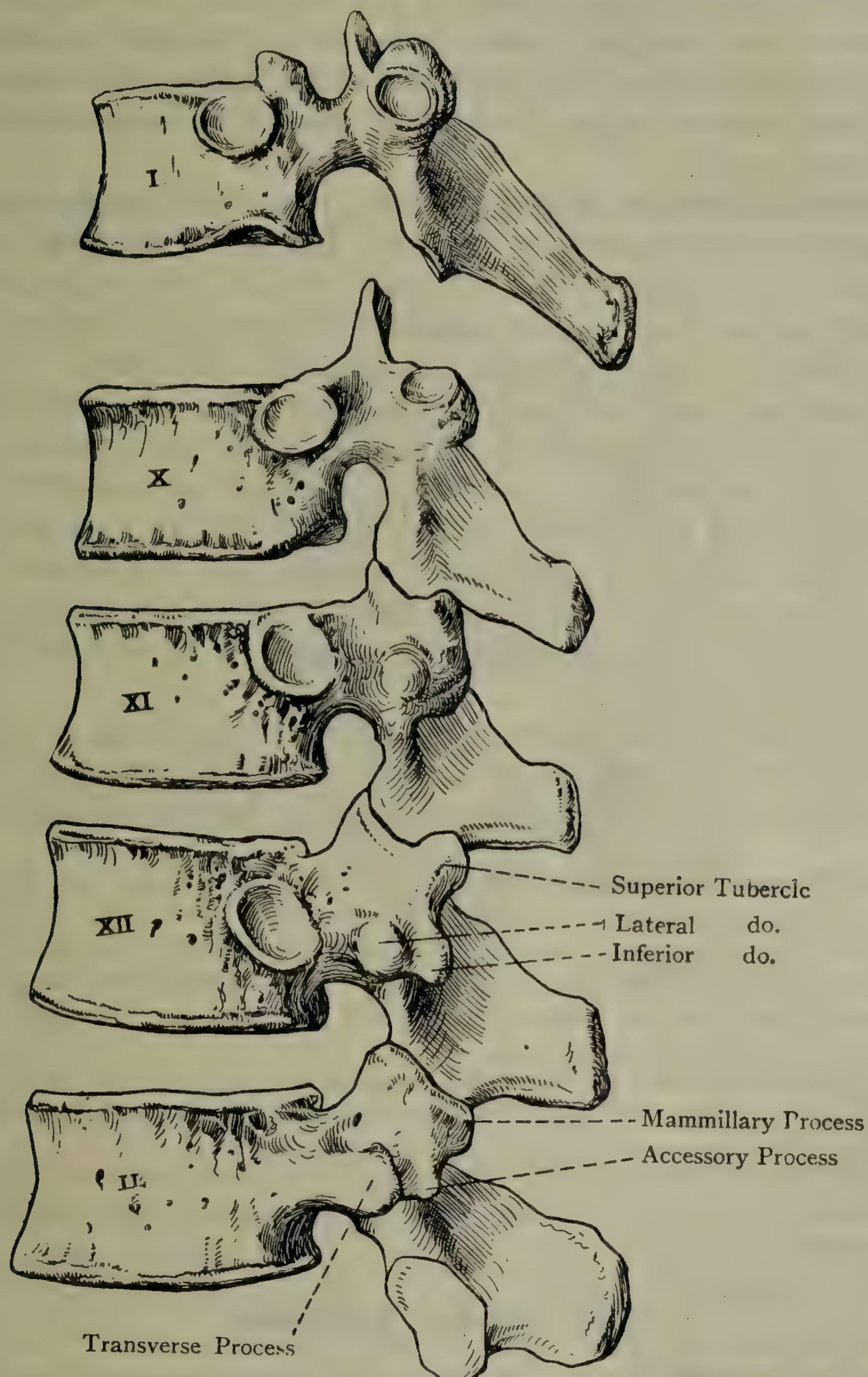


FIG. 89.—THE PECULIAR THORACIC VERTEBRÆ AND THE FIRST LUMBAR VERTEBRA.

The Tenth Thoracic Vertebra.—This vertebra has usually one entire facet on either side, mainly on the pedicle, for the head of the tenth rib. This facet, however, may only be a three-quarter facet, if the ninth thoracic vertebra is normal. It has, usually, a costo-tubercular facet on the extremity of each transverse process for the tubercle of

the tenth rib. This facet may be wanting, though its place will be indicated by a roughness. The body and spinous process of this vertebra show indications of the lumbar type, its other characters being thoracic.

The Eleventh Thoracic Vertebra.—This vertebra has an entire facet on the outer surface of each pedicle for the head of the eleventh rib, but there is no facet on the transverse process, which has become short and stunted, the tendency to the club shape being, however, still perceptible. The lumbar type of the bone is more pronounced than in the case of the tenth.

The Twelfth Thoracic Vertebra, like the tenth and eleventh, has a single facet for the head of the rib, but it is usually ragged and irregular instead of being clean-cut and circular; it is also lower down, so that a horizontal line drawn round the centre of the body cuts the facet in the twelfth, but passes below it in the eleventh.

The transverse processes are more set back and have no articular facet. They are trifid, showing three tubercles: a superior one corresponding to the mammillary process of the lumbar vertebræ, a lateral corresponding to the transverse or costal process, and an inferior corresponding to the accessory lumbar process. A distinctive feature is that the inferior articular processes have their facets facing outwards, thus adapting them to the superior articular facets of the lumbar series, which look inwards.

All these points need attention, as any of them may occur in the eleventh as well, and with the greatest care it is sometimes very difficult to distinguish between an eleventh and a twelfth thoracic vertebra.

Individual Thoracic Vertebræ.—It is usually possible to determine the approximate position of any thoracic vertebra by attention to details. The first two have cervical-shaped bodies, while in the third, fourth, and fifth the bodies are very narrow and heart-shaped. After that they rapidly broaden, until the lower ones are as broad from side to side as they are from before backward.

In the upper and lower parts of the series the spines are fairly horizontal, but in the middle, from the fifth to the eighth, where the backbone is least movable, the spines are much more vertical and imbricated.

The position and appearance of the facet on the transverse process, already drawn attention to, also helps materially in distinguishing a high from a low thoracic vertebra.

The Lumbar Vertebræ.

The **lumbar vertebræ** are five in number, and are so named because they occupy the region of the loins. They are the largest of the true vertebræ, and their negative characters are the absence of a foramen transversarium in the transverse process, and the absence of any kind of costal facet on the side of the body. They increase in size from above downwards, the fifth being the largest, but, as this vertebra has certain distinctive characters, it will be separately described.

A Typical Lumbar Vertebra.—The **body,** when viewed from above or below, is kidney-shaped, being flattened from above downwards,

convex transversely over its antero-lateral surface, and slightly concave transversely on its posterior surface. It is wider from side to side than from before backwards. The anterior depth is slightly greater than the posterior, in adaptation to the forward curve of the vertebral column in the lumbar region. There is no facet on either side of the body.

The **pedicles** are short, strong, and directed backwards. The *superior vertebral notches* are shallow, the *inferior* being deep and wide.

The **laminæ** are short, thick, and deep, and their planes are almost vertical.

The **spinous process** is axe-shaped, its direction being horizontal, and it terminates in a blunt border.

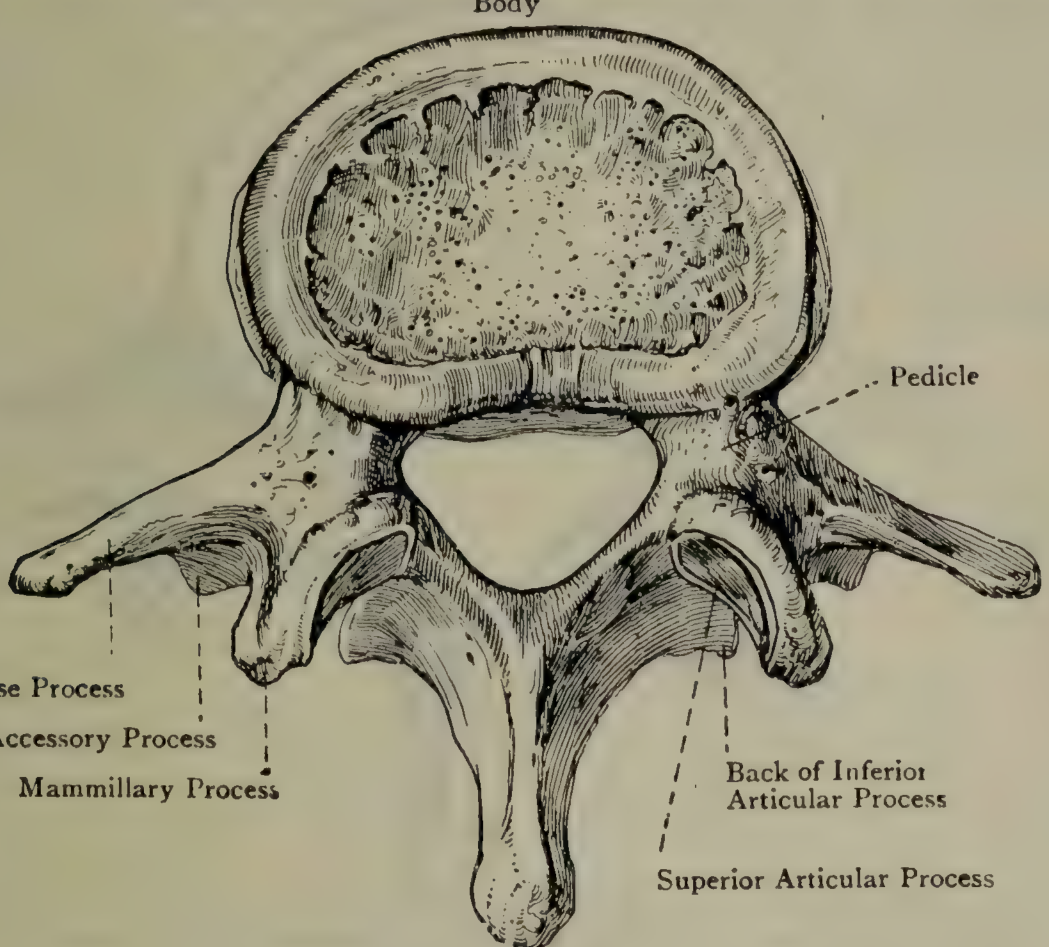


FIG. 90.—THE THIRD LUMBAR VERTEBRA (SUPERIOR VIEW).

The **articular processes** are vertically elongated. The *superior pair* project upwards from the junction of the pedicles and laminæ, and the *inferior pair* project downwards from the lower borders of the laminæ. The *superior pair* are concave, their planes being vertical, and their direction being inwards and backwards, so that they almost face each other. They stand wide apart, so as to embrace the inferior articular processes of the vertebra above. On the posterior border of each there is a nipple-shaped projection directed backwards and slightly upwards, called the *mammillary process* (*metapophysis*), which corresponds with the superior tubercle of the lower thoracic transverse processes. The *inferior articular processes* are convex, their planes being vertical, and their direction being outwards and forwards, so

that they look away from each other. They are nearer to each other than the superior pair, and are received between the superior pair of the vertebra below.

The **transverse processes** are comparatively slender, except in the case of the fifth; they are directed outwards and slightly backwards, and they increase in length from the first to the fourth. Each is spatula-shaped, being compressed from before backwards, and terminates in a short round border. It represents the vertebral portion of a rib, and therefore constitutes the *costal element* of the vertebra. Situated on the posterior aspect of the base of the transverse process, just external to and below the lower border of the superior articular process, there is a small sharp projection directed downwards, called the

Fig. 91.—The Fifth Lumbar Vertebra (Superior View).

accessory process (*anapophysis*), which is the rudiment of the true transverse process. In the case of the fourth and fifth lumbar vertebræ the transverse process becomes shifted on to the body as well as the pedicle.

The lumbar transverse processes (costal elements) of man are serially homologous with the ribs, and also, in the case of the lower thoracic vertebræ, with the anterior tubercles of the transverse process. In the lumbar region each transverse process has fused with the accessory process (true transverse process), and consequently the foramen transversarium in the transverse process of a cervical vertebra has disappeared.

The **vertebral foramen** is larger than in the thoracic vertebræ, but not so large as in the cervical, its shape being triangular with rounded angles.

The Fifth Lumbar Vertebra.—The distinctive characters of this vertebra are as follows: (1) it is the most massive of all the lumbar vertebræ; (2) the greater depth of the body in front is more conspicuous than in the others; (3) the transverse processes are massive, conical, and directed definitely upward; and (4) the inferior articular processes are wide apart.

It will be readily understood that attempts at all these characteristics may occur in the fourth lumbar vertebra, though the marked increase in depth of the anterior surface of the body of the fifth is seldom reached in the fourth.

Ossification of the True Vertebræ.

Each true vertebra ossifies in cartilage from **three primary**, and **five secondary, centres.** One primary centre is for the principal part of the body, and two are for the vertebral arch and its processes, including also a small portion of the body at either side adjacent to the pedicle. The centres for the vertebral arch appear about the *seventh week* of intra-uterine life at the junction of the pedicles and

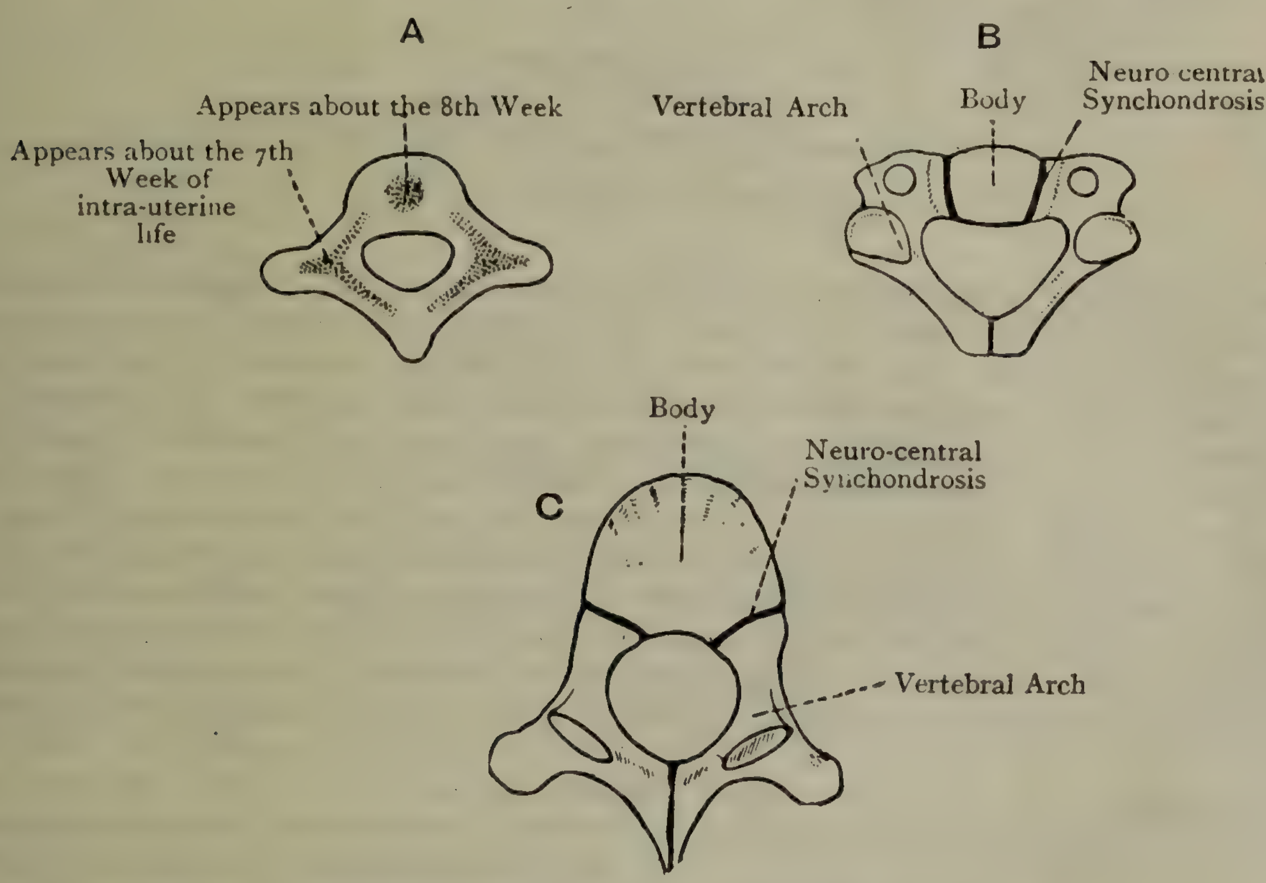


Fig. 92.—Ossification of the True Vertebræ.

A, cervical vertebra at the third month; B, cervical vertebra at birth; C, thoracic vertebra at birth.

laminæ, and from these ossification invades the neural arch, with its processes, and the adjacent portions of the body. The centre for the principal part of the body appears about the *eighth week* in the portion of cartilage dorsal to the notochord. Presumably this nucleus is primitively bilateral, but the two unite very quickly to form a dumb-bell-like ossification. When the two fail to unite the body ossifies in two separate parts, or, if one nucleus should be arrested, only one-half of the body ossifies (Turner). At birth a vertebra is composed of three osseous parts, connected by cartilage—namely, the principal part of the body, and the two halves of the vertebral arch, each bearing a small

portion of the body. The laminæ unite behind in the *first year*, except in the axis, where the union is delayed until the *fourth year*, and the vertebral arch joins the body in the *third year*. The cartilaginous union between the neural arch and the body at either side is called the *neuro-central synchondrosis*. In the thoracic vertebræ the superior costal demi-facets lie behind this, and so they are shown to be placed on the pedicular portion of the body. All vestiges of this synchondrosis have disappeared prior to the *sixth year*. The **secondary centres,** five in number, appear about the *sixteenth year*, and they are consolidated about the *twenty-fifth year*. One appears at the extremity of the spinous process, one at the extremity of each transverse process, and the other two take the form of epiphysial plates, one on the upper surface and the other on the under surface of the body. In the case of the **seventh cervical vertebra,** and sometimes one

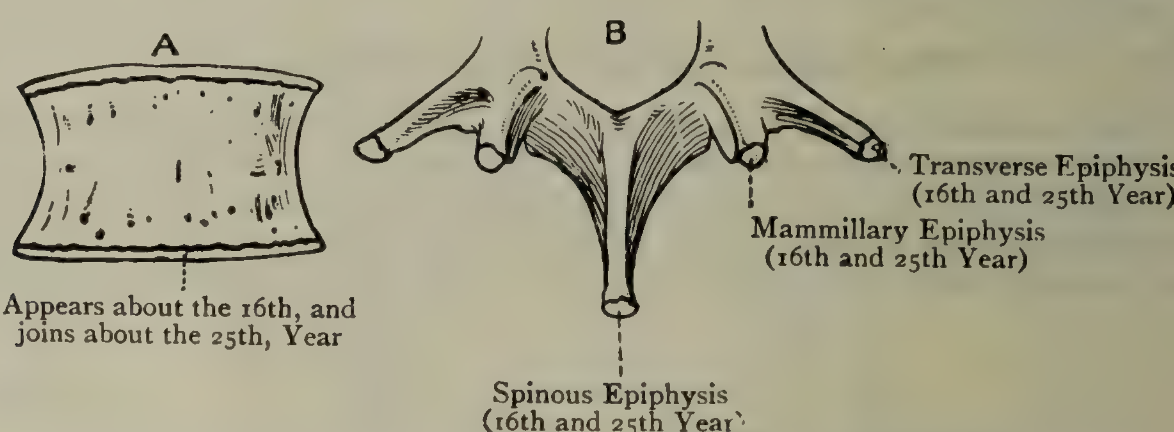


FIG. 93.—LUMBAR VERTEBRA, SHOWING THE EPIPHYSES.

A, the body; B, the neural arch.

or two above it, the costal process has a special centre which appears *before birth*, and it may develop into a cervical rib, a condition often needing operative interference later on. The transverse process (costal element) of the first lumbar has occasionally a special centre, and in these cases it may be developed into a lumbar rib. The lumbar mammillary processes are ossified from special secondary centres. The **fifth lumbar** has sometimes four centres for the vertebral arch, two at either side, one of which is for the pedicle, transverse process, and superior articular process, and the other for the lamina, inferior articular process, and one-half of the spinous process. These parts may fail to unite, in which cases the neural arch presents a synchondrosis on either side, situated between the superior and inferior articular processes (Turner). Sometimes the laminæ of the fifth lumbar fail to unite, and so a space is left, bridged over by fibrous tissue.

The Atlas—The atlas has **three centres** of ossification, two for the lateral masses and posterior arch, appearing in the *seventh week* of intra-uterine life, and one (sometimes two) for the anterior arch, which does not appear until the *first year*. The two halves of the vertebral arch usually join towards the end of the *third year*, there being sometimes a special osseous deposit at the place of junction. The two halves, however, may remain separate throughout life, the interval being bridged over by fibrous tissue.

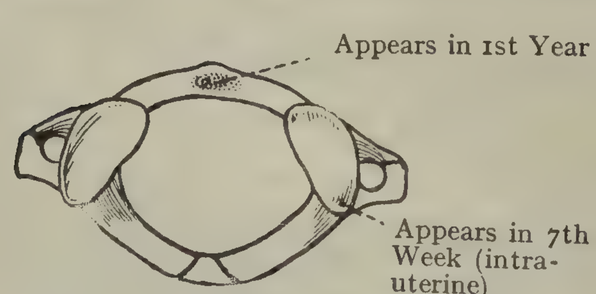


FIG. 94.—OSSIFICATION OF THE ATLAS.

There is no doubt that the odontoid process (dens) of the axis is the separated body of the atlas, and that the anterior arch of the atlas represents something more ventral. Later on, when the ribs have been studied, it will be seen that the middle fasciculus of the radiate ligament runs to the ventral surface of the

intervertebral disc, and in some animals meets its fellow of the opposite side so as to form a fibrous bar, which, since it lies below, in the pronograde position, the notochord, is named the hypochordal bar. In many ruminants another ligamentous bar joins the heads of the ribs above or dorsal to the notochord, and so is named the hyperchordal bar. Here we evidently have the morphological explanation, not only of the anterior arch of the atlas, which is the hypochordal bar chondrified and ossified, but of the transverse ligament as well, which, obviously, is the hyperchordal bar, and it only remains to point out that our chief and most convincing argument for regarding the odontoid process as the body of the atlas is that the notochord passes right through it and is continued up to the skull as the middle check ligament.

The Axis.—Excluding the odontoid process, the axis has **three primary centres,** like an ordinary vertebra, two for the vertebral arch appearing about the *seventh week,* and one (sometimes two) appearing in the lower part of the common cartilage of the body and odontoid process in the *fourth month.* In the upper part of this common cartilage two centres, laterally disposed, appear in the *fifth month* for the **odontoid process,** and these unite into one centre about the *sixth month.* At birth the axis is composed of four osseous parts connected by cartilage—namely, a body, an odontoid process surmounted by cartilage, and two halves of the vertebral arch. The odontoid process joins the body about the *fourth year.* The two halves of the vertebral arch join each other,

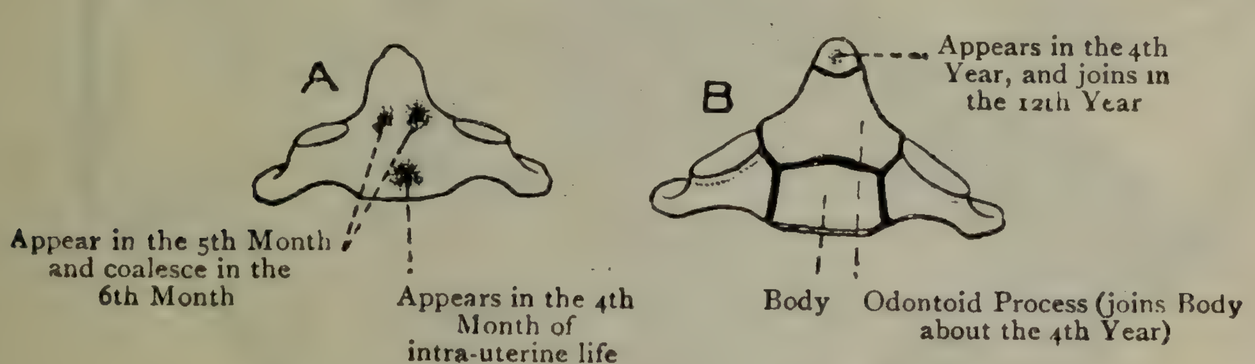


FIG. 95.—OSSIFICATION OF THE AXIS.

A, at the fifth month; B, at the fourth year.

and the arch joins the body, in the *fourth year.* The **apical part** of the odontoid process has a special centre appearing in the *fourth year,* and it joins the rest of the process in the *twelfth year.* The body of the axis has the usual epiphysial plate on the under surface of the body, but there is no such plate on the upper surface. The union between the odontoid process and the body is indicated by a small disc-shaped cavity, centrally placed and persisting until advanced life.

The soft tissue in this cavity, no doubt, represents the intervertebral disc between the axis and the real body of the atlas, and it is situated a good deal lower than the constricted neck of the odontoid process. In many reptiles and in that reptile-like mammal, the ornithorhynchus or duck-bill, the process is separate throughout life, and the separation occurs just where the rudimentary disc is found in man. Again, the double centres for the odontoid are quite in keeping with what would be expected in the body of a vertebra, and the one for the tip is often looked upon as the upper disc-like epiphysis, though its early appearance suggests the possibility of its representing some still more anterior body or pro-atlas.

The Fixed Vertebræ.

The **fixed vertebræ** are usually nine in number, the upper five of which form the sacrum, and the lower four the coccyx.

The Sacrum.

The **sacrum** lies below the fifth lumbar vertebra, and is so arranged that in the erect position it forms the roof and part of the posterior wall of the pelvis. It is important to regard this cavity not as the lower part of the abdomen, but as a cave leading backward and slightly downwards from the lower part of the hinder abdominal wall. The sacral vertebræ diminish in size from above downwards, which renders the bone triangular, the base being upwards and forwards.

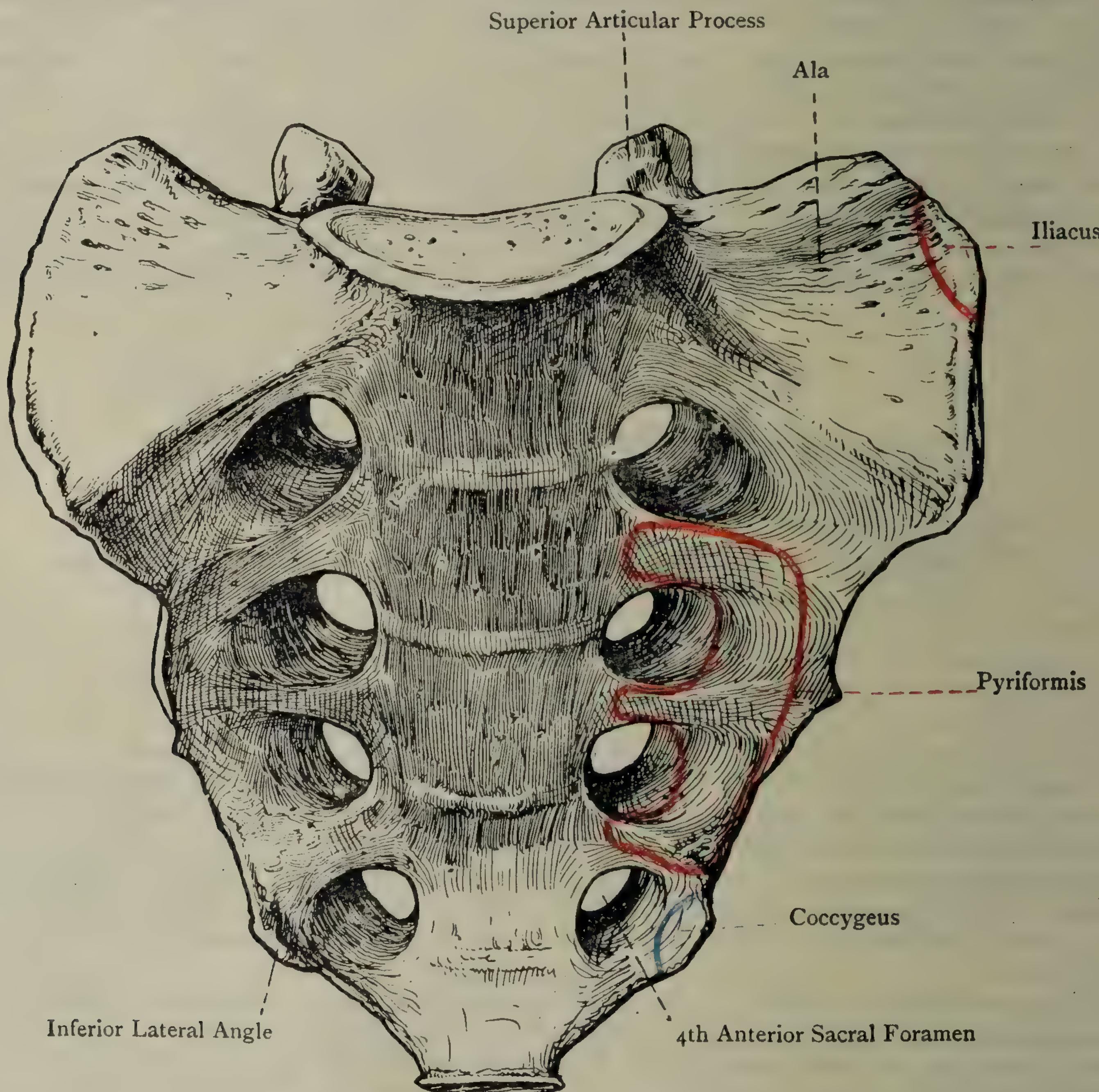


Fig. 96.—The Sacrum (Anterior View).

The **ventral** or **pelvic surface,** which is directed downwards and forwards, is concave from above downwards, and slightly from side to side. It presents along the centre a solid mass, representing the ankylosed bodies and ossified intervertebral discs, which is marked by four transverse ridges situated at the places of junction. Superiorly it presents a projecting lip, called the *promontory*. On either side there is a row of *anterior sacral foramina,* four in number, which diminish in size from above downwards, and are directed outwards

and forwards from the intervertebral foramina, by means of which they communicate with the sacral canal. They transmit the anterior primary divisions of the first four sacral nerves.

The **lateral masses** are situated lateral to the anterior sacral foramina at either side, and each is marked anteriorly by four transverse grooves, which prolong outwards the foramina and lodge the transmitted nerves. The pyriformis muscle arises from the front of each lateral mass by three slips, which are interposed between, and lie lateral to, the

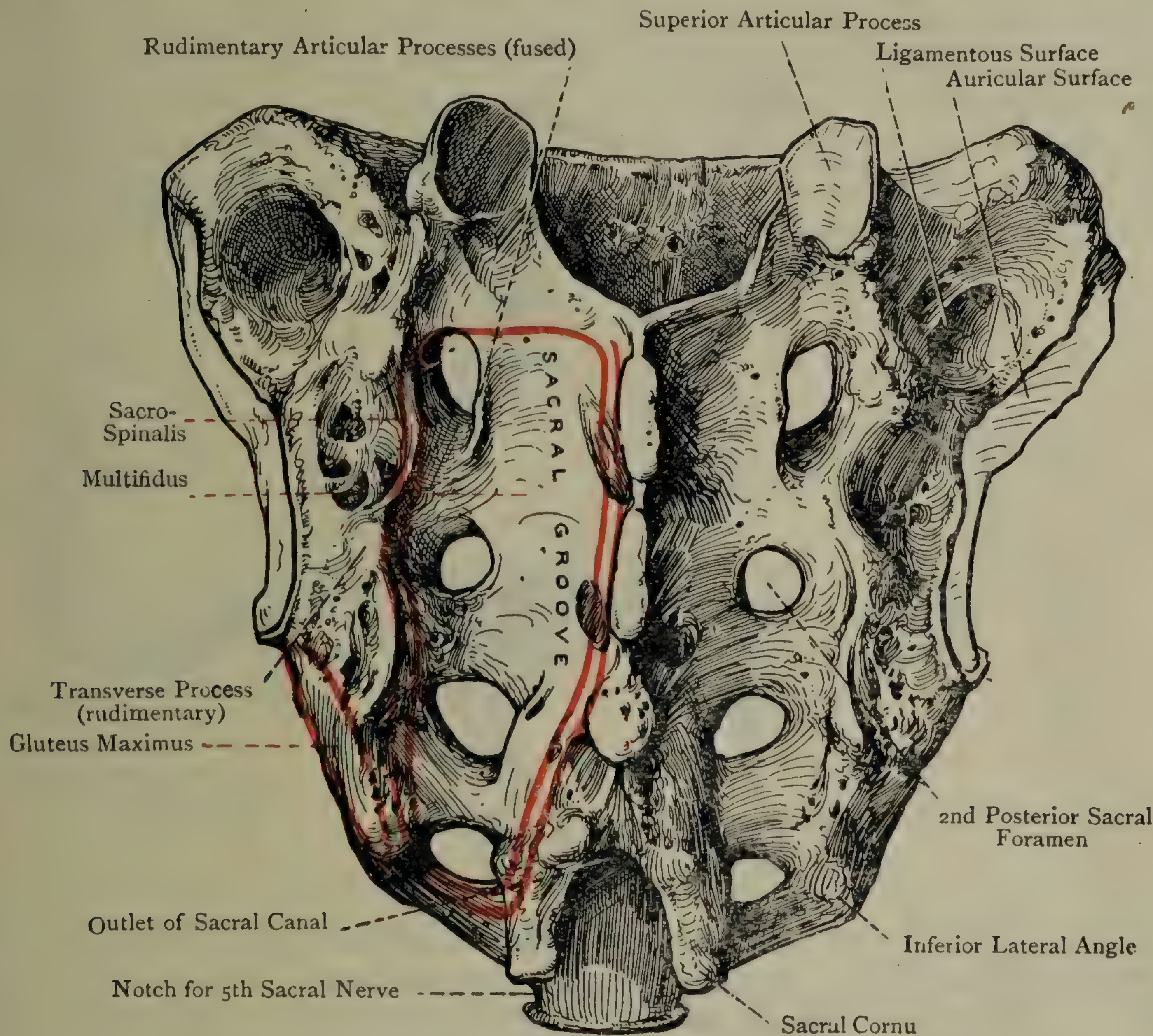


FIG. 97.—THE SACRUM (POSTERIOR VIEW).

foramina. The lateral masses are formed by the fusion of the pedicles, transverse processes, and costal elements of the sacral vertebræ.

The **dorsal surface,** which is directed upwards and backwards, is irregularly convex and narrower than the ventral. In the middle line it presents four eminences, which may be distinct, or fused to form a ridge, representing the spinous processes of the upper four sacral vertebræ. The spinous process of the fifth vertebra is absent, the development of its laminæ having been arrested; and there is thus left a triangular opening, which is the outlet of the sacral canal, to be presently described. On either side of the median row of spines there

is a solid mass formed by the ankylosed laminæ, which forms the *sacral groove* for the origin of a portion of the multifidus. Lateral to this groove there is a row of foramina, four in number at either side, called the *posterior sacral foramina*, which are smaller than the anterior, and, like them, diminish in size from above downwards. These foramina open outwards and backwards from the intervertebral foramina (by which they communicate with the sacral canal), and transmit the posterior primary divisions of the first four sacral nerves. It is to be noted that they lie directly behind the anterior foramina. Medial to

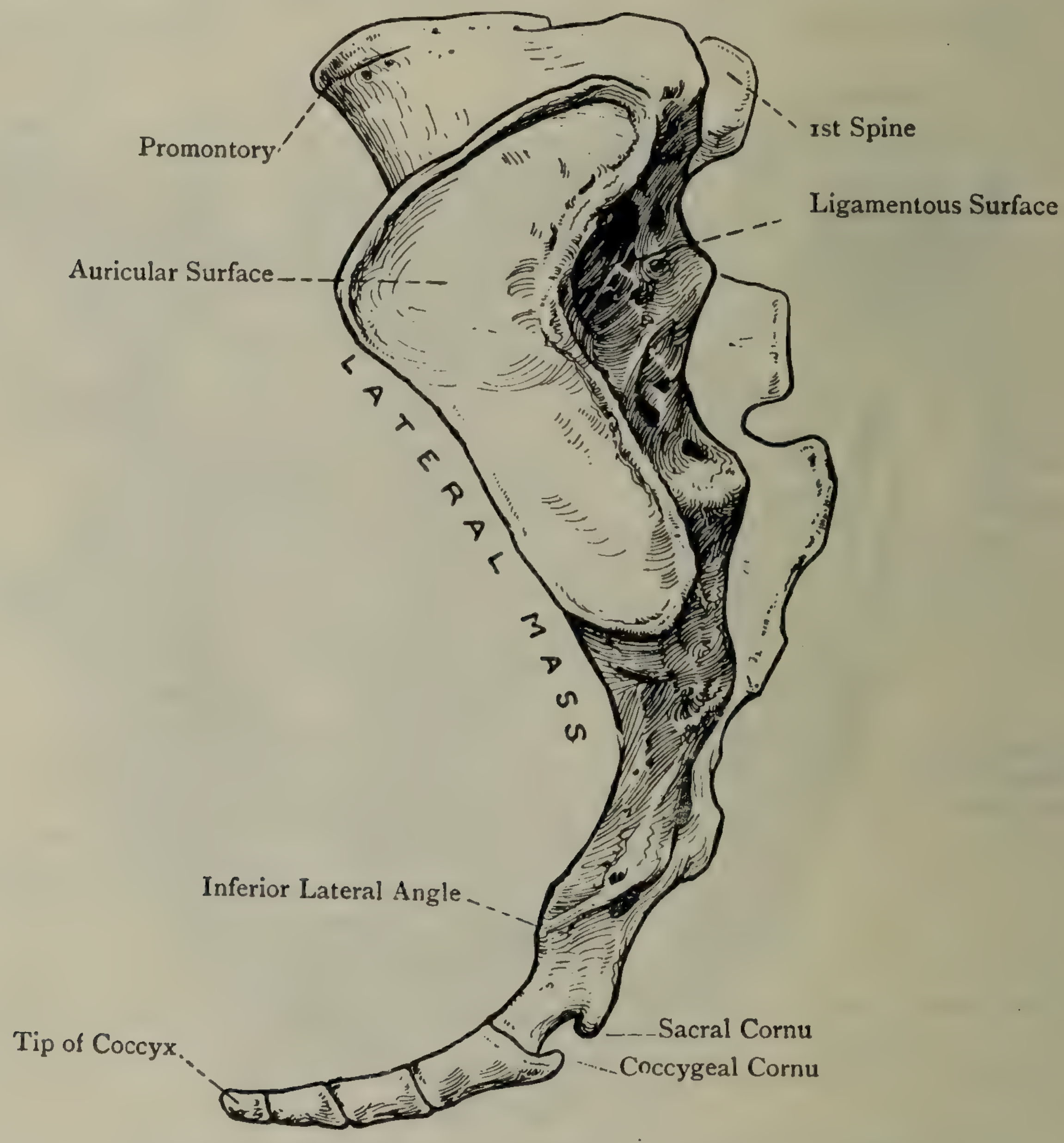


FIG. 98.—THE SACRUM (LEFT LATERAL VIEW).

the posterior foramina, and encroaching upon them, there is a row of small projections which represent the articular processes of the sacral vertebræ. The lower pair, which belong to the fifth sacral vertebra, are prolonged downwards as two plates which end in enlargements. These are called the *sacral cornua*, and they are connected with the cornua of the first coccygeal vertebra, usually by ligaments, but sometimes by osseous union. The interval thus bridged over at either side represents a fifth intervertebral foramen, through which the fifth sacral nerve passes. The solid portion external to the posterior foramina at either side is the lateral mass, and it presents a row of

four tubercles, each of which is situated lateral to a posterior foramen. These represent the transverse processes of the lower four sacral vertebræ. The boundaries of the triangular outlet of the sacral canal are the spine of the fourth sacral vertebra above, and the imperfect laminæ of the fifth sacral and the sacral cornua at either side. It transmits the fifth pair of sacral nerves and the two coccygeal nerves.

The **lateral surface** is broad above and narrow below. The upper part is divided into two portions—articular and non-articular. The articular division, anterior in position, is covered by cartilage, and is shaped like an ear, on which account it is called the *auricular surface*. It articulates with the iliac portion of the innominate bone, and extends at least over the first two sacral vertebræ. The non-articular division, posterior in position, is rough and irregular for the attachment of the interosseous sacro-iliac ligaments, and it is known as the *ligamentous surface*. The lower part of the lateral surface corresponds

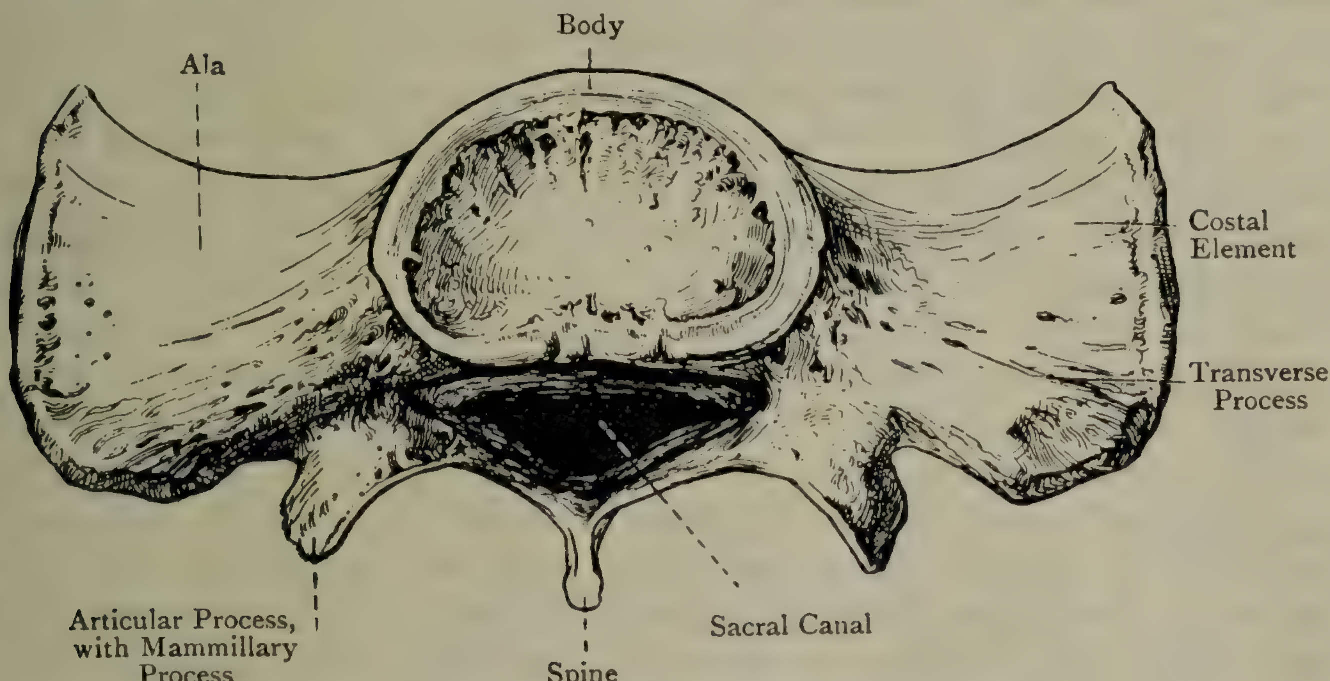


FIG. 99.—THE BASE OF THE SACRUM.

with at least the lower two sacral vertebræ, and may include more or less of the third. It gives attachment to fibres of the sacrotuberous and sacrospinous ligaments and a portion of the coccygeus muscle, whilst the adjacent portion of the posterior aspect gives origin to fibres of the gluteus maximus. Inferiorly the lower part is thinned away to a mere margin, and presents a process, called the *inferior lateral angle*. Below this is the transverse process of the first coccygeal vertebra when that is in position, a notch being thus formed on the side of the fifth sacral vertebra. The inferior lateral angle inclines towards the coccygeal transverse process, with which it is usually connected by a ligament, though in some cases the two processes become ankylosed. There is thus constructed a fifth anterior sacral foramen at either side for the passage of the anterior primary division of the fifth sacral nerve.

The **base** presents a central and two lateral divisions. The central division corresponds in its characters with the superior surface of a

lumbar vertebra. Each superior vertebral notch lodges a fifth lumbar spinal nerve, and the superior articular processes stand wide apart. The lateral divisions of the base are called the *alæ*. Each **ala** is triangular with the apex directed backwards. The alar surface is depressed, concave from side to side, and convex from behind forwards. It gives attachment to fibres of the iliacus, the lateral lumbo-sacral and anterior sacro-iliac ligaments, and it supports the lumbo-sacral nervous cord and the internal iliac vessels. The ala is formed by the fusion of the pedicle, transverse process, and costal element of the first sacral vertebra.

The **apex** is transversely oval, and articulates with the first coccygeal vertebra, with the intervention of an intervertebral disc until advanced life, when ankylosis takes place.

The **sacral canal** is situated behind the bodies of the first four sacral vertebræ, as a rule. It is triangular in the upper part, but somewhat crescentic below. It is closed in front by the ankylosed bodies, and behind by the ankylosed laminæ. Along each side it presents four intervertebral foramina for the passage of nerves. These are bounded laterally by the lateral mass, but each opens on the ventral and dorsal surfaces by the anterior and posterior sacral foramina, which represent the limbs of a capital V, the apex of which corresponds with an intervertebral foramen. The *superior aperture* or **inlet** is large, triangular, and wide transversely. It represents the vertebral foramen of the first sacral vertebra. The *inferior aperture* or **outlet** is comparatively small and somewhat triangular, and is usually situated on the back of the body of the fifth sacral vertebra. It is bounded above by the tubercle which represents the spinous process of the fourth sacral vertebra, and on either side by (1) the imperfectly developed lamina of the fifth sacral vertebra, and (2) the sacral cornu. The outlet transmits the fifth pair of sacral nerves and the two coccygeal nerves. The contents of the canal are the sacral and coccygeal nerves, and the filum terminale of the spinal cord.

The sacrum derives its blood-supply from the lateral sacral and middle sacral arteries.

Articulations.—*Superiorly* with the fifth lumbar vertebra, *inferiorly* with the coccyx, and *at either side* with the innominate bone.

Varieties.—(1) The number of sacral segments may be six, or more rarely four. Increase in the number is usually due to the incorporation of the first coccygeal vertebra, or sometimes the fifth lumbar. The decrease may be due to the fifth sacral vertebra forming a part of the coccyx, or to the first sacral forming a sixth lumbar. (2) The bodies of the first and second sacral vertebræ may remain permanently separate, though ankylosis has taken place in all their other parts. (3) The first sacral vertebra may be normal on one side, but on the other side it may remain separate from the second, and present the characters of a fifth lumbar. (4) The number of sacral spines may be reduced from four to three, two, or one, or they may be entirely absent. As a consequence of this, the sacral canal, which usually opens on the back of the fifth sacral vertebra, may do so on the back of the fourth, third, second, or first, so that in some cases it may be entirely open posteriorly. (5) The sacrum is liable to much variety as regards the extent of its vertical curve.

Characters of the Female Sacrum.—In the female the sacrum is smoother, shorter, broader, less curved, and is set more backwards than in the male.

Another sexual distinction is that the facet for the last intervertebral disc occupies a much smaller proportion of the base in the female than in the male. In spite of these differences it is by no means always easy to distinguish the sex of the sacrum.

Ossification.—The sacrum ossifies in cartilage from **thirty-five centres.** Each segment has **three primary centres,** one for the body and two for the vertebral arch. The centre for the body appears in the *third month* of intra-uterine life in the case of the first three, and after the *fifth month* in the last two. The centres for the vertebral arches appear about the *sixth month.* The vertebral arches join the bodies, in order from below upwards, from the *second* to the *sixth year.* The union of the laminæ takes place from the *eighth* to the *twelfth year.* It, however, fails in the lowest, and sometimes in those higher up. The anterior parts of the lateral masses of the first three vertebræ, which represent the costal elements, have separate centres, which appear about the *sixth month.* These join the vertebral arches before uniting with the bodies, the latter union taking place rather later than the union between the vertebral arches and the bodies. Each vertebra has two annular circumferential epiphysial plates, superior and inferior, which begin to ossify about the *sixteenth year.* On each side of the sacrum there are two epiphyses, an upper for the auricular surface, and a lower for the sharp edge below, which appear about the *eighteenth year.* Consolidation begins about the *eighteenth year,* and proceeds from below upwards, union taking place earlier between the segments of the lateral masses than between the bodies. In the latter case the ossification invades the intervertebral discs, but in the former it is direct union. The union is complete about the *twenty-fifth year,* at which period also the lateral epiphyses join the bone.

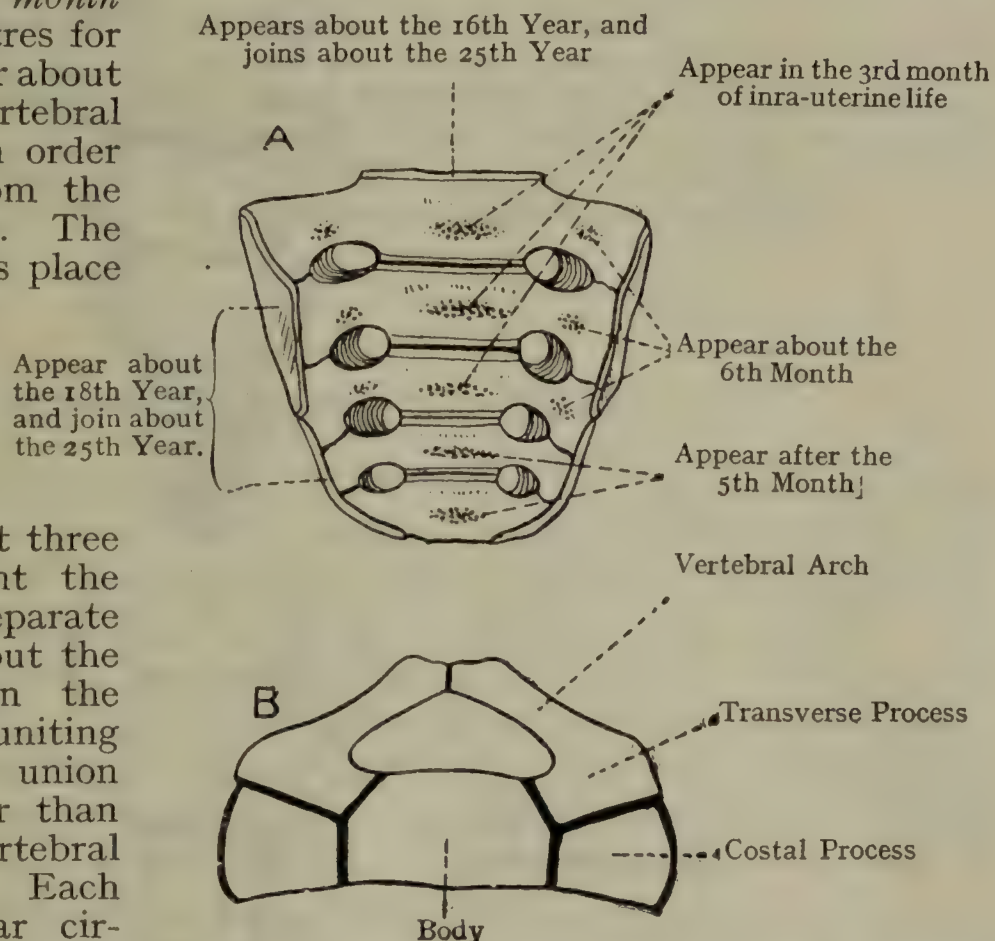


FIG. 100.—OSSIFICATION OF THE SACRUM.

A, anterior view; B, first sacral vertebra in early life (superior view).

The Coccyx.

The **coccyx** is composed as a rule of four rudimentary vertebræ, and it lies below the apex of the sacrum, which constitutes its only articulation. The direction of the bone is downwards and forwards, and its elements diminish in size from above downwards. It is triangular.

The **first coccygeal vertebra** is compressed from before backwards, broad above, narrow below, concave in front, and convex behind. The superior and inferior surfaces are transversely oval, and the lateral borders are sloped downwards and inwards. Two processes project upwards from the dorsal surface at either side, called *coccygeal cornua*, which articulate with the sacral cornua, usually by ligaments, but sometimes directly. Each lateral border presents, superiorly, a projection, called the *transverse process*, which inclines towards the inferior lateral angle of the sacrum, and is usually connected to it by a ligament, which is sometimes ossified.

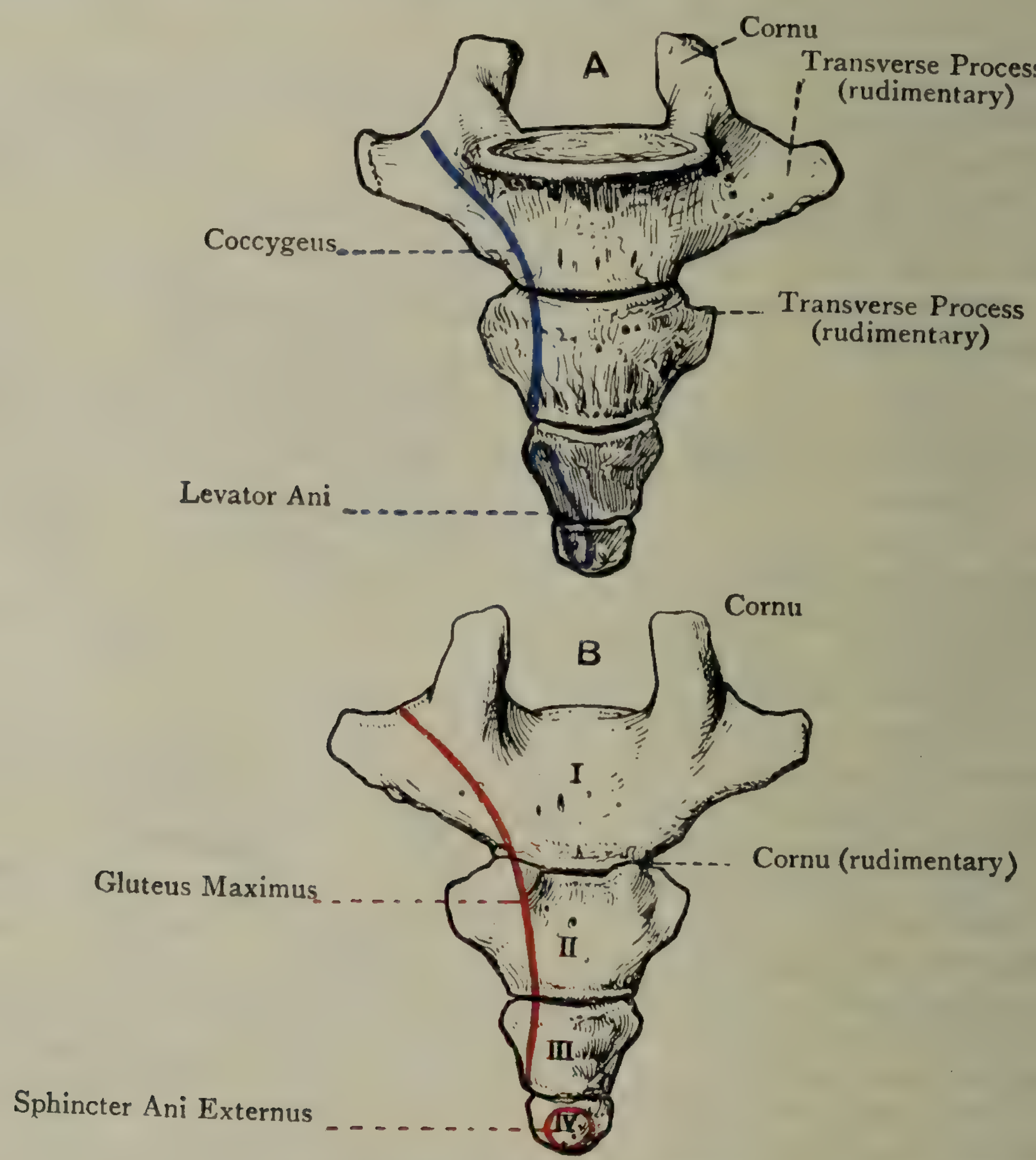


FIG. 101.—THE COCCYX.
A, anterior view; B, posterior view.

The **second coccygeal vertebra** presents traces of transverse processes and cornua, whilst the **third** and **fourth** are reduced to mere nodules.

The muscular attachments of the coccyx are as follows: the gluteus maximus to the back of the upper three segments close to the lateral border; the sphincter ani externus to the tip; the posterior fibres of the levator ani and a portion of the coccygeus to the lateral border. The sacrotuberous and sacrospinous ligaments are partially attached to the lateral border of the first coccygeal vertebra.

The coccyx derives its blood-supply from the inferior lateral sacral and middle sacral arteries.

Varieties.—The number of coccygeal segments may be increased to five, due either to the addition of an extra nodule, or to incorporation of the fifth sacral segment. The number may be reduced to three, due either to incorporation of the first coccygeal segment with the sacrum, or to suppression of one of the nodules. It is often asymmetrical.

Ossification.—The coccygeal vertebræ are cartilaginous at birth. Each vertebra has **one primary centre** and **two secondary centres,** the *first* vertebra having an **additional pair of secondary centres.**

Primary Centres.—The primary centre for the **first vertebra** appears from the *second* to the *fifth year*; that for the **second vertebra** from the *sixth* to the *tenth year,* and those for the **third** and **fourth vertebræ** about *puberty*.

Secondary Centres.— Each vertebra has two secondary centres for the **epiphysial plates**—one on the upper surface, and the other on the under surface of the rudimentary vertebra (centrum or body). In addition, the first coccygeal vertebra has **two special secondary centres,** one for each *cornu*.

Union of the four coccygeal vertebræ takes place from below upwards, as in the sacrum. It commences shortly after the *eighteenth year,* and is not completed until the *thirtieth year* or later, the last two coccygeal vertebræ to join being the first and second. In advanced life it is not uncommon to find the coccyx ankylosed to the sacrum, thus forming one **sacro-coccygeal bone.**

The Vertebral Column as a Whole.

The **vertebral column** supports the other parts of the skeleton, directly or indirectly. Its average length is about 28 inches in the male, and rather less in the female. When viewed from the front, four pyramids are seen. The *first* extends from the axis to the seventh cervical vertebra, its base being downwards. The *second* extends from the first to the fourth thoracic vertebra, its base being upwards. The *third* extends from the fifth thoracic to the fifth lumbar, its base being downwards. The *fourth* extends from the base of the sacrum to the tip of the coccyx. These pyramids are due to the differences in breadth of the bodies in different parts.

The column presents certain curves, which are arranged in two groups, antero-posterior and lateral. The antero-posterior group comprises four curves, named cervical, thoracic, lumbar, and pelvic. The cervical and lumbar curves have their convexities directed forwards, and the thoracic and pelvic curves have their convexities directed backwards. The lumbar and pelvic curves meet rather abruptly and form a projection, called the *sacro-vertebral angle,* which is estimated at 117 degrees in the male and 130 degrees in the female. The curves impart springiness or elasticity to the column, and so guard it against shock. The thoracic and pelvic curves are associated with the thoracic and pelvic cavities, the capacity of which they serve to increase. They appear in early fœtal life, and are known as *primary curves*. The cervical and lumbar curves do not appear until after birth, and are known as *secondary* or *compensatory curves*. The primary curves are brought about by the greater depth posteriorly of the thoracic and sacral bodies, whilst the compensatory curves are largely due to the intervertebral discs, though in the lumbar region

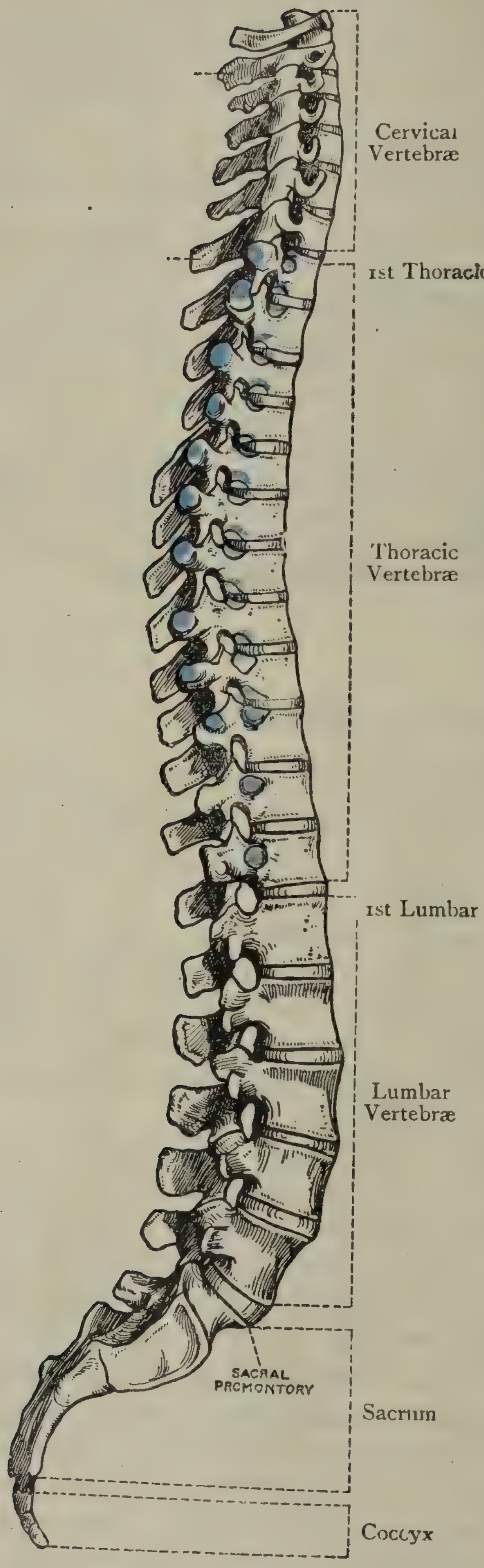


FIG. 102.—THE VERTEBRAL COLUMN (LATERAL VIEW).

(The blue markings represent the facets on the bodies and transverse processes.)

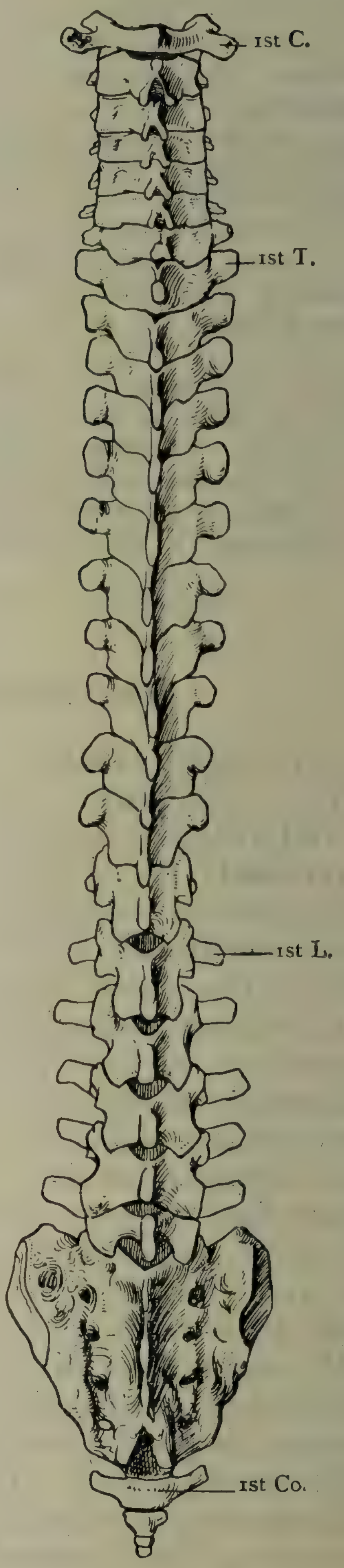


FIG. 103.—THE VERTEBRAL COLUMN (POSTERIOR VIEW).

the greater depth of the bodies anteriorly, especially in the fifth lumbar, must also be taken into account.

The lateral group comprises two curves. One is situated in the upper thoracic region, with its convexity directed towards the right side in right-handed persons, and it is to be regarded as due to the greater use made of the right arm. To compensate for this curve there is another slight curve in the upper lumbar region, with the convexity to the left.

When viewed anteriorly, the column presents the bodies, which form the pyramids already described. When viewed laterally, it presents the sides of the bodies, pedicles, intervertebral foramina, and articular and transverse processes. The *intervertebral foramina* are formed by the apposition of the superior and inferior vertebral notches of contiguous pedicles. They lead outwards from the spinal canal, and each transmits a spinal nerve. They increase in size from above downwards until the sacrum is reached, in which, though hidden at either side of the central mass, they diminish in size from above downwards. In this region each intervertebral foramen opens on the front and back of the sacrum by means of an anterior and posterior sacral foramen, the arrangement thus formed resembling a capital V, the apex being at an intervertebral foramen. On the lateral aspect of the thoracic portion of the column are seen the *costo-capitular facets*, which are twelve in number. The first is situated on the upper part of the side of the first thoracic body. The second to the tenth inclusive are situated on the contiguous margins of the bodies of the vertebræ, each being formed by the small inferior costal facet of the upper body and the large superior costal facet of the lower. The eleventh and twelfth are situated on the sides of the corresponding pedicles. The tenth facet may belong entirely to the tenth thoracic vertebra. The thoracic transverse processes, except the eleventh and twelfth (and sometimes the tenth), are faceted in front at their extremities for the tubercles of the ribs.

When the column is viewed from behind the following parts are seen: the spinous processes; the laminæ; the articular processes; the backs of the transverse processes; and the dorsum of the sacrum and coccyx. The cervical spines, except the sixth and seventh, are short, so as not to interfere with backward flexion or over-extension of the neck. The middle thoracic spines are imbricated, and the lumbar spines stand out horizontally. On either side of the spines there is the *vertebral groove*, which is occupied by the deep muscles of the back, the deepest being the multifidus. This groove is bounded medially by the spines, and laterally by the transverse processes in the cervical and thoracic regions, and by the mammillary tubercles in the lumbar region. The floor is formed by the laminæ, and its continuation over the back of the sacrum is known as the *sacral groove*.

Notice how well the imbricated laminæ protect the spinal canal in the cervical and thoracic region. Except between the occiput and atlas it would be extremely difficult to sever the spinal cord by

a stab in the back; but in the lumbar region the spinal canal and cauda equina can be reached easily enough between the laminæ, and this fact is taken advantage of in 'lumbar puncture' to withdraw cerebro-spinal fluid or inject drugs.

The *vertebral canal* is situated behind the bodies of the vertebræ, and is formed by the vertebral foramina of all the vertebræ except the fifth sacral and four coccygeal. It commences at the level of the atlas, and it terminates as a rule upon the back of the body of the fifth sacral vertebra. It adapts itself to the various curves of the column, and is large and triangular in the cervical and lumbar regions, small and circular in the thoracic, and triangular in the upper part, but crescentic in the lower part, of the sacral region. It contains the spinal cord and its membranes as low as about the level of the disc between the first and second lumbar bodies, and a copious plexus of vessels. Below the level just mentioned it contains the filum terminale of the spinal cord and the leash of nerves known as the cauda equina, with their coverings. The dura-matral covering or theca comes to an end by being attached to the back of the second sacral body, and the filum terminale passes on to be attached to the back of the fifth sacral or first coccygeal vertebra.

It has been pointed out that in the lower sacral and coccygeal regions the vertebral canal is not enclosed by bone posteriorly. This normal failure to close in may sometimes extend much higher, thus allowing the membranes and cauda equina to bulge backward, a condition known as sacral spina bifida.

B. The Ribs.

The **ribs** (costæ) are twelve in number at either side, and are arranged in two groups, true or sternal, and false or asternal. The **true ribs** are those which articulate directly with the sternum by their costal cartilages, and they represent as a rule the first seven at either side. The **false ribs** are those which have no direct articulation by their costal cartilages with the sternum, and they represent, as a rule, the last five at either side. The last two false ribs, eleventh and twelfth, are called the *free* or *floating ribs*, because their costal cartilages stand quite clear of each other and of the tenth. The ribs are elastic, and increase in length from the first to the seventh, whence they decrease to the twelfth. The first is the broadest, and the twelfth the narrowest. Their direction is at first downwards, outwards, and slightly backwards, then downwards and forwards, and finally inwards. The upper ribs are not so oblique as those lower down, the most oblique being the ninth. With the exception of the first rib, the surfaces of the others are vertically disposed posteriorly, but in front they are sloped downwards and forwards, and this circumstance renders most of them twisted.

A Typical Rib.—A typical rib consists of a head, neck, tubercle, shaft, and sternal extremity.

The **head** (capitulum) forms the posterior or vertebral extremity, and is slightly expanded. It presents an irregularly flat surface and an anterior margin. The surface is marked by two oblique facets, upper and lower, which are separated by a horizontal ridge.

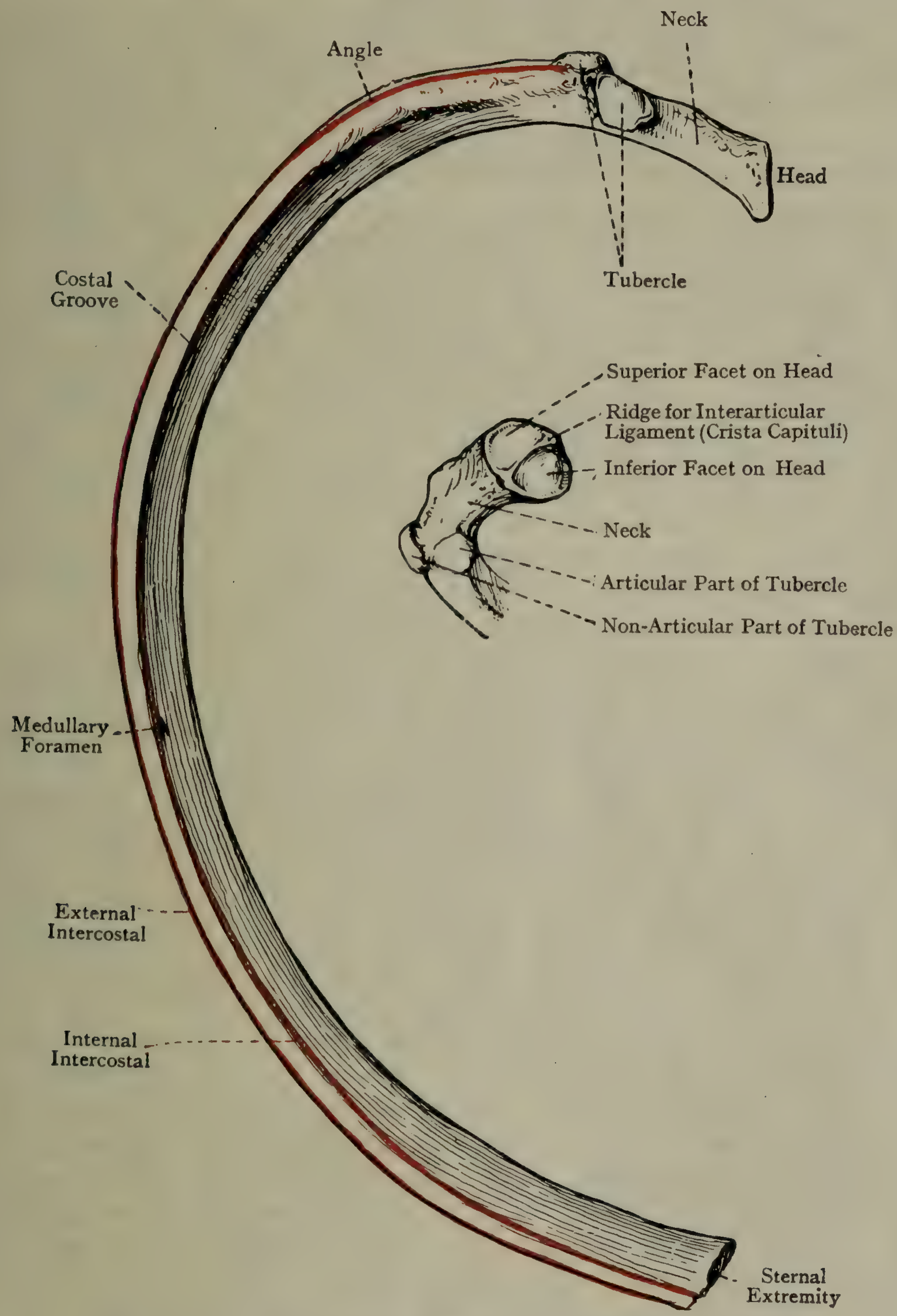


FIG. 104.—THE SIXTH LEFT RIB (INTERNAL VIEW).

The *lower* or *primary facet* is the larger of the two, and articulates with the large superior or primary costal facet of the lower of the two thoracic bodies with which the head is connected—that is to say, with the thoracic vertebra bearing the same number as itself. The

upper facet articulates with the small inferior costal facet on the side of the upper thoracic body, and the intervening ridge gives attachment to the interarticular ligament. The anterior margin gives attachment to the radiate ligament, and the ridge, separating the two facets, to the interarticular ligament.

The **neck** is about 1 inch long, and is compressed from before backwards. Its *anterior surface* is smooth and covered by the costal pleura. Its *posterior surface,* which is rough, faces the anterior surface of the lower thoracic transverse process, or that with which its tubercle articulates, and it gives attachment to the ligament of the neck of the rib. Its superior border forms a sharp lip, called the *crest,* which gives attachment to the anterior costo-transverse ligament. Its inferior border may show traces of the subcostal groove.

The **tubercle** is situated on the lateral surface of the rib at the outer extremity of the neck, and presents two divisions, articular and non-articular. The *articular division,* inferior and slightly internal in position, presents a somewhat oval facet for articulation with that on the front of the extremity of the lower thoracic transverse process. This facet corresponds to the facet on the transverse process of its vertebra, already noticed. In the upper ribs it is convex and looks backward, while in the lower it is flat and looks more downward. The *non-articular division,* superior and slightly external in position, gives attachment to the posterior costo-transverse ligament.

The **shaft** is curved and twisted. It has two surfaces and two borders. The *external surface* is convex, and its plane is vertical behind, but oblique in front, being here sloped downwards and forwards. Opposite the greatest bend of the rib, called *the angle,* it presents an oblique ridge, directed downwards and outwards, for a tendinous slip of the sacrospinalis and for the levator costarum. The surface between the tubercle and the angle gives attachment to the longissimus dorsi, and increases in length with each succeeding rib, in the first being absent, since the tubercle and angle coincide, in the sixth about $1\frac{1}{2}$ inches long, and in the tenth about 2 inches. Near the anterior extremity (about 2 inches from it) the external surface presents another oblique ridge directed downwards and outwards, known as the *anterior angle,* where the rib describes a slight curve. The *internal surface,* which is concave, is covered by the costal pleura. At its lower part it presents the subcostal groove, to be presently described. The *superior border* is thick and round behind, but thin and sharp in front. Its outer lip gives attachment to an external intercostal muscle, and its inner lip to an internal intercostal, a collateral intercostal artery lying between the two muscles. The *inferior border* is for the most part sharp and wiry. Immediately within and above it there is the **costal groove,** which commences behind at the tubercle and disappears over the anterior fifth. Posteriorly the groove belongs to the inferior border. Its inner lip is rounded and gives attachment to an internal intercostal muscle, whilst the outer lip gives attachment to an external inter-

costal. The nutrient foramen is situated in the costal groove a little anterior to the centre of the bone, and the canal to which it leads is directed towards the head. It gives passage to a branch of the intercostal artery which lies in the groove. The contents of the groove from above downwards are an intercostal vein, artery, and nerve, and it is important to notice that the outer lip of the groove descends, like a flange, so far that all these structures are protected by it.

The **anterior** or **sternal extremity** presents an oval pit, which is almost vertical in direction, for the costal cartilage.

The Peculiar Ribs.—These are the first, second, tenth, eleventh, and twelfth.

The First Rib.—This is the shortest, broadest, and flattest of all the ribs, and its curve is very distinct, but there is no twist. The **head** is small, and presents a nearly circular facet for articulation with the entire facet on the body of the first thoracic vertebra. The **neck** is narrow, and compressed from above downwards. The **tubercle,** which is large, is situated on the outer border at the junction of the neck with the shaft. Being placed opposite the greatest bend of the bone, it takes the place of the angle, and presents the usual articular and non-articular portions, the former being for the first thoracic transverse process.

The **shaft** is broad and compressed from above downwards, its surfaces being superior and inferior, whilst the borders are inner and outer. The *superior surface* close to the anterior extremity gives attachment to the tendon of the subclavius and the costo-coracoid ligament. Farther back there are two oblique grooves, separated to a limited extent by a tubercle or spine for the scalenus anterior. The anterior groove is shallow, and lodges the subclavian vein, whilst the posterior deeper groove is occupied by the third part of the subclavian artery and the lower trunk of the brachial plexus of nerves. Behind the posterior groove, and extending as far back as the tubercle, there is a rough impression for the insertion of the scalenus medius. The *inferior surface* is flat and covered by the costal pleura. Near the outer border it gives attachment to the internal intercostal muscle of the first space. The *internal border*, which is thin and concave, gives attachment to Sibson's fascia. Fully 1 inch from the anterior extremity this border presents a projection, called the **scalene tubercle,** for the insertion of the scalenus anterior. It encroaches slightly on the adjacent part of the superior surface, and is inclined backwards. The *outer border* is convex. It gives attachment to the external intercostal muscle of the first space, and a portion of the first serration of the serratus anterior at a point opposite the groove for the subclavian artery, where the outer border is often prominent. The anterior extremity presents the usual oval pit for the first costal cartilage, its direction being horizontal from before backwards. The first rib has no costal groove. In the case of an ill-marked first rib it is always possible to put it in position by laying it on the table. When the superior surface is uppermost the head will touch the table.

The Second Rib.—The surfaces of the shaft of this rib occupy a transitional plane between that of the first and those of the succeeding ribs. It is practically destitute of a twist. The neck is compressed from above downwards, and from before backwards. The distinctive character of the bone is the presence on its supero-external surface, near the centre, of a rough oval eminence for a portion of the first and the second slips of the serratus anterior. Behind this impression the surface gives insertion to the scalenus posterior.

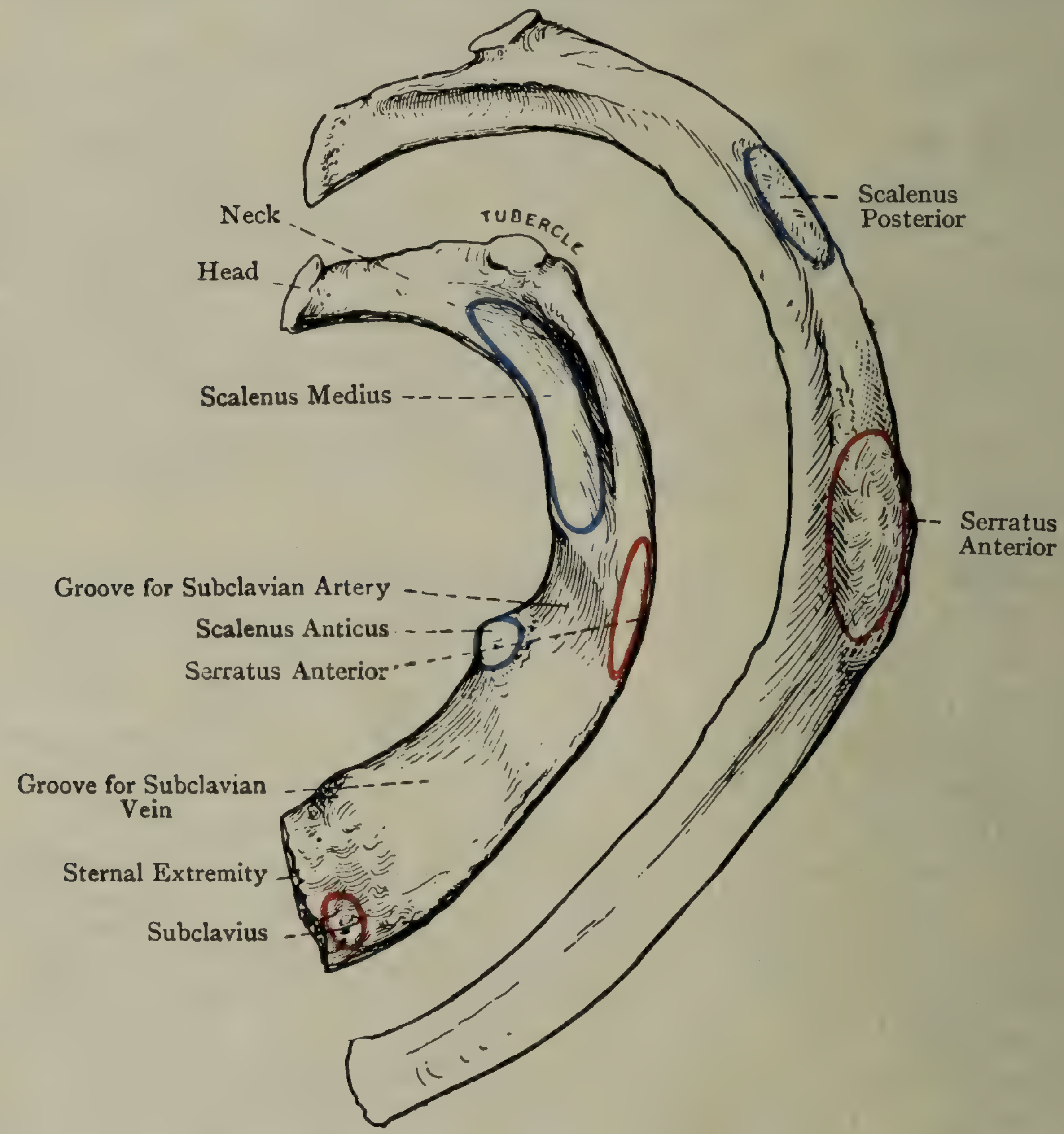


FIG. 105.—THE FIRST AND SECOND RIBS OF THE LEFT SIDE (SUPERIOR VIEW).

The Tenth Rib.—This bone may or may not be peculiar. If the body of the ninth thoracic vertebra has an inferior costal facet, there is nothing peculiar about the head of the tenth rib. If, however, the lower demi-facet is wanting on the ninth thoracic body, the head of the tenth rib has only one facet for that on the body and pedicle of the tenth thoracic vertebra. The tubercle has usually an articular facet for the tenth thoracic transverse process, but this may be wanting. The angle and subcostal groove are well marked.

The Eleventh Rib.—The head of this rib has one facet for that on the pedicle of the eleventh thoracic vertebra. There is a slight tubercle,

destitute of an articular facet, a faint angle, and a more or less well-marked costal groove. The anterior extremity tapers, and is only tipped with a costal cartilage, which is free.

The Twelfth Rib.—This is a very short bone. Its head has one facet for that on the pedicle of the twelfth thoracic vertebra. The tubercle, angle, and costal groove are wanting. The shaft is very narrow, and terminates anteriorly in a pointed extremity, which is merely tipped with a free costal cartilage. The lower border of the shaft has a rough, sharp outline, and gives attachment to a portion of the quadratus lumborum muscle, whilst the upper border, especially towards the back part, is smooth and round, and has a rather definite knob just above the articular facet, which is rather markedly concave. In putting the bone in position, remember that the thorax is barrel-shaped and that the internal surface also looks upwards.

The ribs are supplied with blood by branches of the intercostal arteries.

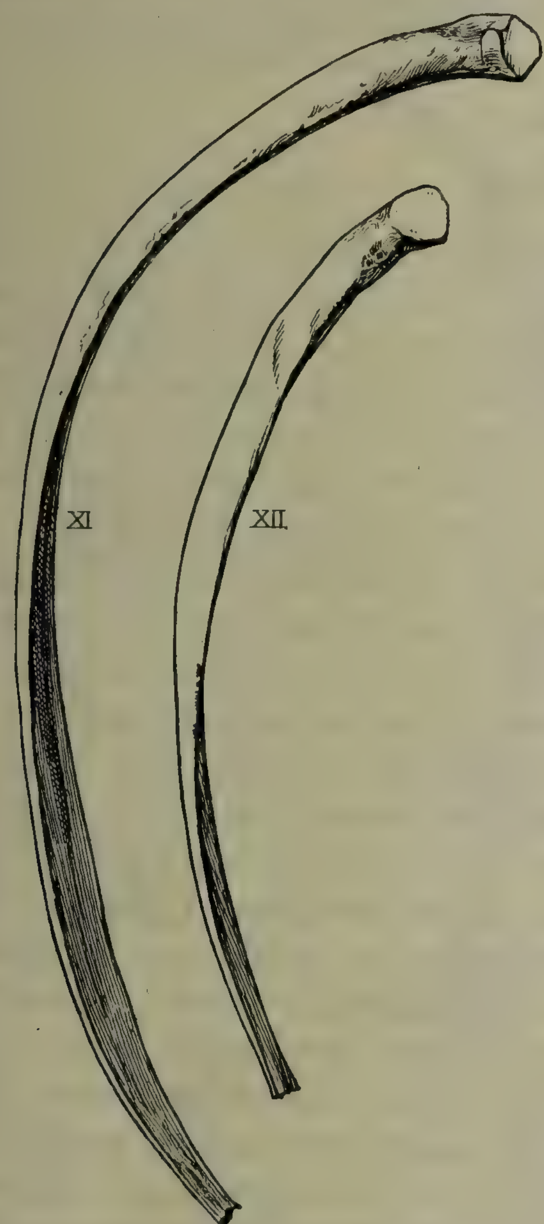


Fig. 106.—The Eleventh and Twelfth Ribs of the Left Side (Inferior View).

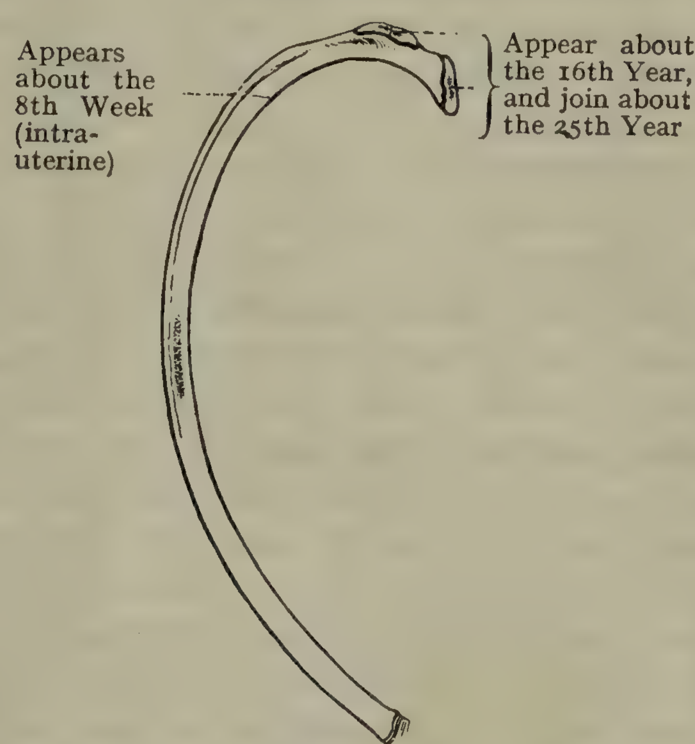


Fig. 107.—Ossification of a Rib.

Structure.—A rib is composed of loose cancellated tissue surrounded by compact bone.

Varieties.—(1) The number may be increased to thirteen on one or both sides, and the supernumerary rib may be cervical or lumbar. If cervical, it is developed in connection with the costal process of the seventh cervical vertebra. It may be free, may join the shaft of the first thoracic rib, or it may be attached to the sternum by ligament. If lumbar, it is developed in connection with the costal element of the first lumbar vertebra, is usually very short, and does not articulate with the body of that vertebra. (2) In rare cases the number

may be decreased by one, at the expense of the twelfth rib. (3) The ribs are subject to variety in form as follows: (*a*) the vertebral end of the first thoracic rib may be joined by a cervical rib, or by the vertebral end of the second rib, in which cases the variety known as *bicipital rib* occurs; (*b*) the anterior extremity of a rib may be bifurcated; (*c*) adjacent ribs may be connected by small plates of bone.

Ossification.—An ordinary rib has **one primary centre** and **three secondary centres.** The **primary centre** for the shaft appears about the *sixth week* near the angle. Ossification proceeds so rapidly along the shaft that by the fourth month the shaft is completely ossified. The **secondary centres** appear about the *sixteenth year*. One gives rise to the head, and of the other two one is for the *rough part* of the tubercle and the other for its *articular part*. The secondary centres join between *twenty* and *twenty-five*. Non-articular centres absent below sixth rib. No tubercular centres at all in eleventh and twelfth.

The Costal Cartilages.

The **costal cartilages,** which are composed of hyaline cartilage, are twelve in number on either side. The outer extremity of each is received into the oval pit on the anterior extremity of a rib, and is there maintained in position by the continuity which takes place between the periosteum of the rib and the perichondrium of the cartilage. The inner extremities of the true ribs articulate with the side of the sternum by means of synovial joints, except in the case of the *first*, which is directly united to the presternum without the intervention of a synovial membrane. The eighth, as a rule, ninth, and tenth do not reach the sternum, and they articulate with each other by synovial joints, each cartilage being widened at the place of articulation, where it sends downwards a process to the upper border of the cartilage below. In this way interchondral joints are formed between these cartilages, as well as between the eighth, seventh, sixth, and sometimes the fifth. The eleventh and twelfth cartilages are mere nodules tipping the corresponding ribs, and they have no articulation with each other, nor has the eleventh with the tenth. The cartilages increase in length from the first to the seventh, beyond which they gradually diminish to the twelfth. They diminish in breadth from above downwards. The direction of the first cartilage is inwards and downwards, and that of the second horizontally inwards, whilst the succeeding ones, except the eleventh and twelfth, incline more and more upwards as they pass inwards. Prior to middle life the first costal cartilage undergoes superficial ossification underneath the perichondrium, and so a thin shell of bone is formed around it. In advanced life this condition may be met with in the other costal cartilages to a certain extent.

C. The Sternum.

The **sternum** or breast-bone is situated in the middle line of the anterior wall of the thorax, where it articulates on either side with the first seven costal cartilages, and superiorly with the clavicle. It occupies an oblique plane, which is directed downwards and forwards, forming an angle with the vertical of about 20 degrees. It is compressed from

before backwards, of unequal width at different parts, and more or less curved from above downwards, the convexity being directed forwards, and being very pronounced in the condition known as 'pigeon-breast.' The bone is originally composed of six segments, called **sternebræ.** The first sternebra forms the manubrium (' handle ')

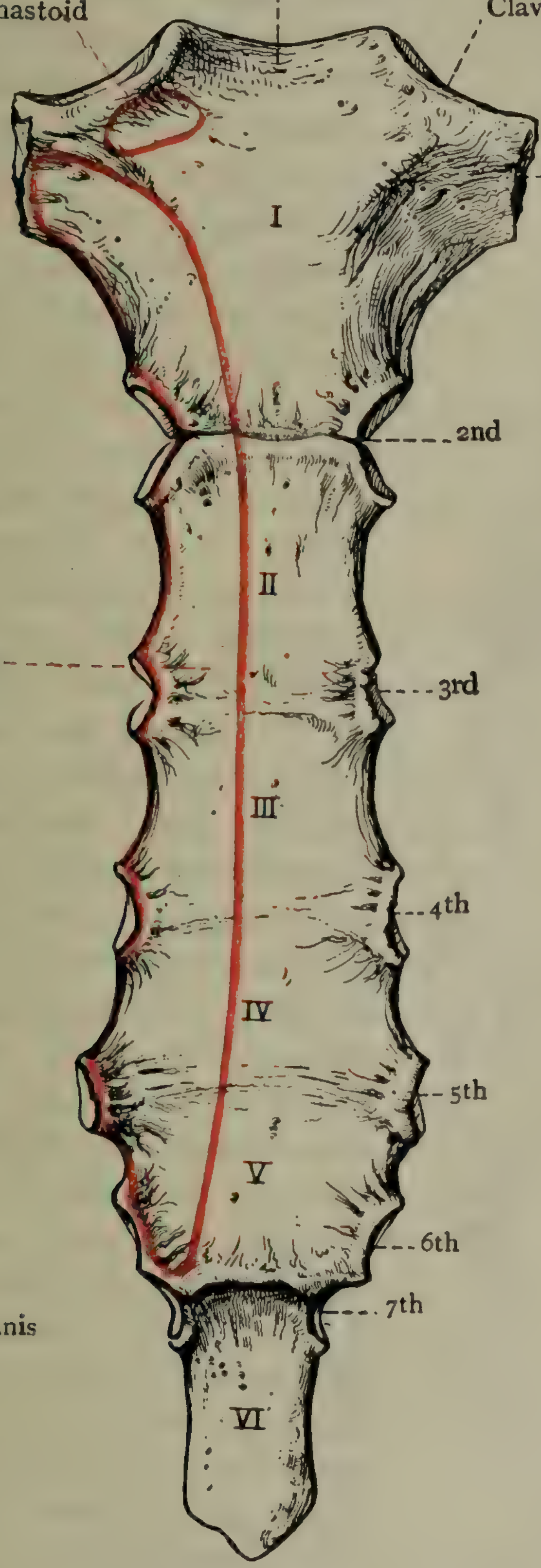


FIG. 108.—THE STERNUM (ANTERIOR SURFACE).

or presternum. The succeeding four sternebræ form the body, gladiolus, or mesosternum, and the sixth sternebra forms the ensiform or xiphoid process (*xiphisternum*), otherwise known as the metasternum.

The **manubrium** is irregularly four-sided, and broader above than below. It presents two surfaces and four borders. The *anterior*

surface is convex from side to side, and concave from above downwards. It gives origin at either side to a portion of the pectoralis major, and at its upper and outer part to the sternal head of the sterno-mastoid. Between the latter point and the clavicular depression on the upper border it gives attachment to the anterior sterno-clavicular ligament.

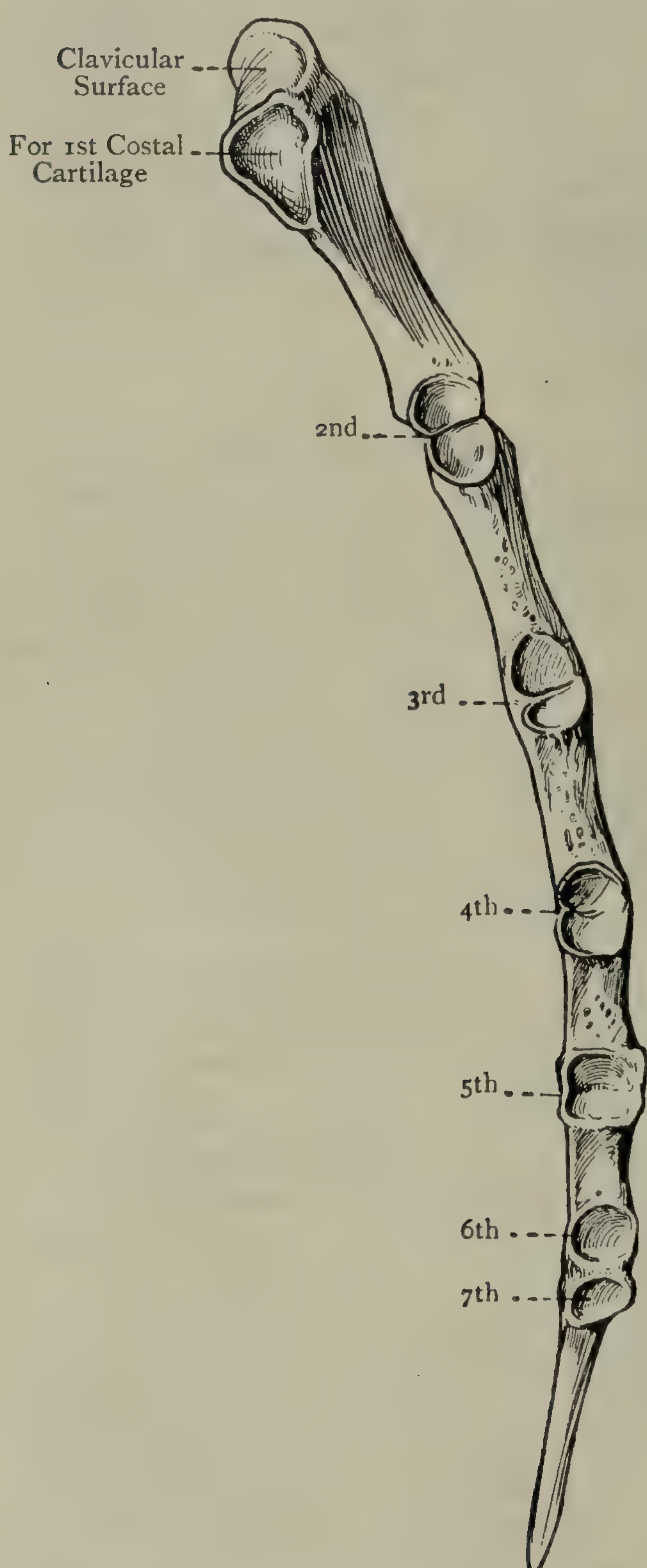


Fig. 109.—The Sternum (Lateral View).

The *posterior surface* is concave. At its upper and outer part it gives origin to portions of the sterno-hyoid and sterno-thyroid, the former being the higher of the two, and close to the clavicular depression it gives attachment to the posterior sterno-clavicular ligament. The *superior border* over its middle portion presents the *suprasternal* (*interclavicular*) *notch*, which gives attachment to fibres of the interclavicular ligament. At either side of this there is a large, oval, concavo-convex articular surface for the clavicle, which is directed upwards, outwards, and slightly backwards, an interarticular fibro-cartilage intervening between the bones. Close to the inner end of each clavicular depression there may be found, on the anterior aspect, an ossicle, known as the *episternal bone*. The *inferior border*, which is short and straight, articulates with the body, a disc of fibro-cartilage intervening. In this situation there is a transverse elevation, called the *sternal angle* (angle of Louis), which serves as a guide to the second rib at either side. Each *lateral border* slopes downwards and inwards. The upper part presents a triangular depression for the first costal cartilage, and close to the lower part a demi-facet for a portion of the second costal cartilage.

The **body** presents two surfaces and four borders. The *anterior surface* is marked by three transverse lines, which indicate the places of junction of the original four sternebræ. At either side it gives origin to a large portion of the pectoralis major. The *posterior surface* presents traces of the highest transverse line, but the lower two have usually become effaced. Adjacent to each lateral border it gives origin to a

portion of the transversus thoracis, as high as the level of the third costal facet. Each *lateral border* presents a series of costal facets, disposed as follows: close to the upper extremity there is a demi-facet for a portion of the second costal cartilage; opposite each of the three transverse lines there is an entire facet for the third, fourth, and fifth costal cartilages; and on the side of the fourth segment of the body there are usually one entire facet and one demi-facet lying close together, the former being for the sixth costal cartilage, and the latter for a portion of the seventh. Altogether there are usually four entire facets and two demi-facets on each lateral border, the demi-facets being situated one at either extremity. Sometimes, however, the inferior demi-facet is replaced by an entire facet for the whole of the seventh costal cartilage. Each of the upper three entire facets is made up of the contiguous demi-facets of two adjacent sternebræ, as in the bodies of most of the thoracic vertebræ. The *superior border* of the body articulates, as stated, with the manubrium. The *inferior border*, which is very narrow, articulates with the xiphoid process, an intersternebral disc intervening until about the fortieth year, when osseous union usually takes place.

The **xiphoid process** (or ensiform cartilage) is subject to much variety as regards condition, direction, and form. It may be entirely osseous, or osseous above and cartilaginous below. Its typical direction is downwards between the seventh pair of costal cartilages, but it may have an inclination forwards, backwards, or even to one side. It is narrow from side to side, and compressed from before backwards. It may terminate in a thin transverse border, in a sharp point, or in a bifurcated extremity. The *anterior surface* corresponds to the position of the infrasternal depression, and does not come up to the level of the anterior surface of the body. The *posterior surface*, which is flush with the posterior surface of the body, gives origin at either side to a portion of the transversus thoracis and inferiorly it gives origin to a portion of the diaphragm, usually in the form of two fleshy slips. The *superior border* articulates with the body, and the *inferior border* gives attachment to the linea alba. Each *lateral border* usually presents superiorly a demi-facet for a portion of the seventh costal cartilage, but this may be transferred to the fourth segment of the body. In rare cases there may be an entire facet for the eighth costal cartilage, this being constant in early life. The lateral border gives insertion at either side to some of the fibres of the internal oblique aponeurosis, and occasionally, at its upper part, to a portion of the rectus abdominis.

The sternum derives its blood-supply from branches of the internal mammary artery.

Articulations.—With the clavicle and first seven costal cartilages, at either side.

Structure.—The sternum is composed of cancellous tissue covered by a thin layer of compact bone.

Varieties.—(1) The sternum is sometimes characterized by its shortness, breadth, and great depression in its lower part. This condition is liable to

be met with in cobblers. (2) A *sternal foramen* may be present in the body, usually in the third or fourth segment. (3) A sternal foramen may be present in the xiphoid process. (4) In very rare cases the sternum may be intersected from end to end by a *sternal fissure*, in which cases the heart and pericardium are left uncovered (ectopia cordis). (5) The costal cartilages may articulate with the sternum *asymmetrically*. (6) Sometimes the xiphoid process is bifid at its lower extremity.

The Sternum of the Female.—The bone is usually shorter than in the male, the shortness affecting the mesosternum.

Ossification.—The sternum ossifies in cartilage from a variable number of centres. There is usually one centre for the manubrium, which appears in the *sixth month* of intra-uterine life. Sometimes there are two, placed one about the other, and there may be as many as six, placed thus . . . The first segment of the body usually ossifies from one centre, appearing in the

FIG. 110.—OSSIFICATION OF THE STERNUM.

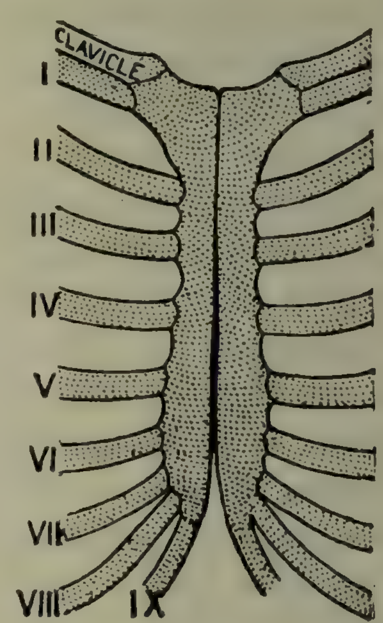


FIG. 111.—DEVELOPMENT OF THE STERNUM (MODIFIED FROM RUGE).

seventh month, though there may be two, disposed laterally. The second, third, and fourth segments of the body usually ossify from two centres each, which are disposed laterally and remain separate for some time, but subsequently unite as a rule. There may, however, be only one medial centre for each of these segments. In the second segment they appear in the *eighth month*, in the third just before birth, and in the fourth during the *first year*. The xiphoid process ossifies from one centre, which appears in its upper part from the *third* to the *sixth year*, though it may be delayed to a later period. The lower three segments of the body unite in order from below upwards, the union commencing about puberty and being completed shortly afterwards. The first segment of the body joins the remainder about *twenty-five*. The xiphoid process unites with the body about *forty*, but the manubrium usually remains permanently separate unless in advanced life, when it may become ankylosed to the mesosternum.

The sternal cartilage from which the bone is developed consists originally of two elongated strips, each of which bears the cartilages of nine ribs. The strips are separated for some time by a median fissure, but fusion subsequently takes place, and so a single sternal cartilage is formed. The eighth costal cartilage usually loses its connection with the sternum, though it may articulate

permanently with the xiphoid process. The ninth costal cartilage at either side is regarded as dividing into two parts, one of which remains connected with the sternal cartilage and forms with its fellow the xiphoid process, whilst the other acquires a connection with the eighth costal cartilage. If the parts of the ninth costal cartilages, which remain connected with the sternal cartilage, do not unite with each other over their whole extent, a bifurcated xiphoid process is the result. They usually, however, unite wholly, or sometimes in such a manner as to leave a foramen at the centre. A sternal fissure is due to the permanent separation of the two original cartilaginous strips, which, as a rule, unite to form the sternal cartilage. A sternal foramen in the second, third, or fourth segment of the body is due to ossification from two collateral centres failing to meet at the median line.

Sometimes two ossicles, called the **suprasternal bones,** are met with at either side of the interclavicular notch of the sternum. These are developed in connection with the suprasternal ligaments, which extend between the inner end of each clavicle and the upper end of the sternum. These supra- (or epi-) sternal ossicles probably represent the sternal extremities of cervical ribs.

The Thorax as a Whole.

The **thorax** constitutes an osseous and cartilaginous cage which lodges the heart and lungs, along with important bloodvessels and nerves, as well as the trachea and œsophagus. It is bounded *anteriorly* by the sternum, with the costal cartilages and anterior extremities of the first eight or nine ribs; *posteriorly* by the bodies of the thoracic vertebræ and the vertebral extremities of the ribs from the heads to the angles; and *laterally* by the ribs beyond their angles. It is barrel-shaped, the truncated apex being directed upwards, and it is somewhat flattened from before backwards.

The **superior aperture** is bounded *in front* by the upper border of the presternum and the first costal cartilages, *on either side* by the first rib, and *behind* by the body of the first thoracic vertebra. Its transverse measurement exceeds the antero-posterior, and it is reniform, due to the forward projection of the first thoracic body. Its plane is oblique, being sloped downwards and forwards, so that the upper border of the presternum is on a level with the disc between the second and third thoracic bodies. The superior aperture transmits the following structures: the apical parts of the lungs and pleuræ; the trachea and œsophagus; the vagus, sympathetic, and phrenic nerves; the terminal part of the innominate artery; the left common carotid and left subclavian arteries; and the right and left innominate veins. In early life it also transmits the thymus gland.

A fact which is seldom appreciated is that the anterior surface of the manubrium continues the plane of the upper aperture, and that perpendiculars dropped on the so-called anterior surface of the manubrium and so-called superior surfaces of the first ribs are parallel.

The **inferior aperture** is of large size, and is bounded *posteriorly* by the twelfth thoracic body, *laterally* by the twelfth rib at either side, and *anteriorly* by a line at either side, connecting the costal cartilages from the twelfth to the seventh inclusive. These two lines constitute the *subcostal angle,* within which the xiphoid process is situated. The

inferior aperture is occupied by the diaphragm, which presents certain openings for the passage of important structures.

In sketching the thorax it is useful to notice that the distance between its lower limit and the apex of the subcostal angle is about equal to the length of the sternum.

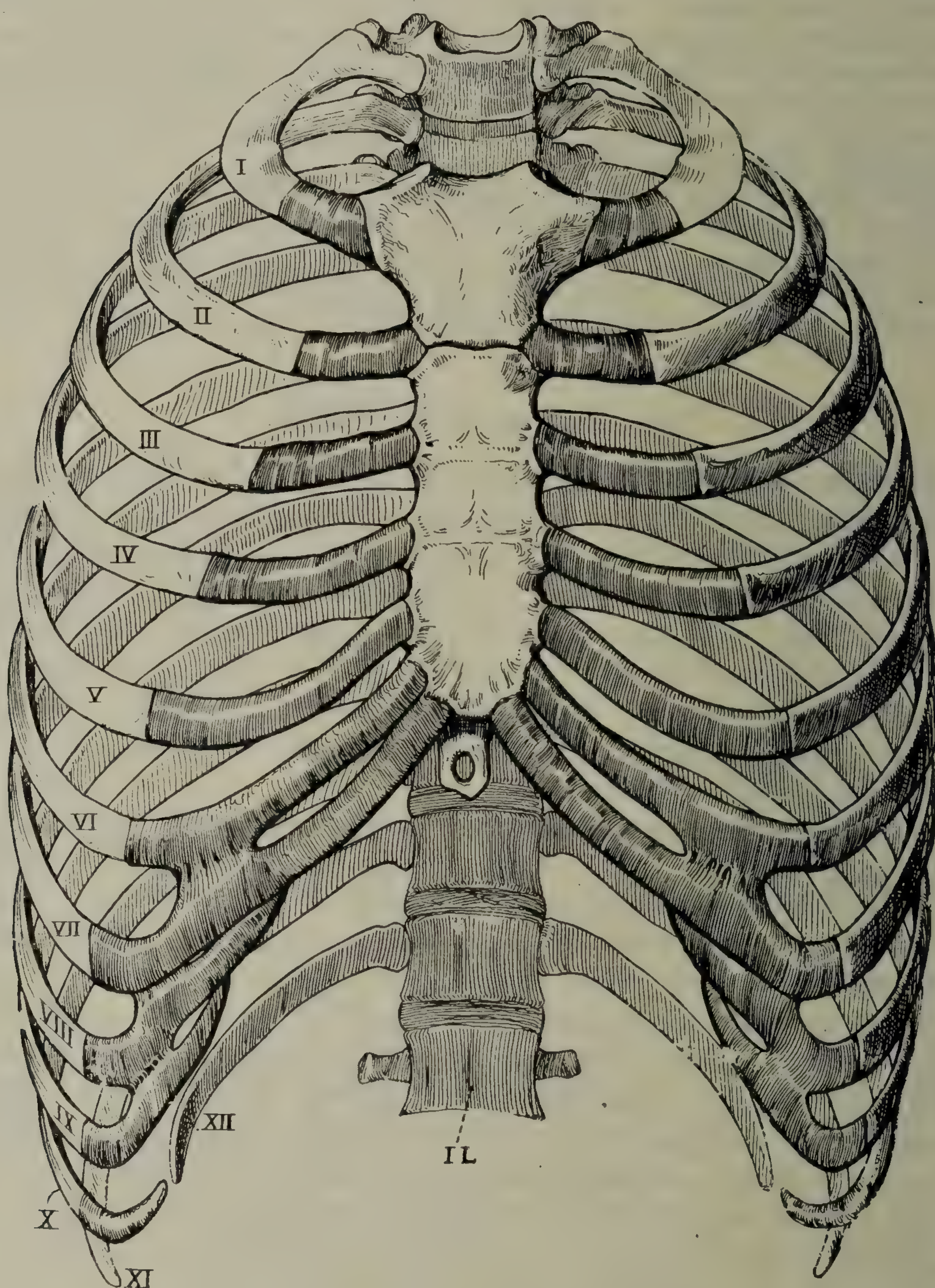


FIG. 112.—THE THORAX (ANTERIOR VIEW).

The **cavity,** on either side of the thoracic bodies, presents an elongated groove, called the *pulmonary groove,* which lodges the thick posterior border of a lung. The cavity has the following diameters—namely, vertical, transverse, and antero-posterior. The *vertical diameter* extends from the superior aperture to the inferior. The *transverse diameter* extends from the centre of a given intercostal space to the centre of the corresponding space of the opposite side.

The *antero-posterior diameter* extends from the anterior to the posterior wall, and is necessarily of less extent in the median line than at either side, on account of the projection formed by the thoracic bodies, its increase at each side being due to the presence of the pulmonary groove. The cavity is increased in all these diameters during inspiration, and diminished during expiration.

The **intercostal spaces** are eleven in number at either side. They increase in length from the first to the fifth, and are occupied for the greater part of their extent by the external and internal intercostal muscles.

The thorax of the female is rather shorter than that of the male, and is not so much flattened from before backwards.

In early life the thorax is flattened from side to side, and its height is relatively less than in the adult.

For the notochord and the development of the vertebral column, ribs, and sternum, see p. 59.

Notochord.

The notochord forms the primitive basis of the axial skeleton, and around it the bodies of the vertebræ are developed. It is a solid cylindrical rod of cells, derived from the cephalic end of the primitive streak, and it occupies the median line, corresponding to the centres of the bodies of the future vertebræ. It lies along the ventral aspect of the neural tube, which constitutes the primitive tubular nervous system, and along the dorsal aspect of the archenteron, or primitive intestinal cavity. The cephalic end of the notochord is situated on the ventral aspect of the mid-brain, and corresponds to the posterior part of the pituitary region of the base of the future cranium. From this region it extends to the caudal end of the future axial skeleton, where it is continuous with the wall of the neurenteric canal. On either side of it there are the mesodermal somites.

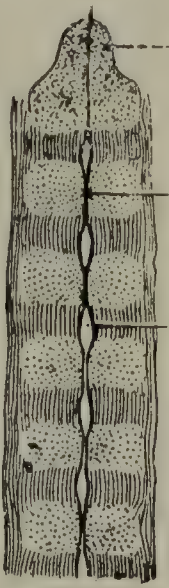


FIG. 113.—THE NOTOCHORD (CERVICAL REGION).

The notochord is of temporary duration, and a considerable part of it is replaced by the bodies of the vertebræ. Certain vestiges of it, however, persist throughout life, these being represented by the *central pulp* of the invertebral discs.

Development.—As already pointed out (p. 34 *et seq.*), the notochord is developed *descriptively* from the cell-layer which lines the roof of the cavity of the enteron. It is derived morphologically from the front wall of the neurenteric canal, 'paid in' to the growing roof of the enteron. A longitudinal thickening here, added to from behind as the embryo increases in length, forms a groove which deepens and makes the **notochordal groove.** This then closes off from the cavity of the enteron by apposition and fusion of its edges, and becomes the 'notochordal tube'; the lumen of the tube opens caudally into the enteron and the lower part of the neurenteric canal, so that all the stages of formation of the chord are to be seen in embryos in which it is still being laid down. When the caudal growth comes to an end, and the number of somites is complete, the tube becomes closed completely. The lumen of the tube exists for a very short time; it is quickly obliterated by a certain amount of swelling of the cells, with some division, the notochord now becoming a solid cylindrical rod. It extends from the end of the tail-process to the original site of the bucco-pharyngeal

membrane—that is, to a point immediately behind the pituitary body. In other words, its extent corresponds with that of the roof of the enteron. It is for the most part surrounded by the skeletal structures of the vertebral column, but it lies below the occipital region of the basis cranii, in relation with the pharyngeal roof, with which it is connected, leading to the formation of a small recess here, the *pouch of Luschka* (pharyngeal bursa). It turns up in front of this, and enters the basi-sphenoid, where it terminates in the *dorsum sellæ*.

Although descriptively derived from the roof of the enteron, there is reason to think that its origin should be classed *morphologically* with that of gastral mesoderm from the same region. This view of its origin is not to be taken as implying that it arises from mesoderm, or is a ' mesodermal structure ' in the usual and restricted meaning of the term. The matter is of great morphological interest, and has been considered in the section dealing with general development; it has not at present any practical anatomical bearing.

Development of the Vertebral Column.

The notochord forms the axis round which the vertebral column is developed, and the formation of the notochord may be regarded as constituting the first or **notochordal stage.** The notochord and the neural tube, which lies along its dorsal aspect, becomes surrounded by mesenchyme (mesoderm), and this undergoes chondrification and subsequently ossification. As the process of ossification proceeds, a great part of the notochord becomes constricted at regular intervals, where the bodies of the vertebræ are undergoing ossification, and these portions of it ultimately disappear. The parts of it, however, round which the intervertebral discs are formed persist and constitute the *central pulp* of each disc, as stated.

In addition to the notochordal stage of development, there are three other stages—namely, membranous, cartilaginous, and osseous.

Membranous or Blastemal Stage.—As already described (p. 59 *et seq.*), the vertebræ are formed in the cell-mass composed of the anterior half of one sclerotome (Fig. 114) joined with the posterior half of the sclerotome in front of it. They are therefore *intersegmental in position,* and the intersegmental artery (*a* in the figure) thus comes to lie on the side of the vertebral body. The thick posterior subdivision of the *sclerotome*—which is therefore the anterior or upper part of the secondary and intersegmental *vertebral formation*—first comes into relation with the notochord and surrounds it, and then gives extensions dorsally and ventro-laterally; these pass between the adjacent margins of the original segmental somites which gave origin to the sclerotomes concerned, and are hence intersegmental. The **dorsal process** or **vertebral arch** is the blastemal rudiment of the vertebral arch. The **ventro-lateral** or **costal process** extends on each side toward the lateral sheet of mesoderm. The looser anterior subdivision of the sclerotome, or posterior part of the vertebral formation, also reaches the notochord and helps to cover it, and fills up the intervals between the dorsal processes. It becomes inseparably associated with the posterior subdivision of the sclerotome in front of it.

The **cartilaginous stage** begins with the formation of a chondral centre in the posterior part of each half of a vertebral formation—that is, in the anterior subdivisions of the more posterior of the original sclerotomes particularly concerned. Centres also appear in the dorsal and ventro-lateral processes, thus making cartilaginous *neural arches* and *primitive ribs.* These cartilaginous structures, extending, become continuous with the cartilaginous body of the vertebra. In the case of the rib-process, however, the continuity is only temporary, and the cartilaginous rudiment of a rib becomes secondarily separate on each side; later it comes into contact with a ' transverse process ' projecting from the neural arch chondrification.

The vertebral ends of the costal processes grow towards one another, and fuse below the notochord, constituting here the so-called **hypochordal bow** or **bar**; the bar is only distinctly formed in the upper cervical region, and it may

be that the temporary fusion of the processes with the vertebral centra is associated with the want of definition of this structure at a lower level. However this may be, the hypochordal bar only persists entirely in the case of the *atlas*, where it forms the anterior arch. In the next few cervical vertebræ the bar

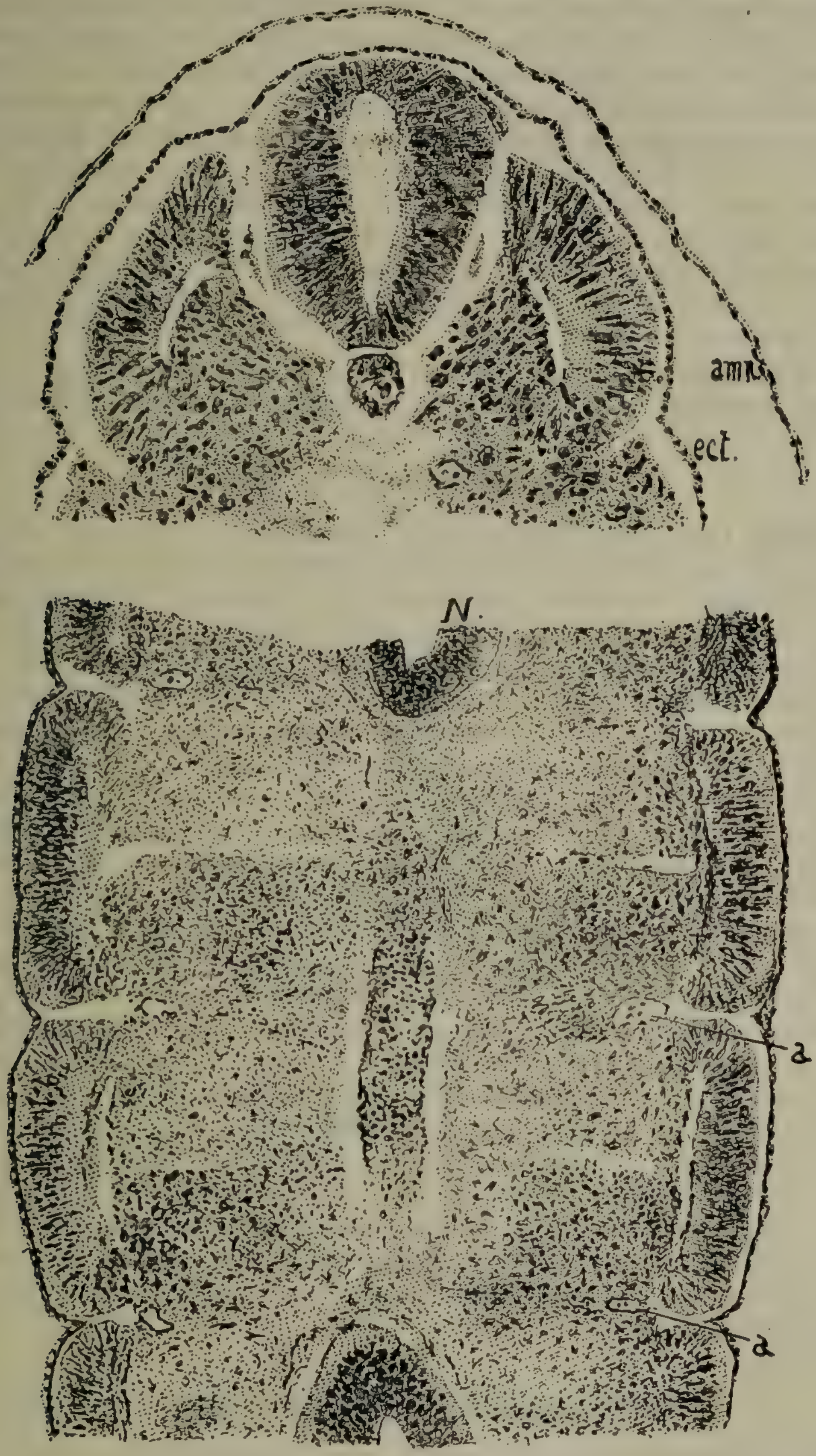


FIG. 114.—TRANSVERSE SECTION OF HUMAN EMBRYO DURING FOURTH WEEK TO SHOW SCLEROTOMES.

Longitudinal horizontal section of same to show subdivision of same: *a*, intersegmental vessel; N, neural tube. The lower end of the section is the caudal end, and the notochord is divided longitudinally.

is formed more or less distinctly, but is secondarily lost in the upper and ventral aspect of the growing centrum.

The *intervertebral discs* are formed from the loose mesenchyme between the subdivisions of the sclerotomes. This tissue, although it increases in amount,

does not compress the notochord, which enlarges within it and makes the *nucleus pulposus* of the disc. In the case of the cartilaginous centra, however, their growth entails pressure on the notochord, leading to its atrophy and subsequent disappearance within them.

In the **atlas** the hypochordal bar forms the *anterior arch,* connected therefore with the rudimentary *costal processes* and, secondarily, with the *vertebral arch.* All these are derived from the anterior part of the vertebral formation, or posterior subdivision of the anterior sclerotome. The usual chondral centres of the *centrum* are developed in the posterior portion of the vertebral formation, however, but do not fuse with the anterior arch, but with the corresponding centrum of the next vertebra, making its odontoid process. At the other end of the column, also, modifications in the development are found, but these take the form of defects, in accordance with the defective development of the hinder portions of the column. The defects are mainly in the neural arch formations and need not be considered in detail.

The final or **osseous stage** of the vertebral formation has already been dealt with under the heading ' Ossification ' in the descriptions of the different parts of the column.

Development of the Ribs.

The **primitive ribs,** represented by the *costal processes* of the blastemal vertebræ, and of the cartilaginous stage, become the separate **secondary ribs** when the temporary chondral continuity is resolved. These secondary ribs, *in the thoracic region,* extend outwards above the broad pericardium and liver, and turn ventrally round these as they grow. In the middle of the second month their distal ends, though they have not as yet grown half-way round the body, are joined together by a blastemal **sternal plate ;** the upper ends of the two plates are connected by a mesenchymal condensation associated with the ends of the clavicles, and the lower end of each plate is placed indefinitely about the level of the eighth rib. The membranous ribs grow in length, chondrification extending somewhat later. The sternal plates meet over the pericardium, but the ribs over the liver do not close, their ends showing instead a tendency to fuse together away from the mid-ventral line. *In the cervical region* no true secondary ribs are formed, as the costal processes do not separate from the cartilaginous centra. Distinct chondral centres for the costal processes have been denied for the vertebræ above the seventh, but it is probable that they do appear normally, and join the centra quickly. In the *lumbar and sacral regions* there occurs also a rapid fusion of the distinct costal centres with the bodies and vertebral arches. In the lumbar type chondrification only affects the basal portions, the rest of the costal process of the blastemal stage remaining, and ossifying, in membrane. In the *sacrum* the distal ends of the costal processes enlarge and join to form a cartilaginous plate, which constitutes the *lateral piece* of the sacrum. This fusion does not occur in the lower sacral vertebræ, whose costal processes are reduced, and the reduction is carried farther in the first coccygeal formation.

Development of the Sternum.

The ventral extremities of the upper nine cartilaginous ribs, on either side, become expanded, and these portions unite. In this manner an elongated strip of cartilage is formed on either side, each of which bears nine cartilaginous ribs. These strips are known as the **hemisternal cartilages,** and by their union a **single sternal cartilage** is formed. This cartilaginous sternum undergoes ossification in the manner described in connection with the sternum as a bone.

The eighth and ninth cartilaginous ribs, on either side, lose their connection with the hemisternal cartilages, and the portions of these hemisternal cartilages, which are contributed by the expanded ventral or anterior ends of the eighth and ninth cartilaginous ribs, give rise, by their union, to the **cartilaginous xiphoid process** (ensiform process).

In exceptional cases ossification may take place in each hemisternal cartilage independently, and under these circumstances the *hemisterna* may remain permanently separate, thus giving rise to the extremely rare condition of *sternal fissure.*

The two halves of the cartilaginous metasternum usually unite along their entire extent. Their distal ends, however, may remain permanently separate, and so give rise to a *bifurcated xiphoid process.* Again, the two halves may unite in such a manner as to leave a permanent *xiphisternal foramen.* The presence of a *sternal foramen* is explained under **Varieties of the Sternum.**

CHAPTER V

THE BONES OF THE HEAD

THE **head** or **skull** is supported on the upper end of the vertebral column, and is divisible into the cranium and face. The **cranium** or brain-case is composed of eight bones—namely, the occipital, two parietals, frontal, two temporals, sphenoid, and ethmoid. The **face,** which protects organs of special sense, such as the eyes, the olfactory mucous membrane, and the tongue, and also supports the teeth, is composed of the following fourteen bones, the majority of which are arranged in pairs: the two maxillæ, two zygomatics, two nasals, two lacrimals, two inferior nasal conchæ, two palatine bones, the vomer, and the mandible. All the bones of the skull, except the mandible, are immovably united by sutures.

The Occipital Bone.

The **occipital bone** is so named because it occupies the posterior and inferior parts of the cranium. It is lozenge-shaped and curved, its long axis extending from above downwards and forwards. At its lower and anterior part there is a large opening, called the foramen magnum, by which the cranial cavity communicates with the vertebral canal. The bone is divisible into four parts, which meet around this opening. The part behind is called the squama, that in front the basilar part, and the part at either side the condylar portion.

The **squama** presents two surfaces, three angles, and four borders. The *posterior* or *external surface* is convex and projected at its centre into the **external occipital protuberance,** from which a median ridge, called the **median nuchal line,** passes downwards and forwards to the foramen magnum. The protuberance and line give attachment to the ligamentum nuchæ. Arching outwards on either side from the protuberance to the lateral angle there is the **superior nuchal line,** the convexity of which is directed upwards. The two lines with the protuberance divide this surface into an upper or interparietal and a lower or supra-occipital part. A little above each superior nuchal line there is the **highest nuchal line,** which has a bold curve with the convexity upwards, and gradually subsides in the superior nuchal line externally. Between these two lines there is a semilunar area, over which the bone is smooth and dense. The highest nuchal line gives attachment to the epicranial aponeurosis medially, and to fibres of the occipitalis laterally. The superior nuchal line gives origin over about its inner third to the trapezius, and laterally to fibres of the occi-

pitalis, whilst over its outer half, or more, it gives insertion to the sterno-mastoid, immediately below which the splenius capitis is inserted over about the outer third. The portion of this surface above the highest nuchal lines is smooth, convex, and covered by the epicranial aponeurosis. The portion below the superior nuchal lines, which is rough and irregular, is divided into two equal lateral parts by the median line, and each of these is subdivided into an upper and lower portion by

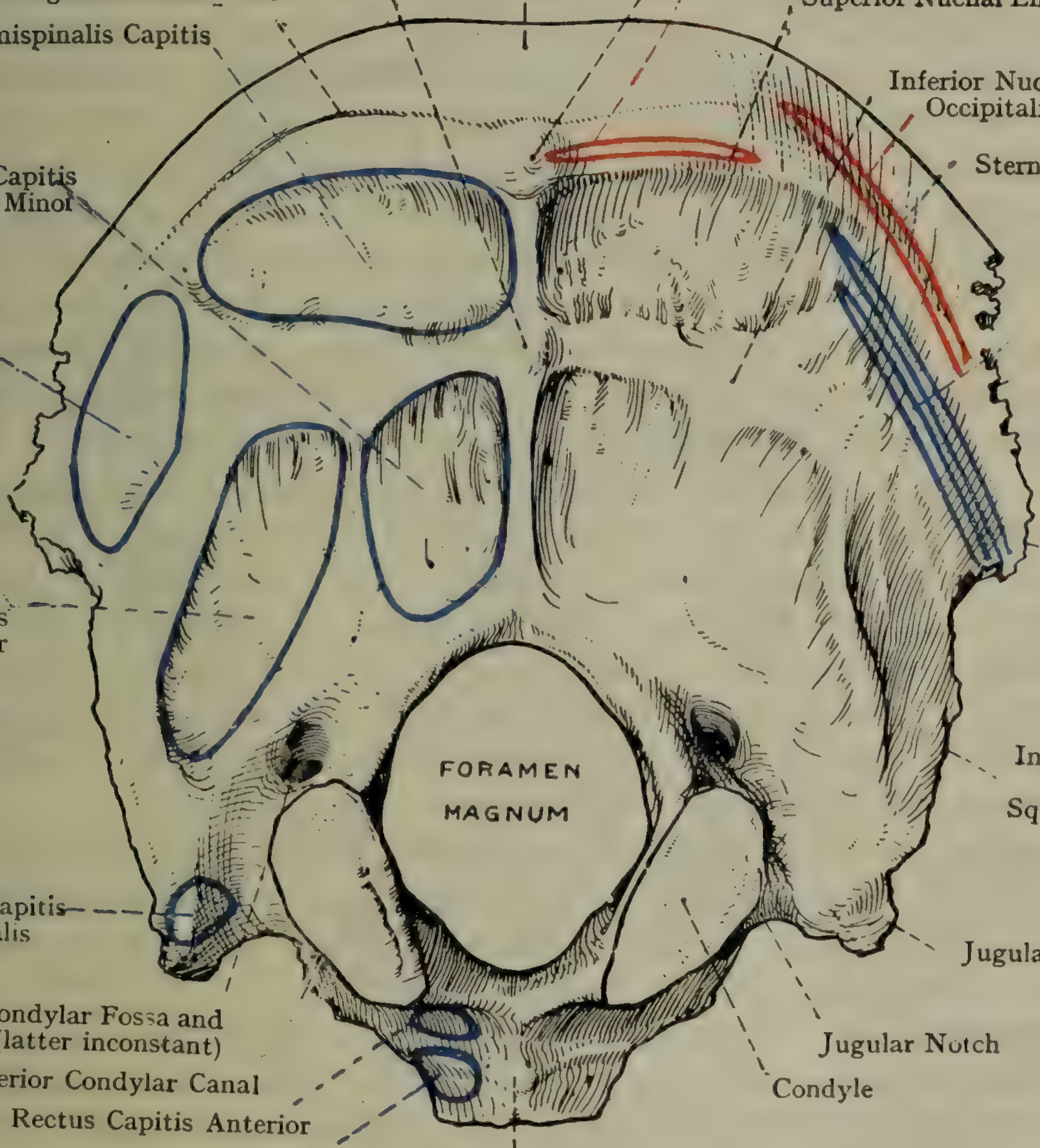


FIG. 115.—THE OCCIPITAL BONE (EXTERNAL VIEW).

the **inferior nuchal line,** which extends from the centre of the crest to the extremity of the jugular process. The space between the superior and inferior nuchal lines gives insertion medially to the semispinalis capitis and laterally, from above downwards, to the splenius capitis and obliquus capitis superior. The inferior nuchal line gives insertion over its outer part to the rectus capitis posterior major. The inner third of this line and the surface between that extent of it and the foramen magnum give insertion to the rectus capitis posterior minor.

The *anterior* or *internal surface* is irregularly concave and divided into four fossæ by two ridges—a longitudinal, extending from the superior angle to the foramen magnum, and a transverse, extending from one lateral angle to the other. At the point where these two ridges intersect there is the **internal occipital protuberance.** The upper half of the longitudinal ridge gives attachment to a portion of the falx cerebri, and is marked by a groove for the superior sagittal venous sinus, this groove being confined to one side of it, usually the right. The lower half is sharp and wiry, and is called the **internal occipital crest.** It gives attachment to the falx cerebelli, and is occasionally grooved for the occipital venous sinus. Near the foramen magnum it divides into two parts, which diverge as they pass to that opening, and enclose between them the *vermian fossa*, which receives a part of the vermis of the cerebellum. The transverse ridge gives attachment to the tentorium cerebelli, and is deeply grooved along each half of the transverse venous sinus. On one side of the internal occipital protuberance, usually the right, there is a wide depression, at which point the longitudinal groove is continued into the corresponding lateral groove. This depression lodges the **torcular Herophili** (or *confluence of the sinuses*), which is a dilatation formed where the superior sagittal sinus bends sharply to become continuous with the right transverse sinus. The four fossæ are arranged in a superior pair, called superior occipital or cerebral, and an inferior pair, called inferior occipital or cerebellar. Each cerebral fossa presents a number of digitate impressions for the convolutions of the occipital lobe of the cerebrum, which is lodged in it. The cerebellar fossæ, which are separated by the internal occipital crest, are smooth, but may show transverse striations. They are much thinner then the cerebral, and lodge the hemispheres of the cerebellum.

The **angles** are superior and two lateral. The superior angle forms the highest part of the bone, and fits in between the postero-superior angles of the parietals. The lateral angles are situated at either end of the transverse ridge on the internal surface.

The **borders** are two superior and two inferior. Each superior border extends from the superior angle to the lateral angle, and is serrated for the posterior border of the corresponding parietal. Each inferior border extends from the lateral angle to the jugular process, and is faintly serrated for the mastoid portion of the temporal.

The **basilar part** (basi-occipital) is a compressed quadrilateral mass, which projects forwards and upwards in front of the foramen magnum. Its *superior surface* presents a broad median depression, called the **basilar groove,** which is sloped downwards and backwards to the foramen magnum, and lodges the medulla oblongata. At either side of this groove there is a narrow groove for the inferior petrosal venous sinus. The *inferior surface* presents at its centre the **pharyngeal tubercle** for the fibrous raphé of the pharynx. On either side of this tubercle there is a rough, oblique impression for the insertion of the longus capitis, and between the outer part of this

impression and the foramen magnum the surface gives insertion to the rectus capitis anterior. The *anterior border* is thick, rough, and truncated, and up to the twentieth year it articulates with the body of the sphenoid by synchondrosis, but thereafter ankylosis takes place. The *posterior border*, which is thin, smooth, and concave, bounds anteriorly the foramen magnum, and sometimes presents a third occipital condyle of small size for articulation with the tip of the odontoid process of the axis. This border gives attachment to the

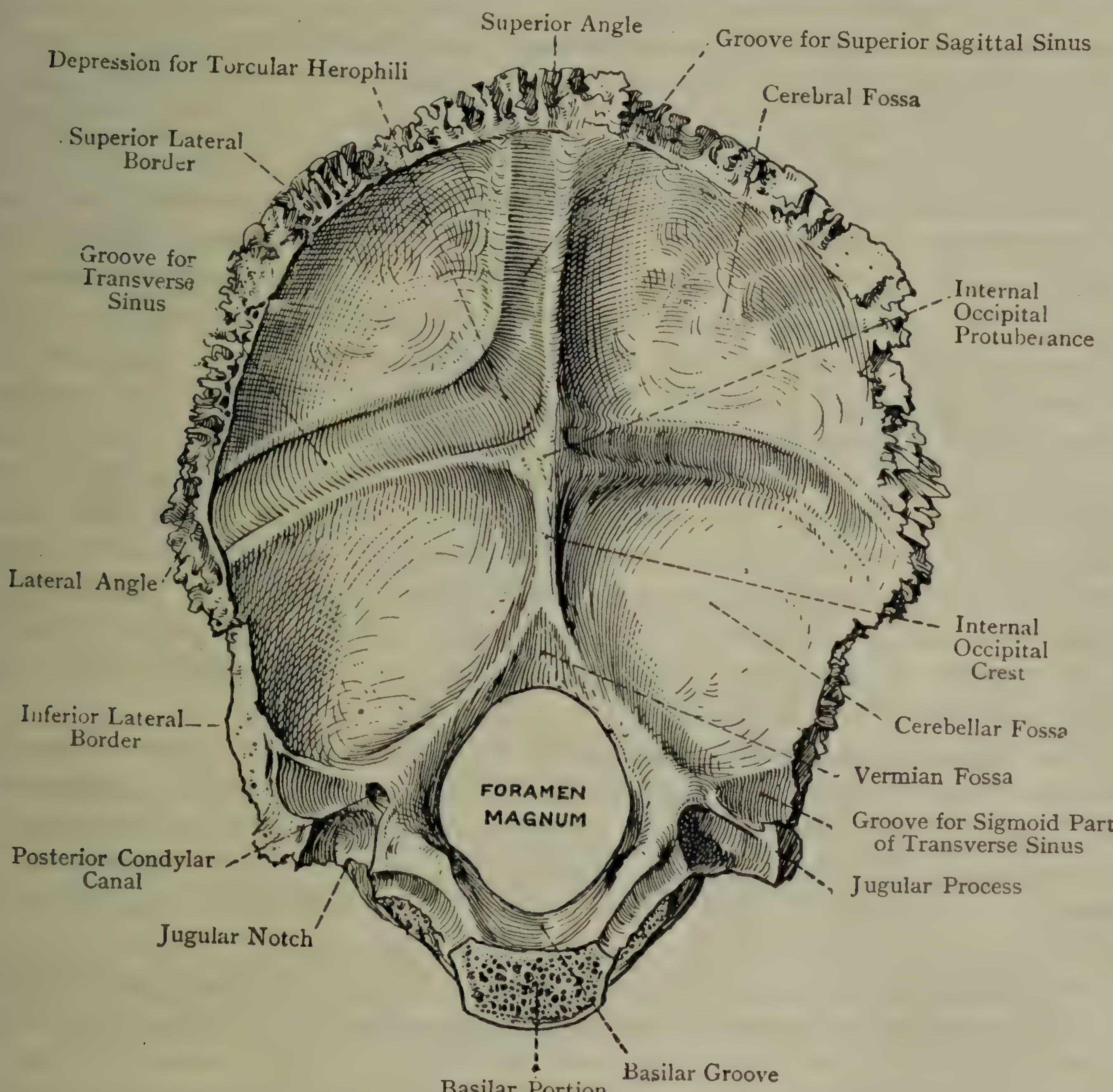


FIG. 116.—THE OCCIPITAL BONE (INTERNAL VIEW).

apical ligament of the odontoid process. Each *lateral border* is thick and rough for the petrous portion of the temporal.

The **condylar portions** (exoccipitals) are placed on either side of the foramen magnum, where they extend as far back as its posterior margin, and very nearly as far forwards as its anterior margin. Each bears on its under surface the greater part of a condyle. The **condyles** are oval, convex, and covered by cartilage, and they articulate with the superior articular processes of the atlas. Their long axes are directed forwards and inwards, and the direction of each surface is

downwards and slightly outwards. They do not extend farther back on the lateral margins of the foramen magnum than the level of the centre, and the front part of each belongs to the basilar portion. The circumference of a condyle gives attachment to the capsular ligament of the corresponding atlanto-occipital joint, and on the inner aspect of each there is a tubercle for the alar ligament. Lateral to the front of each condyle is the **anterior condylar canal,** which opens forwards and outwards from the cranial cavity. It transmits the hypoglossal nerve and a meningeal branch of the ascending pharyngeal artery. Behind each condyle is the **posterior condylar fossa,** which may be pierced by a posterior condylar canal, on one or both sides, for an emissary vein passing between the intracranial transverse (sigmoid) sinus and the extracranial suboccipital venous plexus. The part external to the condyle is called the **jugular process,** which lies above the transverse process of the atlas, and is homologous with it. Posteriorly it is continuous with the tabular portion, and anteriorly it presents the **jugular notch,** which, with the jugular fossa of the petrous portion of the temporal, forms the jugular foramen. Superiorly it presents a short, but deep and wide, groove for a portion of the sigmoid venous sinus just before it leaves by the jugular foramen. This groove may be pierced by a posterior condylar canal. Inferiorly it gives attachment to the rectus capitis lateralis, and may send downwards a projection towards the transverse process of the atlas, which represents the *paroccipital process* of comparative anatomy. Laterally the jugular process articulates with the jugular facet on the petrous portion of the temporal by synchondrosis up to the twenty-fifth year, after which ankylosis takes place.

The **foramen magnum** is situated at the lower and anterior part of the bone, and is oval, its long axis extending from before backwards. The anterior margin, in front of the condyles, gives attachment to the anterior atlanto-occipital membrane, and, behind them, to the posterior atlanto-occipital membrane. The foramen transmits the central nervous axis and its membranes, the spinal accessory nerves, the vertebral arteries, the anterior spinal arteries, meningeal branches of the ascending pharyngeal artery, and parts of the cerebellar amygdalæ.

The chief blood-supply of the bone is derived from the occipital and posterior auricular arteries.

Articulations.—*Superiorly* with the parietals, *laterally* with the temporals (mastoid and petrous portions), *anteriorly* with the sphenoid, and *inferiorly* with the atlas, and in rare cases with the odontoid process of the axis.

Structure.—The occipital, being a tabular bone, is composed of two tables of compact bone, with cancellous tissue, called diploë, between them.

Varieties. — (1) There may be a minute foramen piercing the external occipital protuberance for an emissary vein, which passes between the intracranial torcular Herophili and one of the tributaries of the extracranial occipital

vein. (2) The upper division of the tabular portion may be separate, representing the **interparietal bone** of comparative anatomy, and it may be in one piece, or in two or more. (3) The semilunar area between the highest and superior nuchal lines may be prominent, constituting the *torus occipitalis transversus*. (4) The anterior condylar canal may be double on its cranial aspect. (5) There may be a third occipital condyle on the anterior margin of the foramen magnum. (6) There may be a paroccipital process on the under aspect of the jugular process. (7) The condyle may be divided into two parts, anterior and posterior. (8) There may be an intrajugular process on the front of the jugular notch, which may extend as far as the petrous portion of the temporal. (9) The upper angle may form a separate bone, known as the pre-interparietal.

Ossification.—The bone is developed in **four parts.** The **squamous portion** usually ossifies from **four centres,** which appear around the internal occipital protuberance about the *eighth week* of intra-uterine life. Two are deposited in cartilage, one for each cerebellar fossa, which soon fuse and give rise to the lower or supra-occipital division. The other two are deposited in membrane, one in each cerebral fossa, which also soon fuse, and give rise to the upper or interparietal division. Indeed, as a general rule, all four ultimately blend.

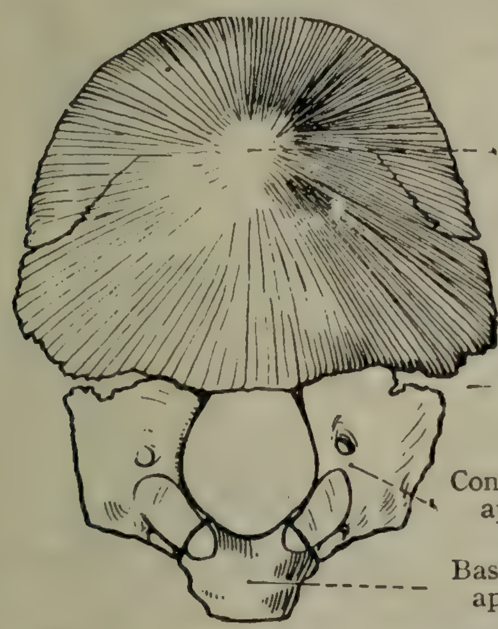


FIG. 117.—OSSIFICATION OF THE OCCIPITAL BONE.

The figure shows the condition of the bone at birth.

There may, however, be two other centres for the interparietal portion, placed on either side of the middle line not far from the future superior angle, which occasionally remain as separate ossicles, or they may fuse and give rise to the pre-interparietals. The interparietal portion may remain separate from the supra-occipital, with which it may be connected by a suture, or they may be separated by a partial fissure. Fissures, which persist for some time after birth, intersect the tabular part at the superior and lateral angles, and a membranous interval extends from the protuberance to the foramen magnum in early life, which remains for some weeks, after which it is replaced by bone. It is in this latter situation that an encephalocele may occur. The **basilar** and **condylar parts** have each **one centre** appearing in cartilage about the *ninth week*, the anterior part of each condylar portion deriving its ossification from the basilar centre. At birth the bone is in four parts, connected by cartilage. Union between the tabular and condylar portions is completed by the *fifth year*, and the condylar and basilar portions unite about the *sixth year*. Between *seventeen* and *twenty* the basilar portion joins the sphenoid, and at the *twenty-fifth year* the jugular process becomes ankylosed to the petrous portion of the temporal.

Obstetrical Hinge-Joint (of Budin).—At birth the tabular or squamous portion of the occipital bone is connected with the two condylar portions by a band of

cartilage. This region is known as the **obstetrical hinge-joint (of Budin).** The connection is such as to allow of limited swinging or see-saw movements in front of, and behind, the cartilaginous band, by which movements the diameters and form of the child's head are liable to be modified during labour.

The Parietal Bones.

The **parietal bones** are so named because they form a large part of the cranial wall. They lie between the frontal and occipital, and superiorly they articulate with each other by the sagittal or inter-parietal suture. Each bone is quadrilateral and curved, and presents

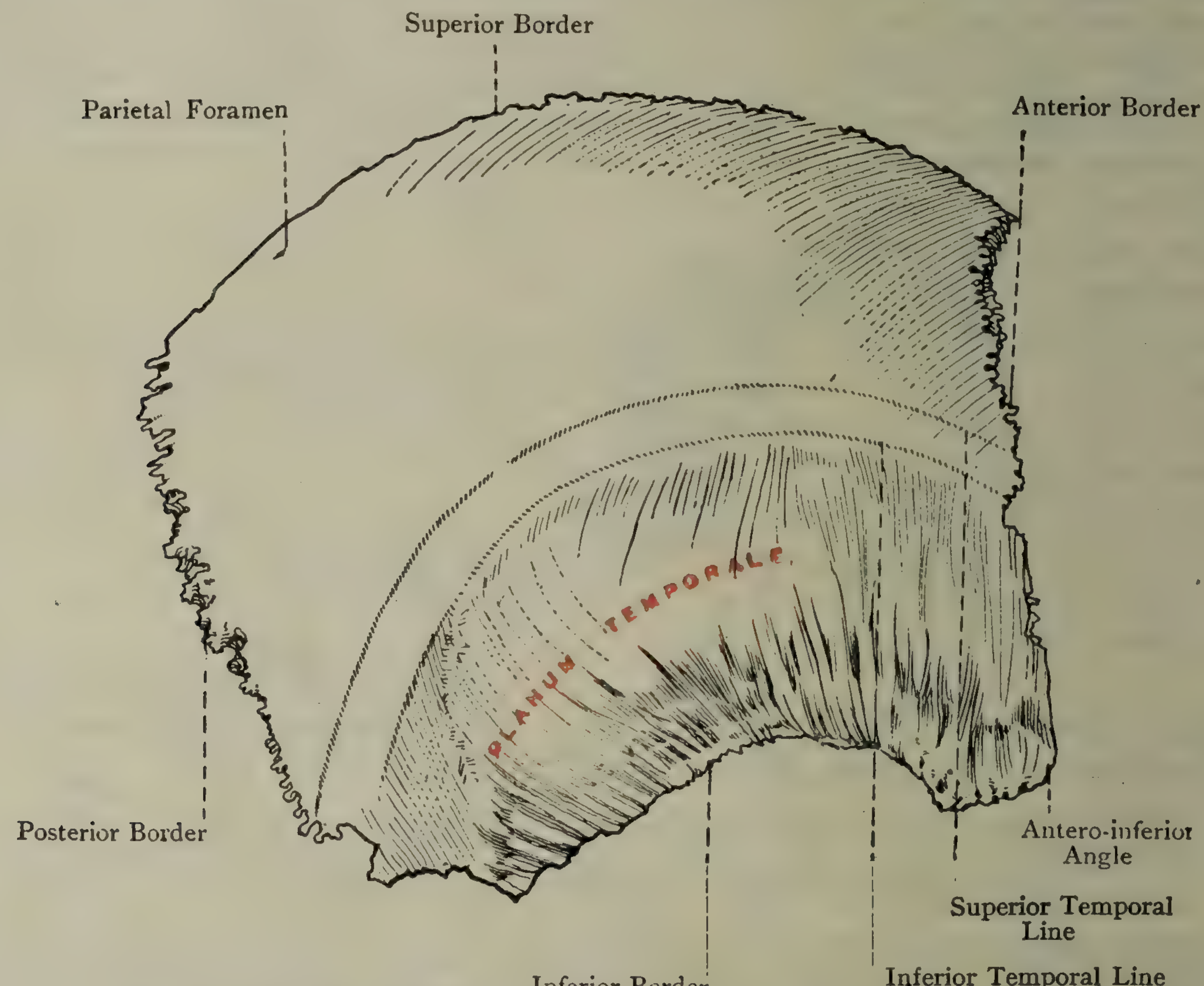


FIG. 118.—THE RIGHT PARIETAL BONE (EXTERNAL VIEW).

two surfaces, four borders, and four angles. The *external surface* is convex, and near its centre is more elevated than elsewhere, this part, from which ossification originally proceeds, being called the **parietal eminence.** About this spot the surface is crossed from before backwards by two curved lines, called the **superior** and **inferior temporal lines,** the narrow space between which is smoother and more glistening than the rest of the surface. The part above the superior line is covered by the epicranial aponeurosis, and the ridge itself gives attachment to the temporal fascia. The inferior temporal ridge limits the origin of the temporal muscle, and the portion between it and the inferior border, which is vertically striated and called the *planum temporale,* forms a part of the temporal fossa, and gives origin to fibres

of the temporal muscle. Near the superior border, about an inch in front of the postero-superior angle, may be the **parietal foramen,** for an emissary vein which passes between the intracranial superior sagittal sinus and one of the tributaries of the extracranial occipital vein.

The *internal surface* is concave, its deepest part, opposite the parietal eminence, being known as the parietal fossa. This surface presents a number of digitate impressions for the convolutions of the parietal and part of the frontal lobes of the cerebrum, and a system of branching meningeal grooves for the divisions of the middle meningeal artery. These begin as two grooves, each of which soon becomes arborescent. The anterior, the larger of the two, starts at the antero-

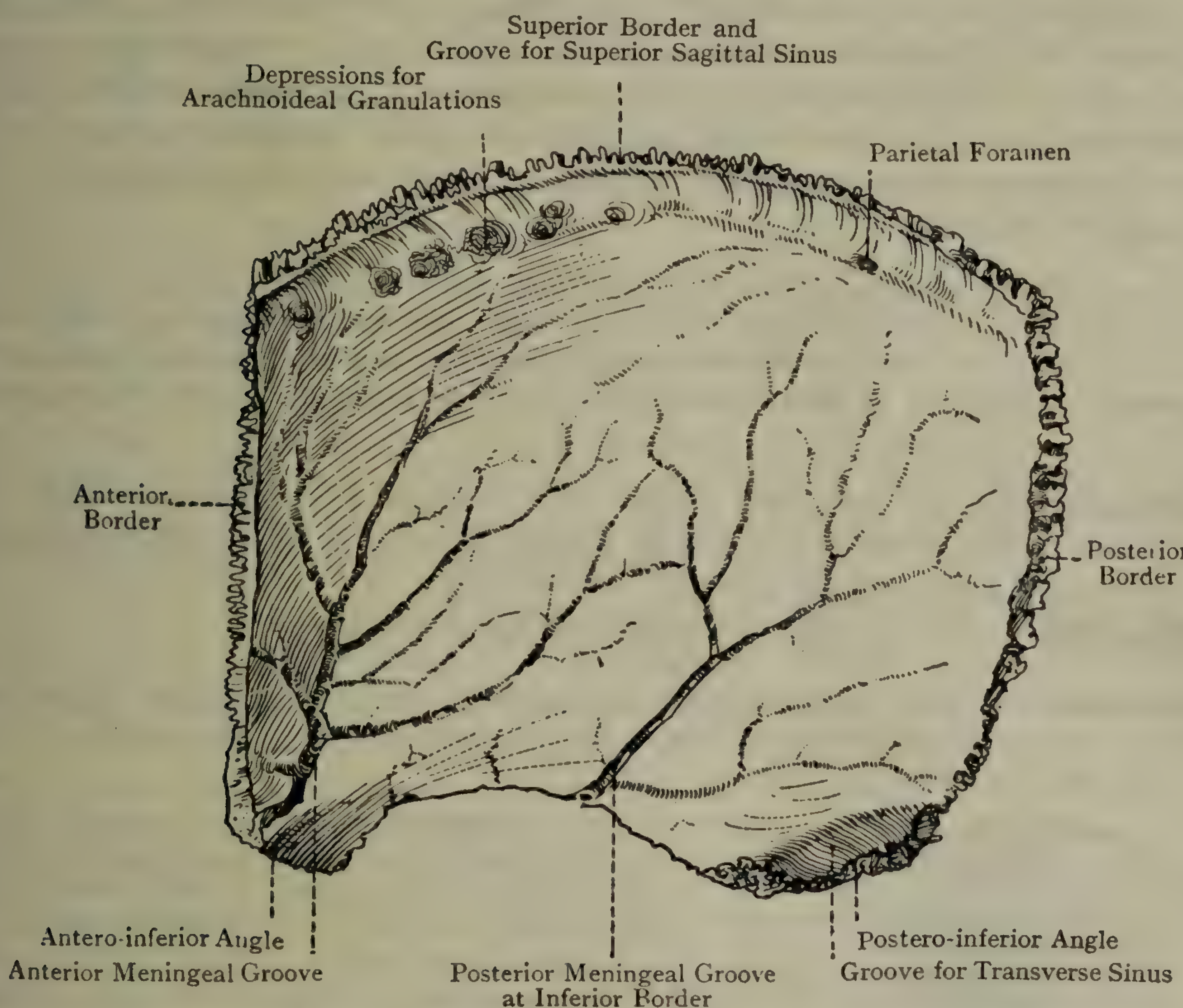


FIG. 119.—THE RIGHT PARIETAL BONE (INTERNAL VIEW).

inferior angle, where it may be bridged over into a short canal, and the posterior begins at the centre of the inferior border. Superiorly, close to the upper border, there is a half groove which, with that of the opposite bone, lodges the superior sagittal venous sinus. Along the course of this groove, but lateral to it, are several depressions, best marked in old persons, which lodge the arachnoideal granulations (Pacchionian bodies). Close to the postero-inferior angle there is a short groove for part of the transverse venous sinus.

Borders.—The posterior, anterior, and superior borders are serrated. The *posterior* border articulates with the occipital; the *superior,* with its fellow; and the *anterior* with the frontal. The anterior border is

bevelled below at the expense of the inner plate, where it overlaps the frontal, and it is slightly bevelled above at the expense of the outer plate, where it is overlapped by the frontal. The *inferior border*, which is the shortest, is for the most part concave and markedly bevelled at the expense of the outer plate, where it is overlapped by the squamous portion of the temporal. Posteriorly, however, it is serrated for the superior border of the mastoid portion of the temporal.

Angles.—The *antero-superior* angle, with its fellow, lies in the situation of the original anterior fontanelle or *bregma*. The *postero-superior* angle, with its fellow, occupies the region of the original posterior fontanelle or *lambda*. The *postero-inferior* angle is truncated, and articulates with the mastoid portion of the temporal, being also recognized by the short groove for the transverse venous sinus on its inner aspect. This region is the *asterion*. The *antero-inferior* angle is prolonged and pointed, and articulates with the great wing of the sphenoid, being also recognized by the large anterior meningeal groove on its inner surface.

Occasionally the parietal fails to articulate with the sphenoid at this point, which is known as the pterion. In that case the frontal will meet the temporal, as it usually does in monkeys, and may be regarded as an atavistic or retrogressive variation, or there may be a Wormian bone known as the epipteric ossicle.

Articulations.—*Posteriorly* with the occipital, *superiorly* with its fellow, *anteriorly* with the frontal, *antero-inferiorly* with the sphenoid, and *inferiorly* with the temporal.

Structure.—It is a characteristic tabular bone.

Varieties.—(1) The bone may persist in two parts, upper and lower, connected by an antero-posterior suture. (2) The parietal foramen may be absent on one or both sides.

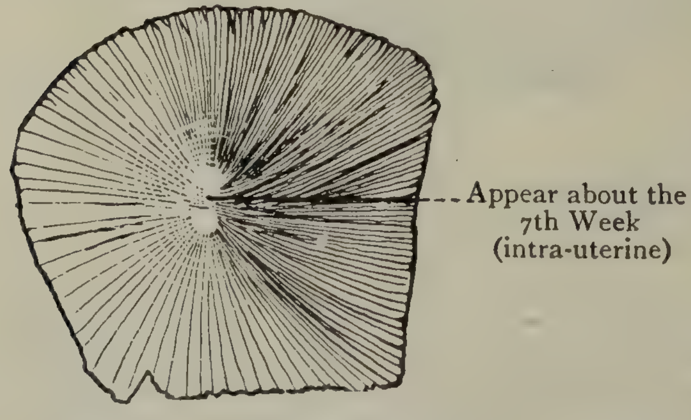


Fig. 120.—Ossification of the Parietal Bone.

Ossification.—The parietal ossifies in membrane from **two centres,** which appear about the *seventh week* in the region of the future parietal eminence, one above and the other below it, and soon coalesce. The ossification radiates from this point in such a manner as to leave a notch on the upper border a little in front of the postero-superior angle, which forms one-half of the sagittal fontanelle of the earlier half of fœtal life, the lateral part of which persists as the parietal foramen.

The Frontal Bone.

The **frontal bone** forms the forehead and greater part of the roof of each orbit, and it lies in front of the parietals. It is divisible into a frontal portion and two orbital plates, the latter being situated inferiorly, where they are separated by the ethmoidal notch.

The **frontal portion** presents two surfaces, external and internal. The *external surface,* which is smooth and convex, has, a little below its centre, on either side, an elevation, called the **frontal eminence.** Below this, and separated from it by a shallow groove, there is the curved **superciliary arch** (or ridge). This ridge is prominent medially, but it subsides laterally. It supports the upper half of the orbicularis oculi, and internally it gives origin to the corrugator, whilst the surface above each ridge supports the frontalis and part of the epicranial aponeurosis. Between the two superciliary ridges is an elevation, called the **glabella.** Below each ridge is the curved **supra-orbital margin,** which is most prominent in its outer two-thirds. At the junction of the inner third and outer two-thirds is the **supra-orbital notch,** sometimes a foramen, for the passage of the supra-orbital nerve and artery. Occasionally there is a frontal notch, inside the normal notch, for a branch of the supra-orbital nerve. The extremities of the supra-orbital arch form the **medial** and **zygomatic processes.** The medial process is stout and serrated for articulation with the zygomatic bone. The internal angular process is faintly marked, and lies by the side of the nasal notch, where it articulates with the maxilla, and gives origin to some fibres of the orbicularis oculi.

On the lateral aspect of the external surface a ridge runs upwards and at first a little inwards from the zygomatic process. This is the beginning of the temporal line, and, at a higher level, divides into the two which are continued on to the parietal bone, though in order to do so they have to arch backwards and upwards. The superior gives attachment to the temporal fascia, and the inferior limits the temporal muscle, which arises from it and the surface below, this latter forming a part of the temporal fossa. Below the glabella on the under aspect there is a rough, semilunar, serrated surface for articulation with the nasal bones and nasal processes of the maxillæ, and behind this is the **nasal notch,** bounded at either side by the internal angular process. Within the notch is the **nasal process,** which supports the nasal bones, and projecting downwards from it is the sharp **nasal spine,** which articulates in front with the upper part of the crest of the nasal bones, and behind with the perpendicular plate of the ethmoid. This spine enters into the nasal septum. On either side of the spine is the **ala,** which is grooved to take part in the roof of the corresponding nasal fossa.

The *internal* or *cerebral surface* of the frontal portion is concave, and in the middle line presents a groove, called the **sagittal sulcus,** which lodges a part of the superior sagittal venous sinus. On either side of the upper part of this groove there are a few depressions for the arachnoideal granulations. Inferiorly the groove is replaced by the **frontal crest,** which terminates at the **foramen cæcum.** This foramen is sometimes partly formed by the crista galli of the ethmoid, and it may be closed below, or it may transmit an emissary vein, which passes between the intracranial superior sagittal sinus and the veins of the roof of the nose. The internal surface shows numerous digitate impressions for the convolutions of the frontal lobes of the cerebrum,

and laterally there are a few meningeal grooves, transversely disposed, for branches of the middle meningeal arteries.

The *supero-lateral* or *parietal border* of the frontal portion is serrated for the parietal bones. Superiorly it is slightly bevelled near the middle line at the expense of the inner plate, where it overlaps the parietal, and at either lower extremity it is distinctly bevelled at the expense of the outer plate, where it is overlapped by the parietal. It will be appreciated that this arrangement enables the bones to support one another mutually. Internal to its lower termination at either

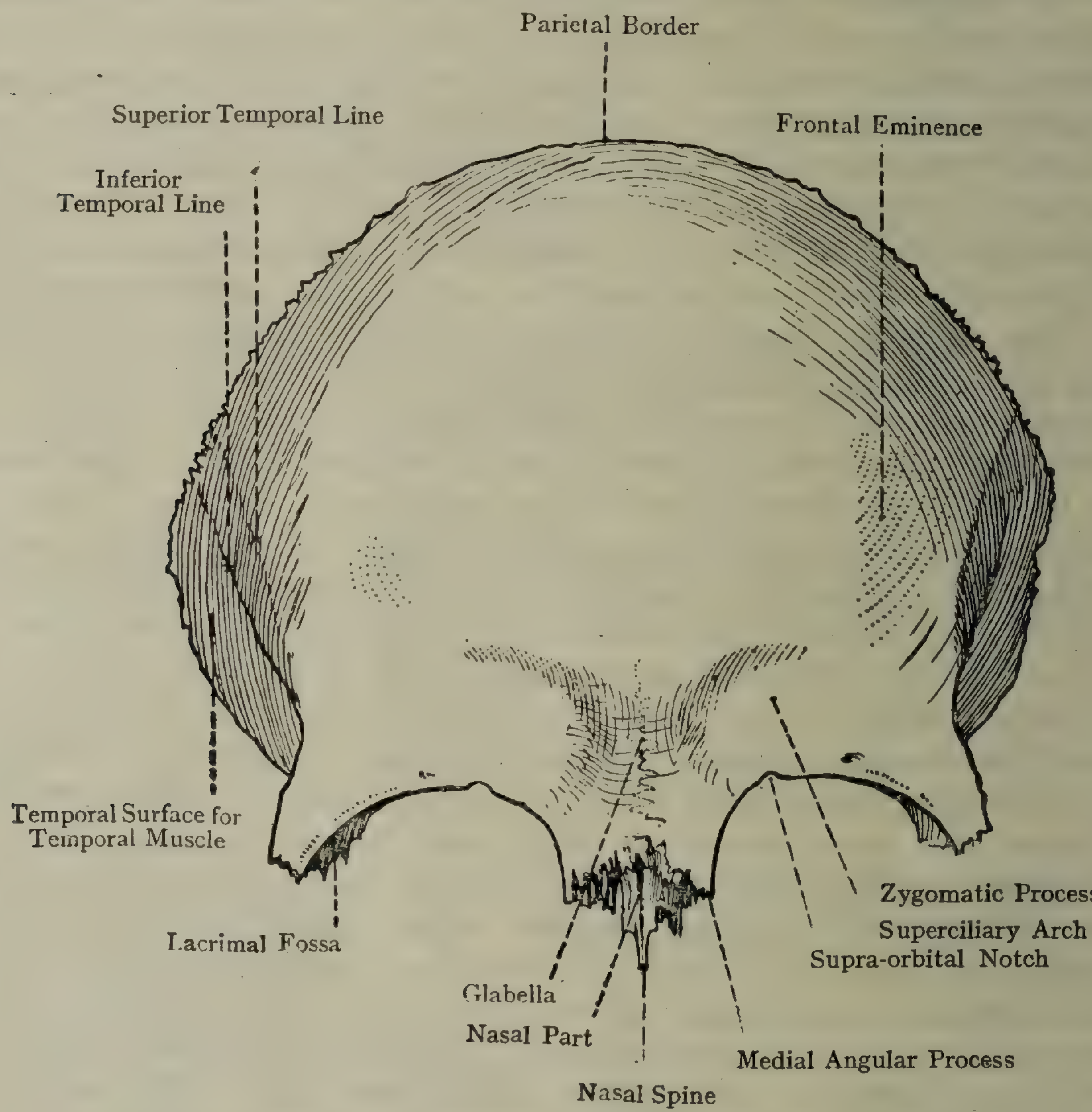


FIG. 121.—THE FRONTAL BONE (ANTERIOR VIEW).

side there is a rough triangular surface, which is serrated for the great wing of the sphenoid.

The **orbital plates,** thin and brittle, project backwards in a curved manner from the supra-orbital margins, and are widely separated by the **ethmoidal notch,** which is occupied by the cribriform plate of the ethmoid. Each is triangular, with the truncated apex directed backwards and inwards, and presents two surfaces and three borders. The *superior* or *cerebral surface* is irregularly convex, and marked by digitate impressions for the convolutions of the orbital surface of the frontal lobe, which rests upon it. The *inferior* or *orbital surface,*

smooth and concave, forms the principal part of the roof of the orbit. Within the zygomatic process is the **lacrimal fossa,** which lodges the lacrimal gland, and near to the internal angular process is the small **trochlear fossa,** which gives attachment to the trochlea of the superior oblique muscle of the eyeball.

The **borders** are anterior, external, and internal. The *anterior border* represents the supra-orbital margin, and is free. The *external border* is sharp and irregular, and its direction is backwards and inwards. It forms a right angle with its fellow of the opposite side, and abuts against the great wing of the sphenoid. The *internal border* is directed from before backwards, is parallel with its fellow of the

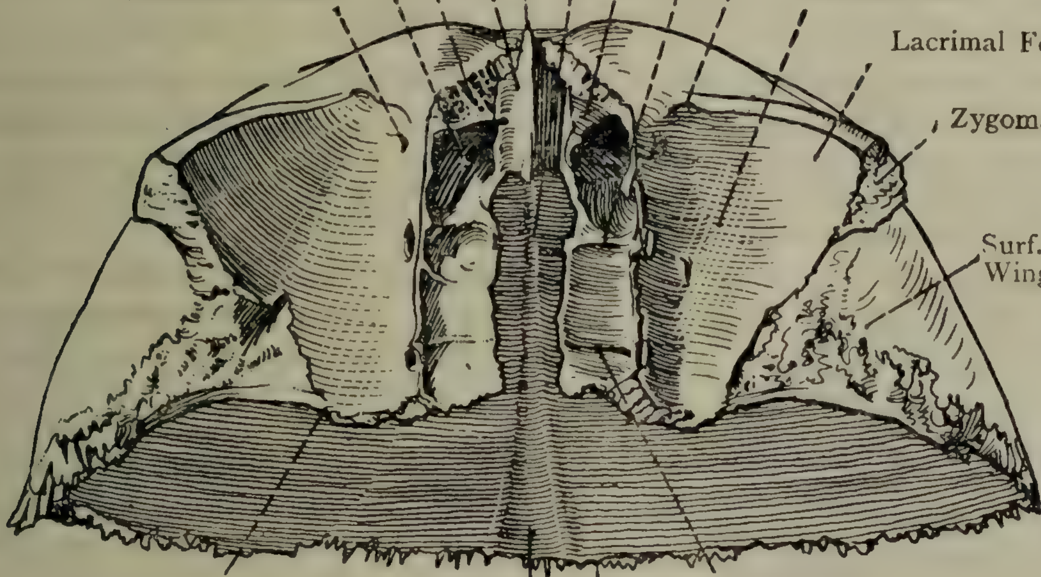


FIG. 122.—THE FRONTAL BONE (INFERIOR VIEW).

opposite side, and forms the lateral boundary of the ethmoidal notch. It is bevelled at the expense of the lower plate, and the bevelled surface presents several excavations, which close in the ethmoidal cells on the upper border of the labyrinth of the ethmoid. This surface is crossed by two transverse grooves, anterior and posterior, which, with similar grooves on the contiguous part of the ethmoid, form the **anterior** and **posterior ethmoidal** (internal orbital) **foramina.** These open on the inner wall of the orbit, and the anterior gives passage to the anterior ethmoidal vessels and nerve, whilst the posterior transmits the posterior ethmoidal vessels and nerve. The truncated apex of the orbital plate articulates with the small wing of the sphenoid.

In front of the anterior ethmoidal groove on either side is the open-

ing of the **frontal air sinus.** Each leads into a cavity within the bone, which extends outwards from near the middle line for a variable distance behind the superciliary arch. The sinuses are separated by a septum which is seldom really median, and may be unilocular or multilocular. In the latter case the subdivisions may extend backwards within the roof of the orbit, which always provides the easiest way of laying them open because the bone here is so thin. Each sinus is lined by mucous membrane continuous with that of the corresponding nasal fossa, with which it communicates by a passage called the **infundibulum.**

Articulations.—These are twelve in number, as follows: *posteriorly* with the two parietals above, and the sphenoid (great and small wings) below; by the *zygomatic processes* with the two zygomatic bones, between the *orbits* with the two nasals, two maxillæ, and two lacrimals; and in the *middle line* with the labyrinths and perpendicular plate of the ethmoid.

Structure.—It is a tabular bone. The orbital plates, being destitute of diploë, are thin and translucent, except in those cases where extensions of the frontal air sinuses invade them.

Varieties.—(1) There is in about 10 per cent. of all cases a persistent frontal suture, called the metopic suture, this condition being known as metopism. (2) Wormian bones are sometimes met with at the centre of the supero-lateral border in the region of the anterior fontanelle, and, if these remain permanent, they give rise by their union to a bregmatic bone.

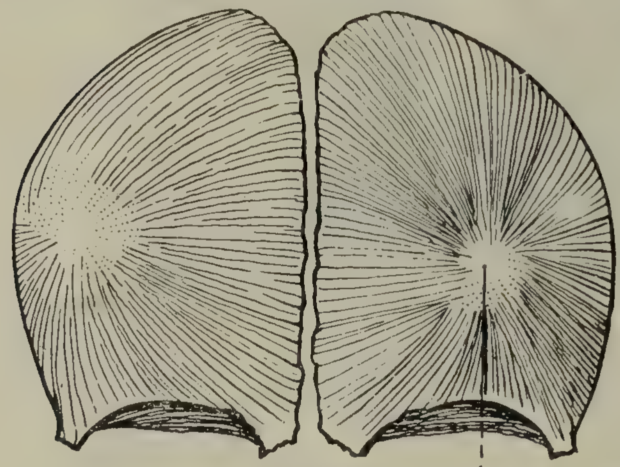


FIG. 123.—OSSIFICATION OF THE FRONTAL BONE.

Ossification.—The frontal ossifies in membrane from **two centres,** one for each half, which appear about the *seventh week* of intra-uterine life in the situation of the future frontal eminences. At birth the bone consists of two halves united by membrane, and in the course of the *first year* they become united by a vertical frontal or metopic suture. This suture gradually becomes obliterated from above downwards, and usually disappears in the *second year,* though slight traces may persist above and below, especially in the latter situation. Three pairs of secondary centres are described, two medially placed for the nasal spine, one at either side in the region of the future trochlear fossa, and one for each zygomatic process. The frontal air sinuses begin to appear in the first few years, but do not attain any size till after puberty. They are rather larger in the male than in the female.

The Temporal Bones.

The **temporal bones** (ossa temporis) are so named because the hair over the temple is the first to become grey, thus indicating advance in life. Each bone is situated on the lateral aspect of the head below the parietal. For convenience of description each is divided into three parts—namely, the **squamous portion,** which bears the **zygoma ;**

the **mastoid portion**; and the **petrous portion**, which bears inferiorly the **styloid process.**

The **squamous portion** (**squamo-zygomatic**) lies almost vertically, and presents two surfaces, outer and inner, and a superior border. The *outer surface* is convex towards its centre, and forms a large part of the temporal fossa. It gives origin to fibres of the temporal muscle, and is marked by a groove for the middle temporal artery, which extends upwards and slightly forwards from a point just above the external auditory meatus to the superior border. The *inner surface,* which is concave, is related to the temporal lobe of the cerebrum, and presents a few digitate impressions and meningeal grooves. The *superior border* is much arched, and describes about two-thirds of a circle. Except over the lower part of its anterior portion, it is markedly bevelled at the expense of the inner plate for the parietal, which it overlaps. Anteriorly over its lower part it is thick and serrated for the lateral border of the great wing of the sphenoid. The place of junction of the squamous and petrous portions is indicated at the lower part of the inner surface of the former by the narrow petro-squamous groove or suture.

The **zygoma** or **zygomatic process** springs from the lower part of the outer surface of the squamous portion. Its base is compressed from above downwards, and directed outwards. It then undergoes a twist, and is directed forwards in a curved manner, being laterally compressed. This part of it presents two borders, two surfaces, and an extremity. The *superior border,* sharp and convex, extends farther forwards than the inferior, and gives attachment to the temporal fascia in two divisions. The *inferior border* gives origin to fibres of the masseter. The *outer surface* is convex and subcutaneous, whilst the *inner,* which is concave and looks towards the upper part of the zygomatic fossa, gives origin to fibres of the deep part of the masseter. The *extremity* is bevelled at the expense of the lower border, and serrated for the zygomatic. The *base* of the zygoma presents two roots, anterior and posterior. The *anterior root,* which is continuous with the inferior border of the process, is directed inwards in front of the mandibular fossa. It is at first narrow, but subsequently thick and convex, where it is covered by cartilage. This portion is called the **articular tubercle,** and in front of it there is a small non-articular triangular area marked off from the articular surface by a sinuous line and looking into the zygomatic fossa. The *posterior root,* which is continuous with the superior border of the process, passes backwards above the external auditory meatus, then between the squamous and mastoid portions, where it is known as the **supramastoid crest,** and finally it turns upwards, where it forms part of the posterior boundary of the temporal fossa. In front of the external auditory meatus it sends downwards a short offshoot, which lies between the external auditory meatus and the anterior part of the mandibular fossa. This is called the **post-glenoid tubercle,** and is sometimes referred to as the middle root of the zygoma.

On the outer surface of the zygoma, above the place where the anterior root becomes continuous with its lower border, there is a projection, called the **preglenoid tubercle,** which gives attachment to the temporo-mandibular of the temporo-mandibular articulation.

Behind the anterior root is the **mandibular fossa,** which extends on to the tympanic plate. It is elongated from before backwards and inwards, and is divided into two parts by the fissure of Glaser. The anterior part, which belongs to the squamo-zygomatic portion of the bone, is covered by cartilage, and is triangular, with the apex at the preglenoid tubercle and the base at the squamo-tympanic fissure. It

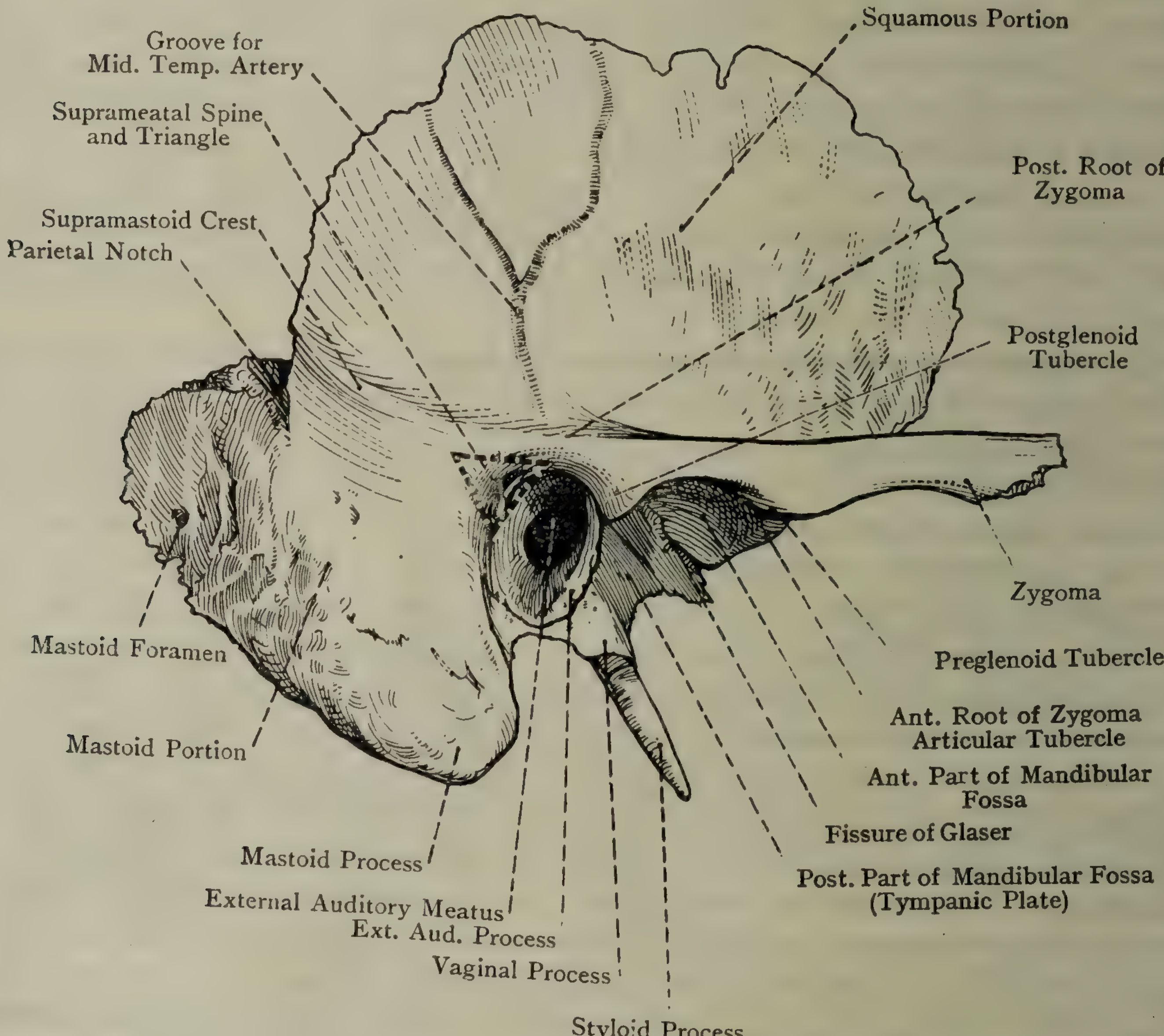


Fig. 124.—The Right Temporal Bone (External View).

is deeply concave, and is bounded anteriorly by the articular tubercle, externally by the commencement of the posterior root of the zygoma, and posteriorly from without inwards by the postglenoid tubercle and squamo-tympanic fissure. It articulates with the condyle of the inferior maxilla when the mouth is closed, an interarticular fibro-cartilage intervening; but, when the mouth is open, the condyle with the fibro-cartilage moves forwards on to the articular tubercle. The posterior part of the mandibular fossa is situated behind the squamo-tympanic fissure, and is formed by the tympanic plate, which separates it from the external auditory meatus. It is shallow, non-articular,

and quadrilateral, and it lodges the deep part of the parotid gland when the mouth is open.

The **squamo-tympanic fissure** (fissure of Glaser) is closed in its outer part, and is divided into two medially by means of a thin plate which descends from the *tegmen tympani,* and forms the chief part of the outer wall of the canals for the osseous part of the pharyngo-tympanic tube and tensor tympani muscle. Between this plate and the tympanic plate the anterior process of the malleus is located internally, and there is a small opening leading to the tympanic cavity for the passage of the anterior tympanic branch of the maxillary artery and the anterior ligament of the malleus (so-called laxator tympani muscle) or band of Meckel. At the inner end of the squamo-tympanic fissure is another minute opening leading from the tympanic cavity, called the **anterior canaliculus for chorda tympani** (canal of Huguier, iter chordæ anterius), which transmits the *chorda tympani* nerve.

The **mastoid portion** is so named from the mastoid process which it bears. It is limited above by the supramastoid crest and its own superior border, in front by the external auditory meatus and tympano-mastoid fissure, and behind by its posterior border. It presents two surfaces and two borders. The *external surface,* rough and convex, is prolonged downwards behind the external auditory meatus into the **mastoid process,** which presents on its inner surface two grooves. The outer, called the **mastoid notch,** is deep, and gives origin to the posterior belly of the digastric; and the inner, called the **occipital groove,** is narrow, and lodges the occipital artery. The upper part of the outer surface of the mastoid process gives origin over its posterior half to the auricularis posterior and part of the occipitalis in this order from before backwards; and lower down it gives insertion to the sterno-mastoid, splenius capitis, and longissimus capitis, in this order from above downwards. At the upper and back part of the mastoid portion, a little below the supramastoid crest, there may be the remains of the squamo-mastoid suture directed downwards and forwards, indicating the line of junction of the squamo-zygomatic and basal part of the petrous portions. Directly in front of the root of the mastoid process there is an important depressed area, called the **supra-meatal triangle** (Macewen), which is bounded as follows: *above* by part of the posterior root of the zygoma, *below* by the postero-superior part of the external auditory meatus, and *behind* by a vertical line connecting the upper and lower boundaries, which line is continuous with the posterior part of the external auditory meatus. In the lower part of the suprameatal triangle is the **suprameatal spine,** a sharp, antero-posterior scale of bone, which gives attachment to a portion of the cartilage of the external ear. The outer surface of the mastoid portion presents several small nutrient foramina, and often there is a large opening, called the **mastoid foramen,** usually placed near the posterior border, for a large emissary vein, which passes between the sigmoid sinus internally and the outermost tributary of the occipital vein, or the posterior auricular vein externally. In addition to these, there

is the minute *arterial fissure* on the outer surface of the mastoid process below its centre for the mastoid branch of the occipital artery.

The *inner surface* presents the deep sinuous **sigmoid groove,** which lodges a part of the sigmoid venous sinus, and from which the mastoid foramen opens. The genu or bend of this groove and its descending limb lie behind the mastoid antrum.

The *superior border,* thick and serrated, articulates with the back part of the inferior border of the parietal. Near its anterior part it presents the **parietal notch,** which receives a portion of the parietal bone. The *posterior border,* also thick and serrated, articulates with the inferior border of the squamous portion of the occipital.

The interior of the mastoid portion contains a number of cavities lined with mucous membrane, called the mastoid air cells. These open into an irregular chamber, known as the **mastoid antrum,** which is situated behind the upper part of the posterior wall of the tympanic cavity, and is lined by mucous membrane continuous with that of the tympanum and mastoid cells. The upper part of the antrum communicates with the epitympanic recess or **attic** of the tympanic cavity by an opening which faces that of the pharyngo-tympanic tube, but the lower part is shut off from the tympanic cavity, and its floor is on a lower level than the floor of that cavity, which explains the difficulty in the drainage of fluid. The roof of the antrum, called tegmen antri, is continuous with the tegmen tympani, and both enter into the formation of the middle fossa of the base of the skull. The lateral wall is formed by the squamo-mastoid junction in the region of the *suprameatal triangle,* and if the bone is drilled here the antrum is reached with great certainty; the floor and medial wall are constructed by the petro-mastoid portion; and the posterior wall represents that part of the mastoid portion which bears the genu or bend and descending limb of the sigmoid groove. The **mastoid air cells** extend from the antrum into the mastoid portion in a backward and downward direction, and are subject to variety as regards number and size. They are arranged in two groups—horizontal or superior, and vertical or inferior. The former are purely pneumatic or air cells, but the latter are of two kinds, the *upper* ones containing air, and the *lower* ones, which extend to the tip of the mastoid process, being diploic—*i.e.*, containing marrow—and of large size. These diminish as age advances. Superiorly the cells extend forwards over the roof of the external auditory meatus, upwards as high as the supramastoid crest, and inwards for a certain distance into the petrous portion. They may also extend into the jugular process of the occipital in old persons. At birth the mastoid cells are not developed, but the antrum is present.

The **petrous portion** is so named from its rocky consistence, and its direction is inwards and forwards into the base of the skull. It has the shape of a three-sided pyramid, and presents three surfaces (one of which is concealed by the tympanic plate), three borders, an apex, and a base. The surfaces are anterior, posterior, and inferior.

The *anterior surface,* which has an inclination forwards, looks into

the middle fossa of the base of the skull, and towards its outer part presents a few digitate impressions for convolutions of the temporal lobe of the cerebrum. Near the apex is the **trigeminal impression** for the trigeminal ganglion, and below this is the outlet of the **carotid canal** for the internal carotid artery. Proceeding backwards and outwards, there is a small groove leading to a foramen called the **hiatus** *for greater superficial petrosal nerve* (hiatus Fallopii), transmitting the nerve of that name along with the petrosal branch of the middle meningeal artery. Below and parallel to this groove is a smaller one lodging the lesser superficial petrosal nerve and leading to the hiatus

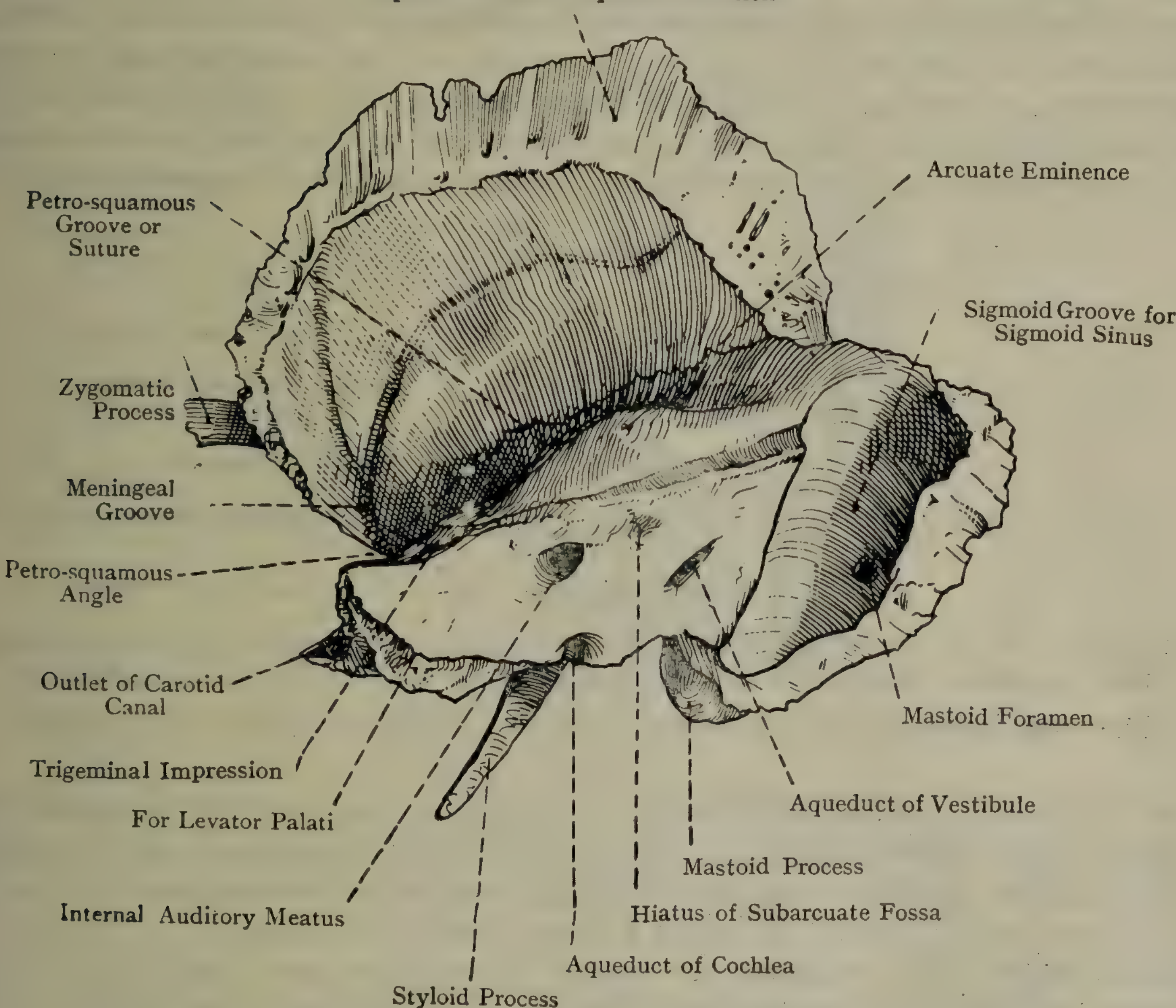


FIG. 125.—THE RIGHT TEMPORAL BONE (INTERNAL VIEW).

for lesser superficial nerve. This latter, however, with the nerve, is inconstant. Behind and lateral to the hiatus for greater superficial petrosal nerve is an elevation, called the **arcuate eminence,** which coincides with the position of the *superior* semicircular canal of the internal ear, and if the bone is perforated just in front of this the tympanic cavity will be opened up. Between this eminence and the hiatus for greater superficial nerve medially and the petro-squamous fissure laterally there is a plate of bone, called the **tegmen tympani,** which forms the roof of the tympanic cavity and of the canal for the tensor tympani muscle.

The *posterior surface,* which looks backwards and inwards, forms part of the posterior cranial fossa. It presents about its centre a large opening, which leads into a short canal, called the **internal auditory meatus,** for the passage of the motor and sensory roots of the facial nerve and auditory nerves, and the internal auditory artery. At the deep end of this meatus there is a perforated plate of bone, known as the **lamina cribrosa,** which is divided into an upper and a lower fossa by a transverse ridge, called the **transverse crest.** The upper fossa presents at its anterior part a special foramen which leads into the facial canal, and by this foramen the facial nerve leaves the meatus. The remainder of the upper fossa is known as the *superior vestibular area* (area cribrosa superior), and it is pierced by the nerves and arteries destined for the utricle and the ampullæ of the superior and lateral semicircular canals. The lower fossa contains the *cochlear area,* which is pierced by the cochlear nerves and arteries, the *inferior vestibular area* for the nerves and arteries to the saccule, and the *foramen singulare*

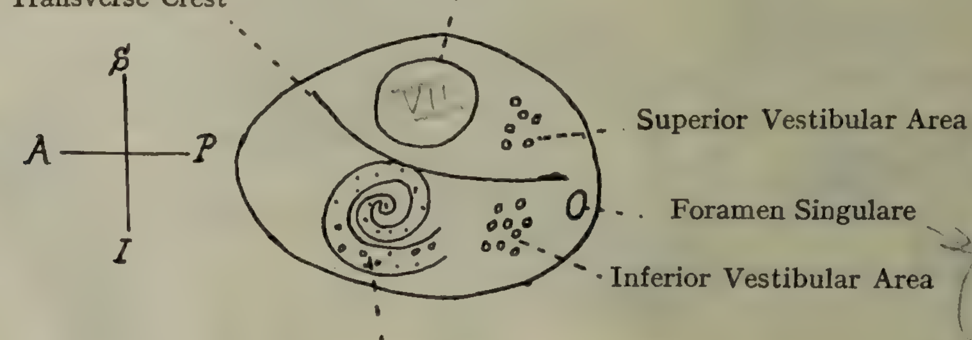


FIG. 126.—PLAN OF FUNDUS OF RIGHT INTERNAL AUDITORY MEATUS, SHOWING THE VARIOUS OPENINGS AND THEIR RELATION TO THE CRISTA FALCIFORMIS.

The cross indicates the directions anterior, posterior, superior, and inferior.

for the nerves and arteries to the ampulla of the posterior semicircular canal. The **facial canal,** for the facial nerve, extends from the deep end of the internal auditory meatus to the stylo-mastoid foramen, between which points it takes a very circuitous course. It passes at first horizontally *outwards* between the cochlea and vestibule to the inner wall of the tympanum, then it bends sharply *backwards,* lying above the fenestra vestibuli, and finally, making another abrupt bend, it *descends* in the angle between the inner and posterior walls of the tympanic cavity to the stylo-mastoid foramen. The hiatus for greater superficial petrosal nerve leads from the commencement of the facial canal to the anterior surface of the petrous portion, and, as stated, transmits the great superficial petrosal nerve. The facial canal, as it descends behind the tympanic cavity, communicates with the canal of the **pyramid** by an opening through which the nerve to the stapedius reaches that muscle, and below the pyramid it presents another opening, called the **posterior canaliculus for chorda tympani,** by which the chorda tympani nerve passes into the tympanic cavity.

About $\frac{1}{4}$ inch lateral to and below the opening of the internal auditory meatus there is a narrow fissure, overhung by a thin scale of bone, called the **aquæduct of vestibule,** which contains a small artery and vein, and the *endolymphatic duct* or its remnants. Close to the superior border, about midway between the opening of the internal auditory meatus and the aquæduct of vestibule, there is a depression containing a small opening, known as the **subarcuate fossa,** which represents the parafloccular fossa of early life.

The *inferior surface* appears on the exterior of the base of the skull. Near the apex there is a large rough surface which gives origin to fibres of the tensor tympani and levator palati, and behind this a circular opening, called the **carotid canal,** which is the inlet to the carotid canal.

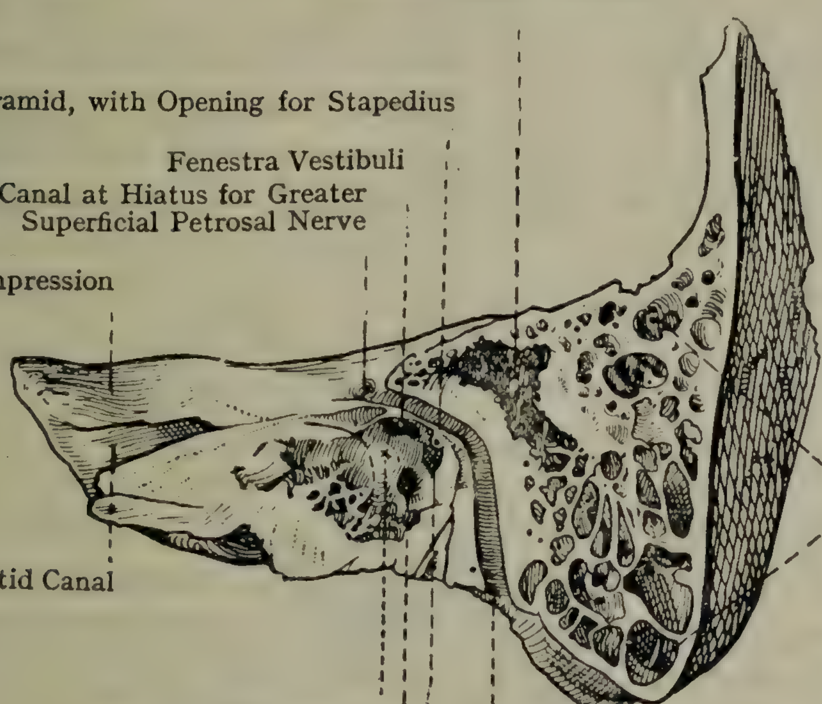


FIG. 127.—SECTION THROUGH THE PETROUS AND MASTOID PORTIONS OF THE TEMPORAL BONE, SHOWING THE TYMPANUM AND MASTOID CELLS.

This canal, which transmits the internal carotid artery and the carotid sympathetic plexus, passes at first vertically *upwards,* and then, bending at a right angle, it passes horizontally *forwards* and *inwards,* to open at the apex, below the trigeminal impression, into the foramen lacerum. On the posterior wall of the vertical portion of the canal is a minute carotico-tympanic canaliculus for the tympanic branch of the carotid sympathetic plexus and carotico-tympanic branch of the internal carotid artery. Behind the carotid foramen is the **jugular fossa,** which, with the jugular notch of the occipital, forms the jugular foramen. On the outer wall of this fossa, near the root of the styloid process, there is the opening of the **mastoid canaliculus** for the auricular branch (Arnold's nerve) of the vagus. On the carotid ridge, between the carotid canal and the jugular fossa, is the opening of the **canaliculus** for

tympanic nerve for the tympanic branch (Jacobson's nerve) of the glosso-pharyngeal and the inferior tympanic branch of the ascending pharyngeal artery. Behind the jugular fossa, medial to the stylo-mastoid foramen, is the rough **jugular facet** for articulation with the extremity of the jugular process of the occipital by synchondrosis up to the twenty-fifth year, after which ankylosis takes place. Lateral to the jugular facet is the styloid process, immediately behind the root of which is the **stylo-mastoid foramen.** This foramen is the outlet of the facial canal, and by it the facial nerve makes its exit, whilst the

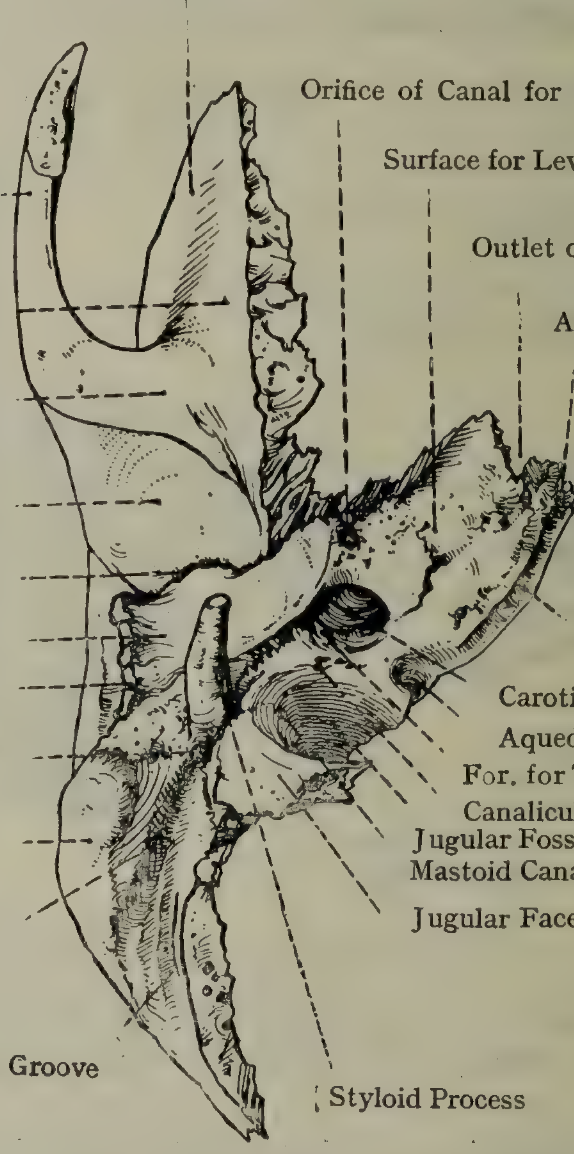


FIG. 128.—THE RIGHT TEMPORAL BONE (INFERIOR VIEW).

stylo-mastoid branch of the posterior auricular artery passes in. A little behind the stylo-mastoid foramen, between the mastoid process and tympanic plate, is the tympano-mastoid fissure for the exit of the auricular branch of the vagus nerve.

Either ensheathing or passing just in front of the root of the styloid process is a sharp ridge of bone running inwards and a little forward; it is known as the vaginal process, and it will be noticed that it is really the lower free border of the tympanic plate described on p. 194.

The **borders** are anterior, superior, and posterior. The *anterior border* separates the anterior from the inferior surface. It is very

short, and forms an acute angle with the squamous portion, within which the posterior pointed extremity of the great wing of the sphenoid is received. This angle presents an opening for the exit of the pharyngo-tympanic tube: the canal to which it leads is divided into two compartments by a thin transverse shelf of bone, scooped out on its under surface, called the **processus cochleariformis.** The upper small compartment lodges the tensor tympani muscle, and the lower large one forms the osseous part of the pharyngo-tympanic tube. Both of these canals lead upwards and backwards to the anterior part of the tympanic cavity. The *superior border,* which is the longest, separates the anterior from the posterior surface. It gives attachment to the tentorium cerebelli, and is grooved for the superior petrosal venous sinus. The anterior part of this border frequently presents a process, which projects over the upper end of the groove for the inferior petrosal venous sinus, and gives attachment to the *petro-sphenoidal ligament.* This ligament connects it with the lateral border of the dorsum sellæ of the sphenoid (which may present a superior petrosal process), and, if it ossifies, it bridges over a foramen through which the inferior petrosal sinus and sixth cranial nerve pass. The *posterior border* separates the posterior from the inferior surface. Its outer part, opposite the jugular fossa, enters into the formation of the jugular foramen, and its inner part presents a groove for the inferior petrosal sinus, and articulates with the side of the basilar portion of the occipital. In line with the opening of the internal auditory meatus it presents a triangular depression, which encroaches on the inferior surface and leads to a small canal, called the **aqueduct of cochlea.** This aqueduct transmits a small vein from the cochlea to the inferior petrosal sinus, and also a communication between the perilymph of the scala tympani and the subarachnoid space, sometimes called the *perilymphatic duct.*

The **apex** of the petrous portion presents the outlet of the carotid canal inferiorly.

The **base** is the part of the petrous portion which appears on the external surface, and it presents a large opening leading into the **external auditory meatus.** This opening is oval, its long axis lying downwards and backwards, and it is bounded above by the posterior root of the zygomatic process, whilst the remainder of its circumference is formed mainly by the external auditory process of the tympanic plate. The canal of the external auditory meatus* is formed chiefly by the tympanic and squamous portions, but also slightly by the mastoid portion. Its direction is inwards, slightly forwards, and finally downwards, its length being rather more than $\frac{1}{2}$ inch (14 millimetres). It leads to the tympanic cavity, and its deep end, which is nearly circular, is closed by the *tympanic membrane.* This membrane is placed obliquely, and forms an acute angle with the lower wall, and an obtuse angle with the upper, so that the floor of the meatus is

* Unfortunately the term 'external auditory meatus' is applied not only to the canal, but to its external opening and to the opening in the soft parts, which lies still more external as well as a little lower.

longer than the roof, the anterior wall being also longer than the posterior. Its floor presents a slight elevation at the centre, where the passage is narrower than elsewhere, this portion being called the **isthmus.**

The **tympanic part** is situated behind the squamo-tympanic fissure, and is quadrilateral. It presents two surfaces and four borders. The *external surface* forms the posterior part of the mandibular fossa, and lodges the deep portion of the parotid gland. The *internal surface* forms the anterior, inferior, and part of the posterior walls of the external auditory meatus, and the anterior and inferior walls of the tympanic cavity, and at its inner or deep end it presents a groove, deficient above, for the tympanic membrane, called the tympanic groove. The *outer border* forms the **external auditory process,** and is curved and rough for the cartilage of the auricle. The *inner border* is situated immediately outside the bony part of the pharyngo-tympanic tube, and is short and irregular. The *upper border* bounds the squamo-tympanic fissure posteriorly, and the *lower border* forms at its back part the **vaginal process,** which ensheathes the base of the styloid process externally. The tympanic plate sometimes presents a small deficiency at its centre, called the **foramen of Hüschke,** which is always present until after five years of age.

The **styloid process,** which is cylindrical and tapering, starts from a point immediately in front of the stylo-mastoid foramen, and is directed downwards and inwards. The muscular and ligamentous relations of the process are as follows: The stylo-pharyngeus muscle arises from the inner aspect of the base; the stylo-hyoid muscle from the posterior and outer aspect of the process near its base; the stylo-glossus muscle from the front of the process near its tip; the stylo-mandibular ligament is attached to it just below the stylo-glossus; and the stylo-hyoid ligament is attached exactly to the tip.

The blood-supply of the bone is chiefly derived from the following sources: The squamous portion receives externally branches from the deep temporal arteries of the maxillary, and internally branches of the middle meningeal. Other arterial twigs enter the bone at definite points as follows: internal auditory from the basilar, through the internal auditory meatus; petrosal from the middle meningeal, through the hiatus for greater superficial petrosal nerve; stylo-mastoid from the posterior auricular, through the stylo-mastoid foramen; anterior tympanic from the maxillary, through the squamo-tympanic fissure; inferior from the ascending pharyngeal, through the canaliculus for tympanic nerve; carotico-tympanic from the internal carotid, through the carotico-tympanic canaliculi on the posterior wall of the vertical portion of the carotid canal; the mastoid from the occipital, through the mastoid foramen on the outer surface of the mastoid process; and twigs from the mastoid division of the posterior auricular, through the foramina on the outer surface of the mastoid portion.

Articulations.—These are usually five in number, as follows: *posteriorly* and *internally* with the occipital, *superiorly* with the parietal,

anteriorly with the sphenoid and zygomatic; and *externally* with the condyloid process of the mandible, the latter being a movable articulation. Sometimes the temporal articulates with the frontal, giving rise to a fronto-squamosal suture.

Structure.—The **squamous portion** is thin, and is practically composed of two plates of compact bone. The **mastoid portion** is thick, and, as stated, contains the tympanic antrum and mastoid air cells. The **petrous portion** is remarkable for its hardness, and it contains all the divisions of the organ of hearing, except the cartilage of the auricle on the outer side of the head. Thus it contains (1) the osseous external auditory meatus; (2) the tympanic cavity or middle ear, with its three ossicles, malleus, incus, and stapes, etc.; and (3) the osseous labyrinth or internal ear, which contains the membranous labyrinth, consisting of the utricle, saccule, semicircular canals, and membranous cochlea. It also contains, for a certain distance, extensions of the mastoid air cells.

Varieties.—(1) Persistence of foramen of Hüschke in the tympanic plate, due to imperfect ossification. (2) Obliteration of petro-squamous suture. (3) Styloid process may be unusually long, or even united to the hyoid bone. (4) Styloid process may be ununited by bone to the rest of the skull.

Ossification.—The temporal bone is developed in four parts, squamosal or squamo-zygomatic, tympanic, petrosal, and hyal. The squamosal and tympanic elements are formed *in membrane*, and the petrosal *in cartilage*. The **squamosal** gives rise to the squamo-zygomatic portion, and the upper and front part of the mastoid portion; the **tympanic** forms the tympanic ring, and from the **petrosal** are developed the petrous portion and the greater part of the mastoid portion, while from the hyal the styloid process is derived. It is to be noted that the mastoid portion is not an independent part developmentally, but belongs chiefly to the petrous and partly to the squamosal portions. The centre for the **squamosal** appears towards the end of the *second month* of intra-uterine life in the region of the root of the zygomatic process, and from this ossification extends upwards into the squamosal, forwards into the zygoma, and inwards into the mandibular fossa in front of the squamo-tympanic fissure. From the posterior part of the squamosal a downward growth of bone takes place below the supramastoid crest, called the **postauditory process,** which forms the outer wall of the tympanic antrum, and gives rise to the upper and front part of the mastoid portion. Its hinder edge sometimes forms a fissure. The centre for the **tympanic element** appears towards the end of the *third month* of intra-uterine life in the lower part of the external membranous wall of the tympanic cavity, and from this is developed the **tympanic ring.** This ring forms about five-sixths of a circle, the deficiency being above, where it is closed by the squamosal, and within the circumference of the ring there is a groove for the tympanic membrane. Previous to birth the extremities of the ring become ankylosed to the squamosal, and the **tympanic plate** is formed by an outward growth from it, so that it is ultimately located at the deep end of the external auditory meatus. The **petrosal element** or **periotic cartilaginous capsule** is developed from four centres, which appear towards the end of the *fifth month,* and from which ossification proceeds rapidly, union between the four centres being effected by the end of the *sixth month* of intra-uterine life. These centres are called opisthotic, pro-otic, pterotic, and epiotic, in the order of their appearance. The **opisthotic centre** appears on the *promontory* on the inner wall of the tympanic cavity, from which point ossification extends downwards around the fenestra cochlea, and forms (1) the floor of the vestibule, (2) the lower part of the fenestra vestibuli, (3) the floor of the internal auditory meatus, (4) the greater part of the bony investment of the cochlea, (5) the carotid canal, and

(6) the floor of the tympanic cavity. The **pro-otic centre** appears near the inner limb of the *superior* semicircular canal in the region of the *arcuate eminence*, and from it are formed (1) the bony investment of the superior semicircular canal, (2) the roof of the vestibule, (3) the roof of the cochlea, (4) the roof of the internal auditory meatus, (5) the upper part of the fenestra vestibuli, and (6) the upper and inner part of the mastoid portion. The **pterotic centre** appears over the outer limb of the lateral semicircular canal, and from it are formed (1) the covering of the lateral semicircular canal, and (2) the tegmen tympani. The **epiotic centre,** sometimes double, appears in the region of the back part

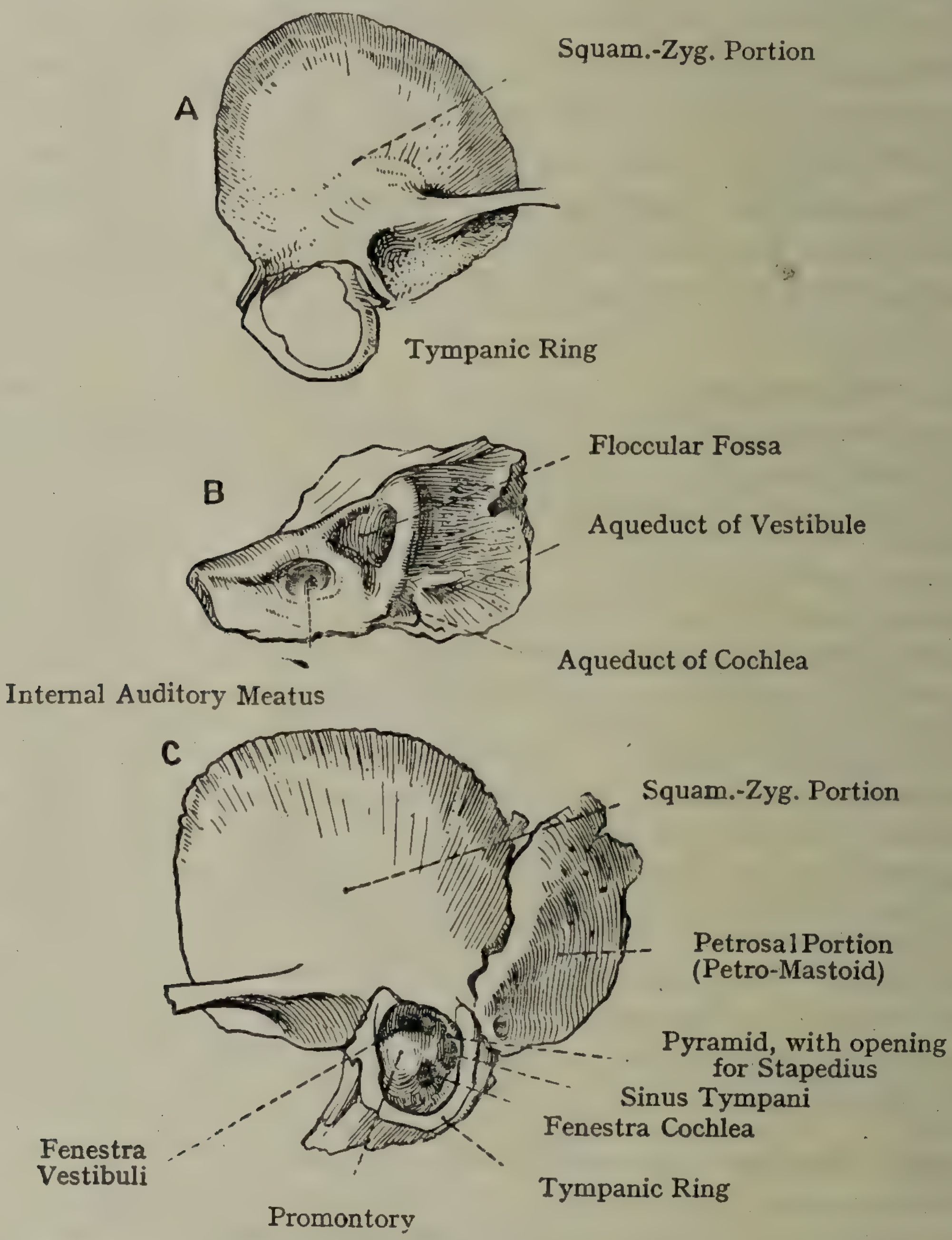


FIG. 129.—THE TEMPORAL BONE IN EARLY LIFE.

A, squamo-zygomatic portion and tympanic ring; B, petrosal portion; C, the bone at birth.

of the *posterior* semicircular canal, and from it the lower part of the mastoid is formed, as well as the investment of the posterior semicircular canal. At the period of birth (the tympanic having previously joined the squamosal) the temporal bone is composed of two parts: (1) a united squamo-zygomatic and tympanic, and (2) a petrosal, a plate of cartilage intervening, and these unite in the course of the *first year*. At birth the bone is of loose consistence, the mastoid portion is flat, the external auditory meatus is undeveloped, the tympanic ring and tympanic membrane are on a level with the exterior of the bone, the mandibular and jugular fossæ are shallow, the parafloccular fossa is a cavity large enough to hold a small pea, and the hiatus for greater superficial

petrosal nerve is an open groove. The tympanic plate now becomes formed in fibrous tissue by the extension of osseous matter outwards from two tubercles on the anterior and posterior parts of the outer aspect of the tympanic ring superiorly. As these tubercles grow, they meet and enclose an opening in the floor of the external auditory meatus, which usually becomes closed about the seventh year, but may persist throughout life as the *foramen of Hüschke.* The tympanic antrum is present at birth, and is of large proportionate size, its outer wall being very thin. The mastoid process becomes developed in the course of the *second year,* and the antrum becomes relatively smaller, its outer wall at the same time becoming thicker. The mastoid air cells do not grow rapidly until the approach of the period of puberty.

Styloid Process.—This process has two centres of ossification, one for the **tympano-hyal** or basal part appearing before birth, which soon joins the rest of the bone, and the other for the **stylo-hyal** appearing in the *first* or *second year.* The latter portion is not well developed until after puberty, and its union with the tympano-hyal usually takes place in adult life, but it often remains separate.

The Sphenoid Bone.

The **sphenoid bone** is so named from the wedge-like position which it occupies in the base of the skull, where it lies with its long axis placed transversely. It enters into the formation of the anterior, middle, and posterior fossæ of the base, the temporal and nasal fossæ, and the orbits. It consists of a central portion or body, two greater wings, two lesser wings, and two pterygoid processes.

The **body** presents six surfaces—superior, inferior, anterior, posterior, and two lateral, one at either side. Within the body are two large cavities, called the **sphenoidal air sinuses,** each of which opens on the anterior surface by a small circular aperture.

The *superior surface* presents at its centre a depression, called the **sella turcica** or **hypophyseal fossa,** for the *hypophysis cerebri,* and in the fœtus it is pierced by the superior opening of the **cranio-pharyngeal canal.** In front of the sella turcica is the **tuberculum sellæ,** which indicates the place of junction of the presphenoid and postsphenoid portions, and anterior to this is a transverse furrow, which, though called the **optic groove,** really lodges the anterior part of the circular sinus. The groove leads at either side to the optic foramen, by which the optic nerve leaves the cranial cavity, and anteriorly it is limited by a transverse ridge, called the **limbus sphenoidalis.** In front of the limbus (border) is a smooth elevated platform, called the **jugum sphenoidale,** which is continuous laterally with the superior surface of the lesser wing, and presents at either side the **olfactory groove** for the olfactory tract. The anterior border or the jugum is projected in the middle line into the **ethmoidal spine,** which articulates with the posterior margin of the cribriform plate of the ethmoid. The sella turcica is bounded posteriorly by a prominent quadrilateral plate of bone, called the **dorsum sellæ** or **dorsum ephippii** (back of the saddle), which is directed forwards and upwards. The antero-inferior surface of this plate overhangs the sella turcica, and the postero-superior surface, called the **clivus** (slope), is inclined downwards and backwards to become continuous with the basilar groove of the occipital. The clivus lodges

the upper part of the pons and the basilar artery. The antero-superior border of the dorsum sellæ presents at either side the **posterior clinoid process** for a portion of the tentorium cerebelli and the interclinoid ligament, which latter connects it with the anterior clinoid process, and is sometimes ossified. On each lateral border of the dorsum sellæ, a little below the posterior clinoid process, is a notch, which is often said to transmit the sixth nerve, but is really made by the inferior petrosal sinus. At the lower end of each lateral border there is a projection, called the **posterior petrosal process,** which articulates with the apex of the petrous portion of the temporal, and bounds medially the foramen lacerum.

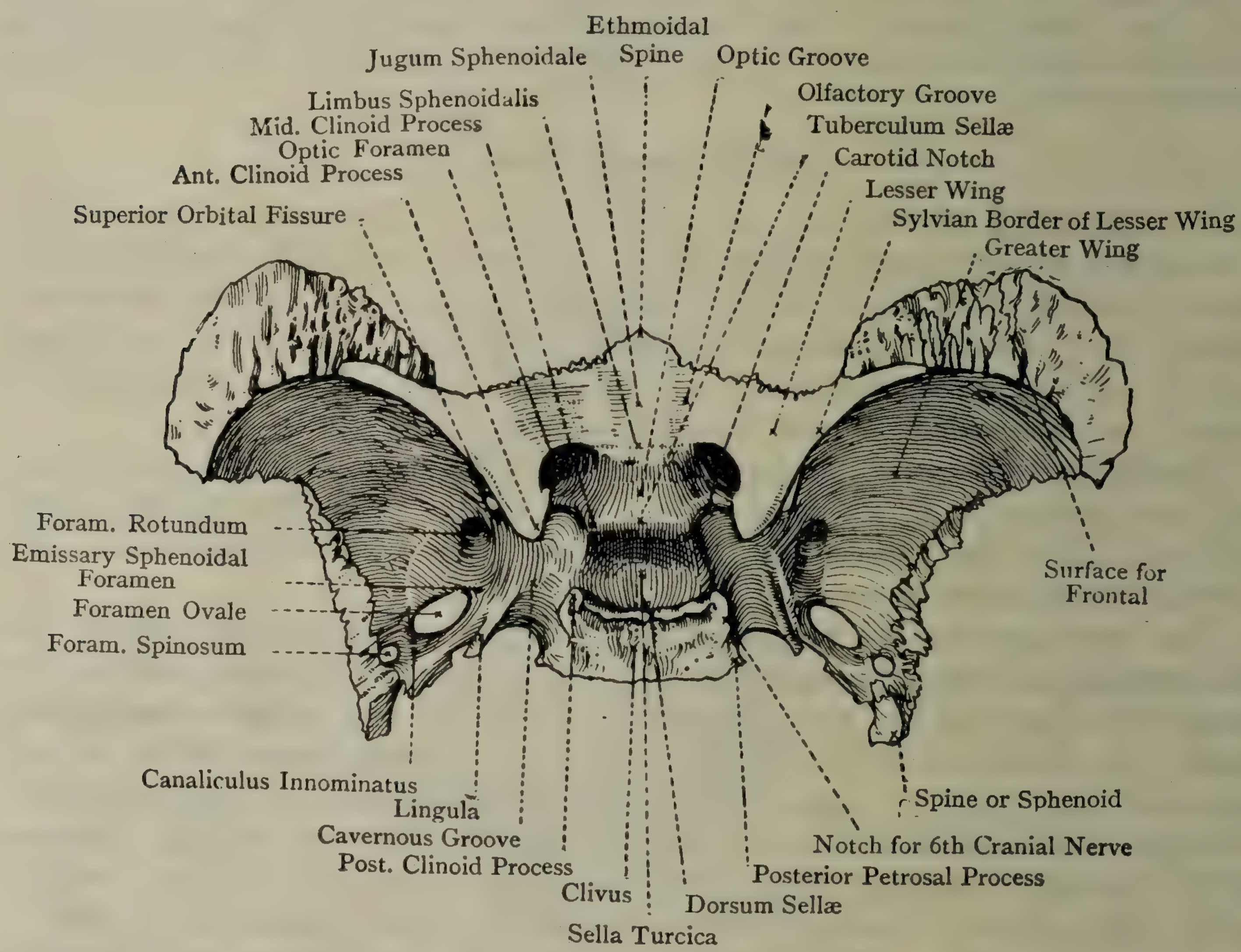


FIG. 130.—THE SPHENOID BONE (SUPERIOR VIEW).

The *inferior surface* of the body is limited at either side by the medial pterygoid plate of the pterygoid process. In the middle line it presents a vertical, antero-posterior ridge, called the **rostrum,** which is continuous with the sphenoidal crest on the anterior surface, and is received into the cleft between the alæ of the vomer. At either side of the rostrum there is a thin scale of bone projecting inwards for a short distance from the root of the internal pterygoid plate, called the **vaginal process,** which articulates with the ala on the upper border of the vomer, and with it covers the greater part of the inferior surface of the body at either side of the middle line. On the inferior surface of this process there is a groove, which is converted by the sphenoidal

process of the palatine bone into a canal, called the **palatino-vaginal canal,** for the passage of the pharyngeal nerve and corresponding vessels.

The *anterior surface* presents in the middle line a vertical ridge, continuous above with the ethmoidal spine and below with the rostrum, called the **sphenoidal crest,** which articulates with the perpendicular plate of the ethmoid and forms part of the nasal septum. On either side of this crest the surface is divided into two parts, outer and inner. The outer part is rough and often cellular to complete the posterior ethmoidal air cells and to articulate with the orbital process of the palatine bone. These cells are sometimes called the sphenoidal air

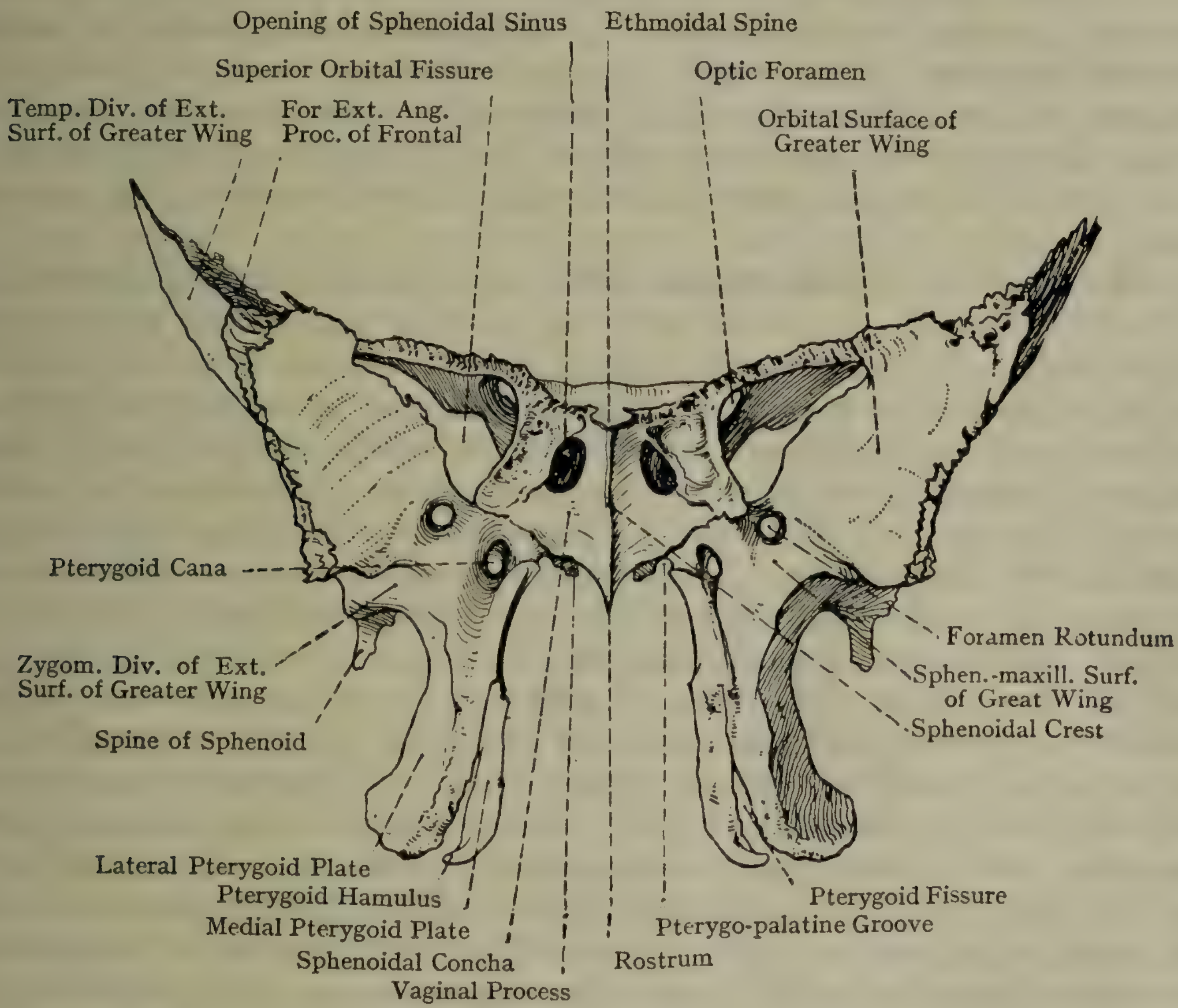


FIG. 131.—THE SPHENOID BONE (ANTERIOR VIEW).

cells to distinguish them from the sphenoidal air sinuses into which they do not open. The inner part presents the opening of the sphenoidal air sinus of its own side, with the margins of which the sphenoidal concha or spongy bone articulates. When this bone is in position the opening of the sinus is small and circular, and is placed superiorly, but when the bone has been removed the opening is of large size and irregular outline. It communicates anteriorly with the spheno-ethmoidal recess of the nasal fossa above and behind the superior meatus. The part of the anterior surface which presents the opening of the sphenoidal air sinus enters into the formation of the roof of the corresponding nasal fossa.

The *posterior surface* is rough and truncated. It articulates with the basilar process of the occipital by synchondrosis up to the twentieth year, after which ankylosis takes place.

The *lateral surface* gives attachment to the greater wing and a portion of the lesser wing. Anteriorly, beneath the lesser wing, it forms the inner boundary of the sphenoidal fissure and the back part of the inner wall of the orbit. Above the attachment of the greater wing it presents a winding groove, called the **carotid groove,** which contains the cavernous venous sinus and the internal carotid artery. The direction of this groove is from behind forwards, and its deepest part is placed posteriorly, where it is bounded internally by the posterior petrosal process, and externally by the **lingula** of sphenoid or **anterior petrosal process.** This latter process is a sharp scale of bone which projects backwards in the angle between the greater wing and body, fitting close against the outer side of the internal carotid artery where it is running upwards after leaving the carotid canal in the temporal bone.

The **lesser** or **orbital wings** (orbito-sphenoids) extend almost horizontally outwards on a level with the anterior part of the upper surface of the body. Each arises by two roots—an upper, which is expanded and compressed from above downwards, and is on a level with the anterior part of the upper surface of the body; and a lower, slender and compressed from before backwards, which arises from the anterior part of the side of the body. The wing is triangular and flattened from above downwards. The *superior surface,* smooth and somewhat concave, forms the back part of the anterior cranial fossa. The *inferior surface* overhangs the superior orbital fissure, and forms the back part of the roof of the orbit. Laterally the wing ends in a slender, pointed extremity, which lies very near the greater wing, but does not as a rule touch it, though it may do so. The *anterior border* is thin and serrated for the orbital plate of the frontal. The *posterior border,* smooth, thick, and round, corresponds with the lateral sulcus (or Sylvian fissure) of the cerebrum, from which circumstance it is known as the Sylvian border. It forms at either side the line of demarcation between the anterior and middle cranial fossæ, and terminates internally in the **anterior clinoid process** for a portion of the tentorium cerebelli and the interclinoid ligament.

Between the anterior clinoid process and the side of the olivary eminence is the semicircular **carotid notch,** which is the anterior termination of the carotid groove, and lodges the internal carotid artery.

On either side of the body, close to the inner side of the anterior extremity of the carotid groove and posterior to the carotid notch, opposite the anterior clinoid process, there is usually a small tubercle, called the **middle clinoid process.** It is connected with the anterior clinoid process by the carotico-clinoid ligament, which bridges over the carotid notch. When this ligament undergoes ossification a **carotico-clinoid foramen** is formed, through which the internal carotid artery ascends after leaving the carotid groove.

In front of the carotid notch, between the upper and lower roots of the small wing, there is a circular aperture, called the **optic foramen,** which leads forwards and outwards into the orbit, and transmits the optic nerve and the ophthalmic artery.

The **greater** or **temporal wings** (alisphenoids) extend outwards, upwards, and forwards from the sides of the body. The posterior part of each projects backwards, and ends in a pointed extremity, which is received within the petro-squamous angle of the temporal bone. From this extremity a sharp projection extends downwards for a short distance, called the **spine** of sphenoid or **alar spine,** which often has a groove on its inner aspect for the chorda tympani nerve. Anterior to this groove, and encroaching on the posterior border of the greater wing, is another groove for the cartilaginous part of the pharyngo-tympanic tube. The spine of the sphenoid gives attachment to (1) the spheno-mandibular ligament, (2) some fibres of the tensor palati, and (3) the anterior ligament of the malleus.

Each greater wing presents three surfaces—superior, antero-internal, and external; and four borders—posterior, lateral, anterior, and medial.

The *superior* or *cerebral surface,* which at its front part rises almost vertically upwards, is concave, and enters into the formation of the lateral division of the middle cranial fossa. It supports the temporal lobe of the cerebrum, and presents a few digitate impressions, whilst laterally it is grooved for a branch of the middle meningeal artery. This surface presents several important foramina. At the anterior part of its attachment to the side of the body, just below the inner end of the superior orbital fissure, is the **foramen rotundum,** which is directed from behind forwards and transmits the maxillary division of the fifth cranial nerve. A little behind and lateral to this foramen is the **foramen ovale,** of large size and opening vertically downwards, for the passage of the mandibular division and the motor root of the fifth cranial nerve, the accessory meningeal artery, the middle meningeal vein, and sometimes the lesser superficial petrosal nerve. Medial and anterior to the foramen ovale, between it and the lingula sphenoidalis, there is sometimes a small opening, called the **emissary sphenoidal foramen** (foramen Vesalii), which leads to the scaphoid fossa on the outer side of the root of the medial pterygoid plate, or to the pterygoid fossa lateral to the scaphoid fossa. It transmits a small emissary vein from the cavernous sinus. Behind and external to the foramen ovale is the small circular **foramen spinosum,** close to the spine of the sphenoid, which opens vertically downwards. It transmits the middle meningeal artery and nervus spinosus branch of the mandibular nerve, and is sometimes incomplete posteriorly. Medial to this foramen, between it and the foramen ovale, there is sometimes a small opening, called the **innominate canal,** for the lesser superficial petrosal nerve.

The *antero-medial surface* is divisible into a large orbital portion and a small pterygo-palatine portion. The *orbital division* is quadrilateral, smooth, and slightly concave, and it forms the greater part of

the outer wall of the orbit. The *pterygo-palatine division* is situated at the lower and inner part above the root of the pterygoid process. It is pierced by the foramen rotundum, and lies in the posterior wall of the pterygo-palatine fossa.

The *lateral* or *temporo-zygomatic surface* is elongated from above downwards, and is continuous with the outer surface of the lateral pterygoid plate of the pterygoid process. Towards its lower part it is crossed by the **infratemporal crest,** which divides it into a large upper and a small lower portion. The *upper* or *temporal division,* which is directed outwards, forms part of the temporal fossa, and gives origin to fibres of the temporal muscle. The *lower* or *zygomatic division* looks downwards into the infratemporal fossa, and gives origin to the upper head of the lateral pterygoid muscle. At its lower and back part are the openings of the foramen ovale and foramen spinosum.

The *posterior border* extends from the spine of sphenoid to the body, passing in its course behind the foramen ovale. Over its inner two-thirds it bounds the foramen lacerum anteriorly, and over its outer third, where it becomes serrated, it articulates with the petrous portion of the temporal, the two forming a groove for the cartilaginous part of the pharyngo-tympanic tube. The *lateral border* separates the superior or cerebral from the lateral or temporo-zygomatic surface. It is serrated behind, where it is bevelled at the expense of the upper or inner plate, but in front it is squamous and bevelled at the expense of the outer plate.

It is worth calling attention here to the frequency with which this alternate bevelling is found in the skull bones, and how greatly it adds to the strength of the sutures.

The entire border articulates with the squamous portion of the temporal. The *anterior border* or **zygomatic crest** separates the orbital and temporal surfaces. Its direction is downwards and inwards, and it is sharp and irregular for the malar. The *medial border* is situated between the orbital and cerebral surfaces. Its direction is backwards and inwards, and it forms the lower boundary of the superior orbital fissure. About its centre it presents a small spine, which gives origin to fibres of the lower head of the lateral rectus muscle of the eyeball. The greater wing antero-superiorly becomes thick and expanded, and it here presents a rough, triangular, serrated surface for the frontal. At the outer end of this surface there is another small triangular, serrated impression for the antero-inferior angle of the parietal.

The **superior orbital fissure** is situated between the greater and lesser wings. It is triangular, and its direction is inwards and downwards. It is bounded above by the lesser wing, below by the medial border of the greater wing, and medially by the anterior part of the side of the body, whilst laterally it is closed by the frontal, or, it may be, the meeting between the two wings. It leads from the middle cranial fossa to the orbit, and transmits the following structures:

the third cranial nerve, the fourth, the three branches of the ophthalmic division of the fifth (namely, frontal, lacrimal, and naso-ciliary), and the sixth cranial nerves, the sympathetic root of the ciliary ganglion, the superior ophthalmic veins, the orbital branch of the middle meningeal artery, and a portion of the dura mater to form the orbital periosteum.

The **pterygoid processes** project downwards from the junction of the body and greater wings. Each is composed of two plates, lateral and medial, united in front to form a thick round border, except inferiorly, where they are separated by the **pterygoid fissure,** which receives the tubercle of the palatine bone. At the upper end of the anterior border a triangular surface opens out, which lies in the posterior wall of the pterygo-palatine fossa, and presents the anterior orifice of the pterygoid canal. Posteriorly the two plates diverge, and

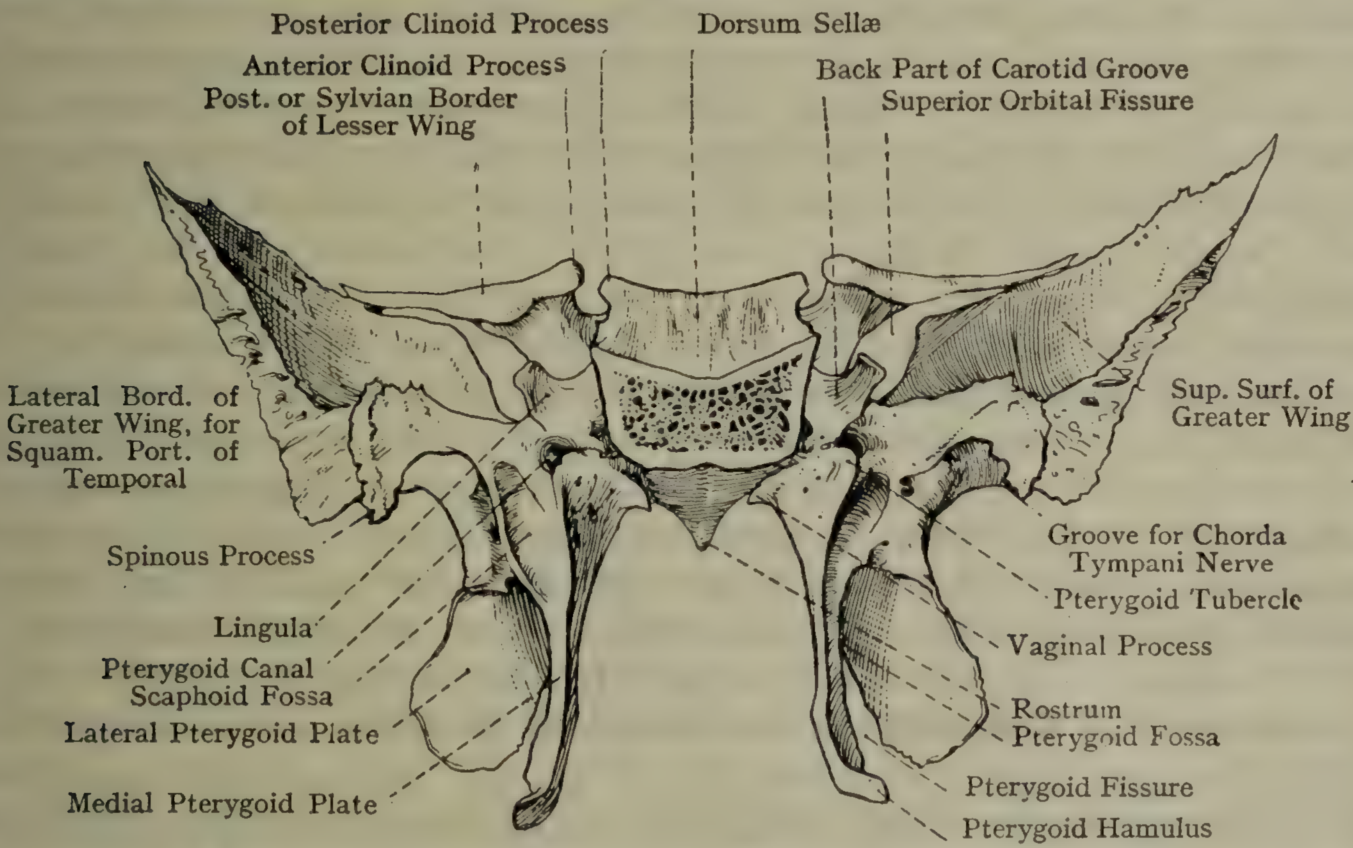


FIG. 132.—THE SPHENOID BONE (POSTERIOR VIEW).

enclose between them the **pterygoid fossa,** which contains the medial pterygoid and tensor palati muscles.

The **lateral pterygoid plate** is broader and shorter than the medial, and is directed backwards and slightly outwards. Its outer surface looks into the zygomatic fossa, and gives origin to the lower head of the lateral pterygoid muscle. Its inner surface looks into the pterygoid fossa, and gives origin to the medial pterygoid muscle. The posterior border usually presents towards its upper part a sharp spine, from which the pterygo-spinous ligament extends backwards and outwards to the spine of the sphenoid. This ligament sometimes becomes ossified, and a foramen is then formed, called the **pterygo-spinous foramen,** for the passage of muscular branches of the mandibular nerve. Sometimes there is another spine towards the lower end of this border for another pterygo-spinous ligament.

The **medial pterygoid plate,** narrower and longer than the lateral, is prolonged inferiorly into the **pterygoid hamulus,** which is inclined outward and backward, its outer and lower aspects being smooth and grooved for the play of the tendon of the tensor palati. Superiorly this plate is inflected as the vaginal process, which articulates with the ala of the vomer, and has on its under surface the groove, forming part of the greater palatine canal, already referred to. The outer surface of the medial pterygoid plate looks into the pterygoid fossa, and is related to the tensor palati. The inner surface forms the back part of the outer wall of the nasal fossa. The posterior border at its upper end presents the **pterygoid tubercle,** which has the posterior end of the pterygoid canal above and lateral to it. Between this tubercle and the pterygoid canal on the one hand, and the pterygoid fossa on the other, is the **scaphoid fossa,** which gives origin to the tensor palati. On the posterior border of the medial pterygoid plate, below the lower pointed end of the scaphoid fossa, is the *processus tubarius,* which supports the cartilage of the pharyngo-tympanic tube. The lower third of the posterior border and the pterygoid hamulus give origin to fibres of the superior constrictor muscle of the pharynx, and the pterygoid hamulus also gives attachment to the pterygo-mandibular ligament. The anterior border articulates with the posterior border of the perpendicular plate of the palate bone.

The **pterygoid canal** pierces the bone from before backwards at the junction of the internal pterygoid plate and body on either side. Its anterior orifice appears on the posterior wall of the pterygo-palatine fossa, below and internal to the anterior orifice of the foramen rotundum, and posteriorly it opens on the anterior wall of the foramen lacerum medium, above and lateral to the pterygoid tubercle. It gives passage to the nerve and artery of the pterygoid canal.

Summary of Openings in the Sphenoid Bone.—(1) Superior orbital fissure, between lesser and greater wings; (2) optic foramen, between the two roots of the lesser wing; and, in the greater wing, (3) foramen rotundum; (4) foramen ovale; (5) emissary sphenoidal foramen (inconstant); (6) foramen spinosum; (7) innominate canal (inconstant); and (8) pterygoid canal, the last-named being between the medial pterygoid plate and the body. All these openings are common to each side.

The **sphenoidal air sinuses** are situated within the body, and are two in number, right and left. They are separated from each other by a septum, which is seldom quite median and often incomplete. The sinuses are—at least, after adult life—usually multilocular, and they may extend backwards so as to invade the basilar process of the occipital, especially in old age. Each sinus may even extend slightly into the attached portion of the greater wing. They are lined with mucous membrane, which is continuous with that of the nasal fossæ, and each opens anteriorly by a small circular aperture into the spheno-ethmoidal recess above and behind the corresponding superior meatus.

The **sphenoidal conchæ** are situated on the anterior and inferior surfaces of the body of the sphenoid, of which they form a large part. In the adult they are blended with the sphenoid and adjacent parts of the ethmoid and palatine bones, but in early life they are quite distinct. Each has the form of a three-sided, hollow pyramid, the apex of which is directed backwards and downwards to the front part of the vaginal process, whilst the base is in contact with the back part of the labyrinth of the ethmoid. The inferior surface looks into the posterior part of the roof of the nasal fossa, and it converts the spheno-palatine notch on the upper border of the perpendicular plate of the palatine bone into a foramen. The lateral surface appears on the inner wall of the pterygo-palatine fossa, and a portion of it is sometimes seen on the inner wall of the orbit, behind the orbital plate of the ethmoid. The superior surface is in contact with the anterior and inferior surfaces of the front part of the body of the sphenoid. It is at the upper part of this surface, on either side of the middle line, that the openings of the sphenoidal air sinuses ultimately appear as small oval apertures. When the sphenoidal conchæ are broken away these openings are of large size and irregular outline.

The blood-supply of the bone is derived from branches of the deep temporal arteries externally, the middle and accessory meningeal internally, and the artery of pterygoid canal, greater palatine, and spheno-palatine branches of the maxillary, as these traverse their respective passages.

Articulations.—The sphenoid articulates with fourteen bones as follows: occipital, two temporals, two parietals, frontal, ethmoid, two sphenoidal conchæ, two zygomatics, two palatines, and vomer. It sometimes also articulates with the maxillæ.

Structure.—The body of the bone is excavated into two air sinuses.

Varieties. — (1) Middle clinoid process. (2) Carotico-clinoid foramen. (3) Ossification of interclinoid ligament between anterior and posterior clinoid processes. (4) The lateral margin of the dorsum sellæ may present a superior petrosal process for the attachment of the petro-sphenoidal ligament, which connects it with a projection sometimes present on the inner part of the superior border of the petrous portion of the temporal. This ligament, which is sometimes ossified, bridges over a foramen through which the inferior petrosal venous sinus and sixth cranial nerve pass. (5) Pterygo-spinous foramen. (6) Foramen ovale and foramen spinosum are sometimes incomplete. (7) Emissary sphenoidal foramen. (8) Innominate canal. (9) The cranio-pharyngeal canal may remain persistent, opening into the hypophyseal fossa. (10) The dorsum sellæ may be joined to the rest of the bone by membrane only.

Ossification.—The sphenoid is developed in cartilage, with the exception of the medial pterygoid plates, which are developed in fibrous tissue.* The bone is originally divided into two parts—presphenoid, representing the part of the body in front of the tuberculum sellæ, and the lesser wings; and postsphenoid, including the part of the body behind the tuberculum sellæ, the greater wings, and the pterygoid processes. The **postsphenoid division** is developed from

* According to recent observations made by Fawcett, the lateral pterygoid plates are also developed in fibrous tissue.

four pairs of centres. One pair appear in the *eighth week* of intra-uterine life, one at either side in the greater wing between the foramen rotundum and foramen ovale, and from this ossification extends outwards into the greater wing and downwards into the lateral pterygoid plate. Another pair appear about the same time in the sella turcica on either side of the cranio-pharyngeal canal, from which ossification extends around the canal, gradually constricting it, and finally leading to its closure. At this time another pair (sphenotics of Bland-Sutton) appear, one at each side, for the lingula. In the *fourth month* (ninth or tenth week, Fawcett) another pair of centres appear in fibrous tissue, one at either side, for the medial pterygoid plate, which unites with the lateral pterygoid plate before the *sixth month.* The **presphenoid division** is developed from **two pairs of centres.** Two appear in the *ninth week,* one at either side, lateral to the optic foramen, for the lesser wing. Another pair appear in the *eleventh week* medial to the optic foramina for the presphenoid portion of the body. The latter pair soon unite with each other, and also with those for the lesser wings. The presphenoid division, bearing the lesser wings, joins the post-sphenoid division shortly before birth in the region of the tuberculum sellæ.

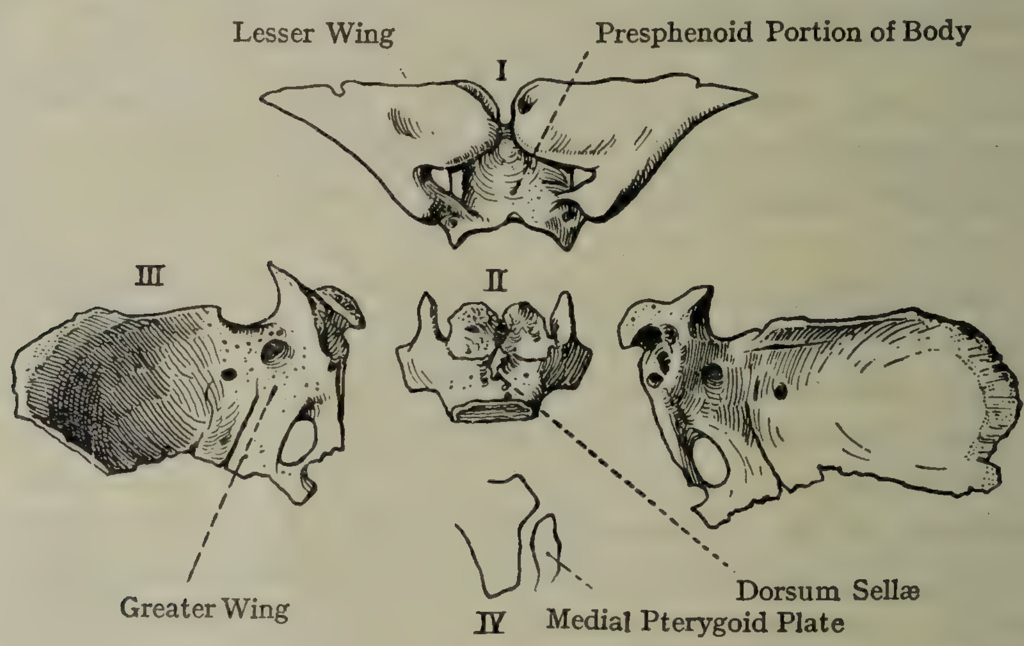


Fig. 133.—The Sphenoid Bone in Early Life.

I, presphenoid division; II, postsphenoid portion of body; III, greater wing and pterygoid process; IV, elements of pterygoid process.

At birth the place of junction is indicated by a wide depression on the under aspect of that eminence, which may even extend through it and give rise to a small foramen on its upper surface.

At birth the bone is composed of three parts—a **central,** representing the presphenoid and postsphenoid portions of the body, the former bearing the lesser wings; and **two lateral,** each of which represents a greater wing bearing a pterygoid process. In the *first year* the lingula joins the greater wing, and the wing and body unite. About the same time the lesser wings come together and blend over the anterior part of the upper surface of the presphenoid portion of the body, where they give rise to a smooth, elevated, flat platform, called the **jugum sphenoidale.**

In fœtal life a canal, called the **cranio-pharyngeal canal,** leads downwards from the sella turcica into the body, and contains a process of the dura mater. This canal is the remains of a cleft originally present in the base of the skull, through which a diverticulum of the buccal ectoderm, known as the **pouch of Rathke,** originally passed upwards to form the anterior lobe of the hypophysis cerebri. Such a communication through the base of the skull, in the mid-line, could not have occurred farther back, because the anterior end of the notochord corresponds in position with the dorsum sellæ.

The sphenoidal air sinuses begin to invade the bone by the *fifth year.*

In most animals the presphenoid and postsphenoid portions remain permanently separate, and the medial pterygoid plates form the pterygoid bones.

The sphenoidal conchæ commence to ossify in the *fifth month* of intra-uterine life. At birth each partially envelops a small extension of the nasal mucous membrane, and by the *third year* it has surrounded it in the form of a bony capsule, except anteriorly, where an opening, called the sphenoidal foramen, is left. Subsequently a portion of this capsule becomes absorbed, and its place is taken by the presphenoid, which latter, after the *seventh year,* is gradually invaded by the original extension of the nasal mucous membrane. The sphenoidal conchæ become ankylosed to the ethmoid about the *fourth year,* and are sometimes regarded as belonging to that bone. By the *twelfth year* they have become united to the sphenoid and also to the palatine bones.

The Ethmoid Bone.

The **ethmoid bone** is situated at the anterior part of the base of the skull, where it lies in the middle line in front of the sphenoid. A portion of it occupies the ethmoidal notch between the orbital plates of the frontal, whence the greater part of the bone projects downwards, to take part in the formation of the orbits and nasal fossæ. The only portions of the bone visible in the interior of the base are the cribriform plate and crista galli. It is irregularly cubical, its long axis being directed from before backwards, and it is remarkable for its lightness, which is due to the great number of enclosed air cells, these being surrounded by very thin plates of bone. It is composed of four parts—namely, a cribriform plate, a perpendicular plate, and two ethmoidal labyrinths.

The **cribriform plate** connects the upper borders of the labyrinths, and enters into the formation of the middle division of the anterior cranial fossa, where it occupies the ethmoidal notch of the frontal bone. In the middle line anteriorly it presents an upward extension of the perpendicular plate, called the **crista galli.** This is a stout, triangular, laterally-compressed process, which has a smooth, sloping posterior border, for the falx cerebri. The anterior border, short and vertical, is somewhat narrow above, but soon expands into two **alæ,** for the frontal bone, and it here sometimes completes the foramen cæcum. The posterior border is prolonged backwards as a median ridge, and on either side of this ridge and the crista galli is the **olfactory groove,** which lodges the olfactory tract and bulb. Each half of the cribriform plate, which lies in the roof of the corresponding nasal fossa, is pierced by foramina for the filaments of the olfactory bulb. The foramina in each half are arranged in three sets as follows: a middle set, which are simple perforations, and a medial and lateral set, which lead into small canals. These canals descend on the perpendicular plate and inner surface of the ethmoidal labyrinth respectively, branching and opening out as they descend. All the foramina lead to the upper part of the corresponding nasal fossa. At the anterior and inner part of each half of the cribriform plate, close to the side of the crista galli, near its anterior border, there is an antero-posterior fissure, called the **nasal slit,** which transmits the nasal branch of the

anterior ethmoidal artery to the nasal fossa, while a small foramen just in front and to the outer side of it is for the nasal nerve. Leading backwards and outwards from this foramen to the anterior ethmoidal groove on the upper border of the labyrinth is the **nasal groove,** also for the anterior ethmoidal nerve. The posterior border of the cribriform plate articulates with the ethmoidal spine of the sphenoid.

The **perpendicular plate** (mesethmoid) extends downwards from the cribriform plate in the middle line. It lies between the labyrinths, where it forms about the upper third of the nasal septum, and it is usually inclined more to one side than the other. It is very thin and irregularly pentagonal. The *superior border* projects above the cribriform plate and forms the crista galli. The *antero-inferior border* articulates with the septal cartilage of the nose, the postero-inferior

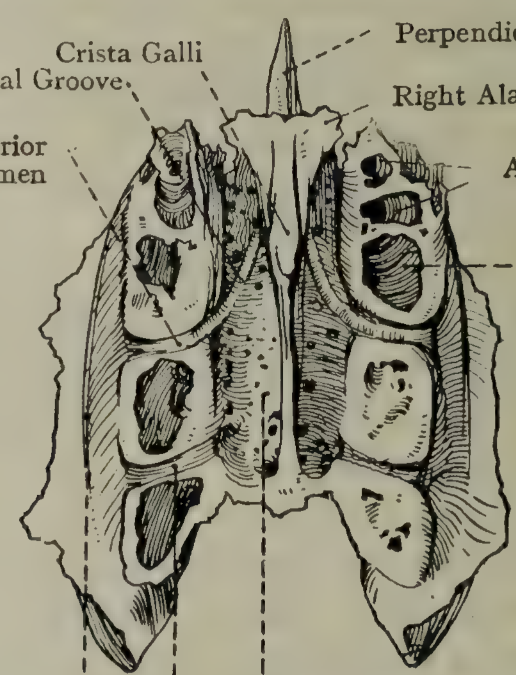


Fig. 134.—The Ethmoid Bone (Superior View).

with the alæ of the vomer in the intervening cleft, with which alæ it is usually ankylosed in adult life. The *anterior border* articulates with the nasal spine of the frontal and the nasal crest of the nasal bones. The *posterior border* articulates with the crest of the sphenoid. Each *lateral surface* looks into the corresponding nasal fossa, and presents superiorly several small canals and grooves, which lead downwards from the medial set of foramina in each half of the cribriform plate, and transmit olfactory filaments.

The **ethmoidal labyrinths** (lateral masses) form the principal part of the bone, and contain a number of air cells enclosed within very thin osseous plates. Each **labyrinth** is elongated from before backwards, and presents two surfaces and four borders.

The *lateral surface*, smooth and quadrilateral, with the long axis directed from before backwards, is called the **orbital plate** (os planum), and forms the principal part of the inner wall of the orbit. It articu-

lates *superiorly* with the inner border of the orbital plate of the frontal, *anteriorly* with the lacrimal, *inferiorly* with the inner margin of the orbital plate of the maxilla, and behind this with the orbital process of the palatine bone, close to the postero-inferior angle, and *posteriorly* with the sphenoid, or, it may be, with a portion of the sphenoidal concha. At the lower part of the lateral surface, below the orbital plate, there is a deep channel, elongated from before backwards, which forms the middle meatus of the nose, and is limited below by the inferior rolled border of the middle nasal concha. This groove turns upwards in front, under cover of the anterior part of the middle nasal concha, and is continued into the **infundibulum** which communicates with the frontal sinus of the same side. The anterior ethmoidal sinus opens into the ascending part of the middle meatus, whilst the middle ethmoidal sinus and the maxillary sinus open into its horizontal part. Lying in the anterior part of this meatus is the uncinate process.

FIG. 135.—THE ETHMOID BONE (LATERAL VIEW).

The *medial surface* of the labyrinth forms a part of the outer wall of the nasal fossa. Superiorly it has several small canals and grooves which lead downwards from the lateral set of foramina in the cribriform plate and transmit olfactory filaments. This surface is doubly convoluted, and presents the **superior** and **middle nasal conchæ,** which are sometimes spoken of as the *superior* and *middle spongy bones*. These are continuous with each other in front, but posteriorly they are separated by the **superior meatus,** which is directed obliquely forwards and upwards, and communicates with the posterior ethmoidal sinus or sinuses. The **superior nasal concha** is short, and overhangs the superior meatus. The **middle nasal concha** is longer and more convoluted than the superior. Its lower border, which is thick, is rolled outwards, and has been referred to in connection with the outer surface. It is free, as are also its thick anterior and pointed posterior extremities. This process overhangs the **middle meatus.** Both conchæ are pierced by nutrient foramina, and present grooves for olfactory filaments.

The *superior border* is covered by the bevelled inner margin of the orbital plate of the frontal, which closes in the depressions upon it, and converts them into sinuses. Besides these depressions this border presents two transverse grooves about ½ inch apart, which, with corresponding grooves on the orbital plate of the frontal, form the **anterior** and **posterior ethmoidal foramina.** These open upon the inner wall of the orbit, and the *anterior* transmits the anterior ethmoidal vessels and nerve, whilst the *posterior* gives passage to the posterior ethmoidal vessels and nerve. The *inferior border*, which is free on the outer wall of the nasal fossa, is formed by the lower border of the middle nasal concha. *Anteriorly* it articulates with the superior turbinate crest of the maxilla, and *posteriorly* with the ethmoidal or superior turbinate crest of the palatine bone. The *anterior border*, like the superior, presents depressions, which form sinuses when the lacrimal and nasal process of the maxilla are in position. This border projects

FIG. 136.—THE LEFT LATERAL MASS OF THE ETHMOID BONE (INTERNAL VIEW).

slightly in advance of the front of the orbital plate (of ethmoid), and from the lower part of this projecting portion there springs the **uncinate process.** This is a long, thin, curved plate which extends downwards, backwards, and slightly outwards into the anterior part of the middle meatus. In its course it crosses the opening of the maxillary sinus in the maxilla, and thus forms part of the inner wall of that sinus. The lower border of the process presents two spur-like projections, between which the border is markedly concave. The posterior terminal spur articulates with the ethmoidal process of the inferior nasal concha. The *posterior border* of the lateral mass presents a few depressions, closed by the sphenoidal concha and orbital process of the palatine bone, which latter process becomes ankylosed with it about the fourth year.

The **ethmoidal sinuses** are contained within each labyrinth, and are lined with mucous membrane, which is continuous with that of the nose. They are arranged in three sets—anterior, middle, and

posterior. The **anterior ethmoidal sinuses,** along with the frontal sinus of the same side, open by a common passage, already described as the infundibulum, into the ascending front part of the middle meatus; the **middle ethmoidal sinus** opens into the horizontal part of the middle meatus; and the **posterior ethmoidal sinus** opens into the superior meatus.

The bone receives its blood-supply from the anterior and posterior ethmoidal branches of the ophthalmic, and the spheno-palatine branch of the maxillary.

Articulations.—The ethmoid articulates with fifteen bones as follows: (1) frontal (nasal spine and orbital plates); (2) sphenoid (ethmoidal spine and sphenoidal crest); (3) two sphenoidal conchæ; (4) two nasal bones (nasal crest); (5) vomer (cleft between alæ); (6) two palatine bones (ethmoidal or superior turbinate crests and orbital processes); (7) two lacrimals (upper part of internal surface); (8) two maxillæ (nasal processes, orbital plates, and opening of each maxillary sinus); and (9) two inferior nasal conchæ (ethmoidal processes).

Structure.—The labyrinths are excavated into many thin-walled air cells, and the crista galli contains a small amount of cancellated tissue.

Ossification.—The ethmoid is developed in cartilage from **three centres.** Two of these appear in the *fifth month* of intra-uterine life, one in each orbital plate, from which ossification extends into the superior and middle nasal conchæ. At birth the labyrinths are ossified, but the perpendicular plate and crista galli are cartilaginous. In the *first year* a centre appears at the base of the crista galli, and from this ossification extends upwards into that process, downwards into the perpendicular plate, and outwards into the cribriform plate, into which latter osseous matter also extends inwards from each labyrinth. The three original parts unite about the *fifth year*. The osseous ethmoidal sinuses usually make their appearance about the *third year*.

The Maxillæ.

The **maxilla** forms, with its fellow, a large part of the face, and, besides supporting the upper teeth of its own side, it enters into the formation of the orbit, nasal fossa, and hard palate. It is composed of a central portion or body, and four processes—frontal, zygomatic, alveolar, and palatine.

The **body** is excavated into a large cavity, called the maxillary sinus, and it presents four surfaces—anterior, posterior, orbital, and nasal.

The *anterior* or *facial surface* is limited above by the infra-orbital border, below by the alveolar border, medially by the medial border, presenting the nasal notch, and laterally by the zygomatic process and a ridge of bone extending downwards from it to the first molar alveolus. It presents inferiorly five ridges, coinciding with the roots of the incisor, canine, and premolar teeth, of which that of the canine is conspicuous, and is called the **canine ridge.** Medial to this ridge is the **incisive fossa,** which gives origin medially to the depressor septi, and externally

to a deep slip of the orbicularis oris, whilst above, and lateral to, the latter the compressor naris arises. Lateral to the canine ridge is the **canine fossa,** which, at its upper part, gives origin to the levator anguli oris, the bone being here thin and translucent in front of the maxillary sinus. Above the canine fossa, near the infra-orbital border, is the **infra-orbital foramen,** which is the outlet of the infra-orbital canal, and transmits the infra-orbital nerve and vessels. Immediately above this foramen the levator labii superioris arises. The medial border of the facial surface presents the deep **nasal notch,** at the lower

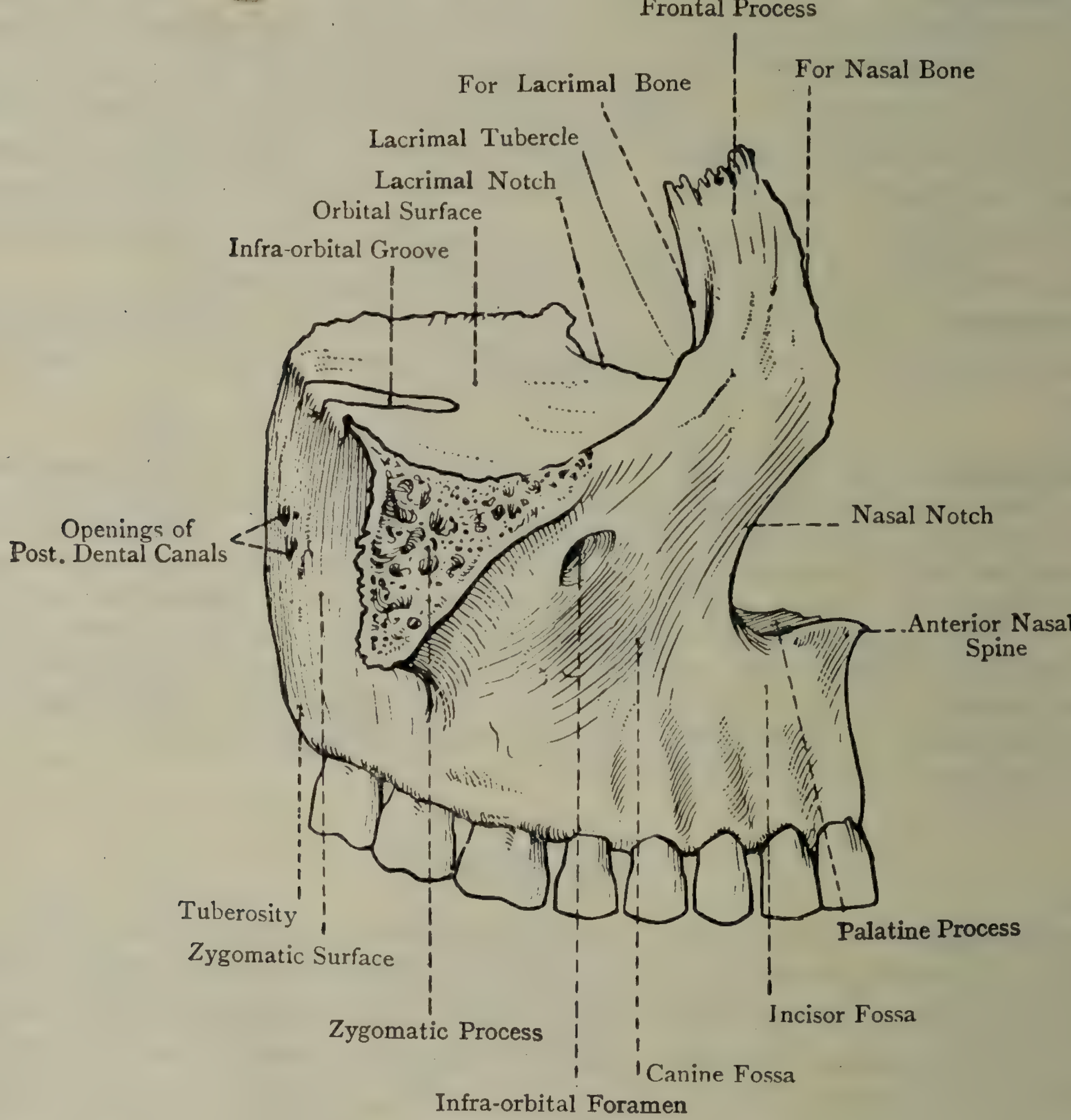


FIG. 137.—THE RIGHT MAXILLA (LATERAL ASPECT).

and inner part of which is a sharp projection, forming, with its fellow, the **anterior nasal spine,** below which the border is vertical.

The *posterior* or *zygomatic surface* is situated behind the zygomatic process and the ridge connecting that process with the first molar socket. Superiorly it is limited by the posterior border of the orbital surface, inferiorly by the molar portion of the alveolar arch, and posteriorly by the posterior border of the bone. It looks into the zygomatic and pterygo-palatine fossæ, and its outline is convex. Towards the centre it presents the openings of two or three **posterior dental canals,**

which lead to the molar sockets, and transmits branches of the posterior superior dental nerve and artery. At the lower and back part this surface gives rise to the **tuberosity,** which lies above and behind the last molar tooth. This tuberosity articulates with the tubercle of the palatine bone, and gives origin to some fibres of the medial pterygoid muscle.

The *superior* or *orbital surface* is triangular, smooth, and slightly concave, and it forms the greater part of the floor of the orbit. This portion of the bone is known as the **orbital plate.** It presents the **infra-orbital groove,** which at first runs outwards, slightly grooving the bone just behind the orbital plate; this leads, at the middle of the posterior border of the plate, into a well-marked groove which runs forwards and ultimately becomes converted into the **infra-orbital canal.** This canal transmits the infra-orbital nerve and vessels. From its posterior part the **middle dental canal,** for the middle superior dental nerve and a branch from the posterior superior dental artery, passes downwards and forwards to the premolar sockets, lying at first in the postero-lateral wall of the maxillary sinus, and subsequently in the antero-lateral wall. The canal is often for the most part a groove. The **anterior dental canal,** for the anterior superior dental nerve and artery, descends in a branching manner from the anterior part of the infra-orbital canal to the incisor and canine sockets, lying in the antero-lateral wall of the sinus. At the anterior and inner part of the orbital plate, lateral to the naso-lacrimal groove, there is a slight depression which gives origin to the inferior oblique muscle of the eyeball. The borders of the orbital surface are anterior, posterior, and medial. The anterior border coincides with the infra-orbital border. The posterior border, which has an inclination outwards, forms the anterior boundary of the inferior orbital fissure, and presents a notch which is the beginning of the infra-orbital groove. The medial border, antero-posterior in direction, presents, behind the nasal process, the **lacrimal notch** for the lacrimal bone, and behind this it articulates from before backwards, with the lower border of the orbital plate of the ethmoid and the orbital process of the palatine bone. This border presents a few depressions which close in ethmoidal sinuses.

The *nasal surface* forms part of the outer wall of the nasal fossa. It is limited in front by the medial border of the bone, behind by the posterior border, above by the medial border of the orbital surface, and below for the most part by the palatine process. It presents the opening of the maxillary sinus, in front of which is the deep **lacrimal groove,** directed downwards, outwards, and backwards, and, after a course of about $\frac{1}{2}$ inch, opening into the front part of the inferior meatus of the nose. This groove is converted posteriorly and medially into the lacrimal canal by the lacrimal and inferior nasal concha bones, and it transmits the naso-lacrimal duct. In front of the lacrimal groove is a slightly oblique ridge, called the **conchal crest,** for articulation with the inferior nasal concha, and below this is a smooth concave surface

which forms the anterior part of the inferior meatus. Above the crest is the commencement of another smooth surface, which extends upwards on to the inner aspect of the frontal process, and forms the outer wall of the atrium of the middle meatus. Behind the opening of the maxillary sinus the internal surface articulates with the perpendicular plate of the palatine bone, and it presents, from the centre downwards, a groove, directed downwards and forwards, which, with the palatine bone, forms the greater palatine canal for the greater palatine nerve and vessels. Above the opening of the sinus are a few depressions on the medial border of the orbital surface, forming ethmoidal sinuses.

The **frontal process** ascends vertically from the medial part of the facial surface above the nasal notch. It is somewhat triangular, and presents two surfaces and three borders. The *lateral surface* is continuous with the facial surface of the body, and gives attachment to the orbicularis oculi, medial palpebral ligament, and levator labii superioris alæque nasi. It will be noticed that the lower margin of the orbit is continued up on to this surface, and that, behind it, is a groove which lodges part of the lacrimal sac. The *medial surface* forms part of the outer wall of the nasal fossa, and, at its back part superiorly, it presents one or two depressions, completing cells on the anterior border of the labyrinth of the ethmoid. The surface is crossed obliquely backwards and upwards by a ridge, called the **agger nasi,** which represents an additional nasal concha present in most mammals. This crest bounds superiorly the atrium of the middle meatus, and articulates posteriorly with the anterior extremity of the middle nasal concha of the ethmoid. Above the agger nasi there is a groove, called the *sulcus olfactorius*. The superior border is short, thick, and serrated for the frontal. The anterior border is sharp and articulates with the nasal.

The **zygomatic process** is stout and triangular. Its anterior surface is continuous with the facial surface of the body, and its posterior with the zygomatic surface, whilst the superior surface is rough and slightly serrated for the zygomatic bone.

The **alveolar process** forms the dependent part of the bone, and is thick and curved, being convex laterally and concave medially. The outer plate is known as the labial plate, and the inner as the lingual. The two plates are widely separated, and the intervening space is partitioned off into **sockets** by septa which pass between the two plates. The number of sockets in the adult bone is as a rule eight, and they gradually narrow towards their upper or deep ends, where they are perforated by foramina for the nerves and arteries of the teeth. They lodge the roots of the teeth, which, in order from the middle line outwards and backwards, are as follows: central incisor, lateral incisor, canine, first premolar, second premolar, and first, second, and third molars. The **sockets** correspond in shape with the roots of the teeth, the canine being the deepest. The outer surface of the alveolar border, over the extent of the three molar sockets, gives origin to fibres of the buccinator.

It should be remembered that the presence of an empty socket shows that the tooth has fallen out after death. When a tooth is lost during life the socket is absorbed. Carious teeth are less likely to fall out post-mortem than sound ones.

The **palatine process** is situated on the medial surface of the body, from which it projects horizontally inwards, and, with its fellow, it forms three-fourths of the hard palate. It is quadrilateral, and presents two surfaces and four borders. The *superior surface* forms three-fourths of the floor of the nasal fossa, and is smooth, concave, and

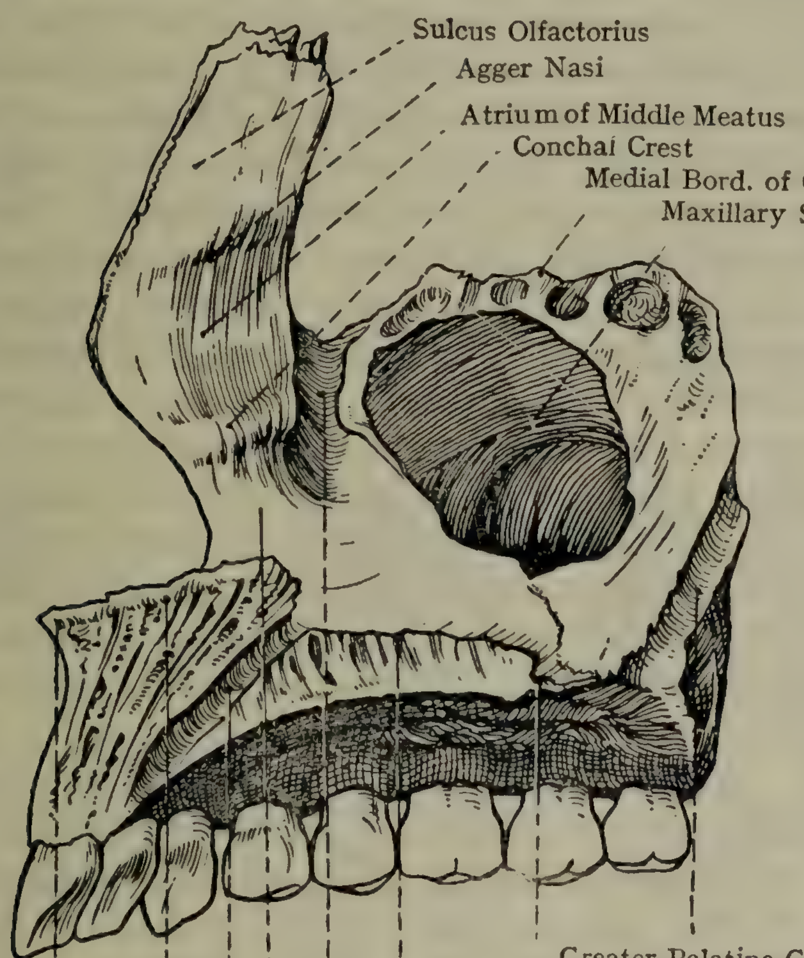


FIG. 138.—THE RIGHT MAXILLA (MEDIAL ASPECT).

covered in the recent state by the nasal mucous membrane. The *inferior surface* forms a part of the hard palate, and is rough, arched, and covered in the recent state by the buccal mucous membrane. It presents several depressions for the palatine mucous glands, and is perforated by several nutrient foramina. Laterally it is marked by a groove, directed from behind forwards, for the nerve and artery which reach the hard palate through the greater palatine canal. The posterior border stops short of the back part of the alveolar arch, and is short and serrated for the horizontal plate of the palatine bone. The anterior border, superiorly, forms the lower part of the nasal notch. The

lateral border is attached to the body. The medial border is faintly serrated, and articulates with its fellow. At the place of meeting it is elevated into a ridge, forming, with that of its fellow, the **nasal crest,** which is grooved to receive the lower border of the vomer. This medial ridge becomes prominent in front, where it forms the **incisor crest,** which is projected to constitute, with its fellow, the **anterior nasal spine.** It supports the septal nasal cartilage, and the anterior extremity of the vomer lies behind it.

Close to the outer side of the incisor crest the palatine process is pierced by an opening leading into a canal, which is bounded medially by a thin plate of bone, and descends to the front part of the hard palate, being ultimately converted into a groove, due to its inner thin wall becoming deficient. This passage is known as the incisive canal, and the two canals, right and left, in the articulated condition form inferiorly a large orifice, called the **incisive fossa.** This fossa, which is somewhat diamond-shaped, is situated in the middle line of the hard palate, behind the central incisor teeth. On looking into it from below four foramina are seen, two of which are placed in the middle line, where they lie in the intermaxillary suture. These are known as the **median incisive foramina,** and they transmit the long spheno-palatine nerves, the *left nerve* passing through the *anterior,* which usually communicates with the left nasal fossa, and the *right* through the *posterior,* which usually communicates with the right nasal fossa. The other two foramina are situated one at either side, and are known as the **lateral incisive foramina,** and the canal into which each leads opens superiorly on the floor of the corresponding nasal fossa, close to the outer side of the incisor crest. Each lateral incisive foramen transmits a branch of the greater palatine artery from the incisive fossa to the nasal fossa. The inner wall of Stensen's canal, on each side, represents the medial palatal process of the premaxilla or intermaxillary bone, and also a portion developed from the prepalatine centre. The lateral incisive canals correspond to the incisor foramina of many animals—*e.g.*, the ruminants, in which they are of large size, and each opens independently on the front part of the hard palate as a large aperture, there being no incisive fossa. In such animals each incisive foramen leads up to the orifice of the vomero-nasal organ, which is a supplementary organ of smell. In man the incisive canals are the remains of a communication which existed in early fœtal life between the nasal and buccal cavities.

Passing transversely outwards from the incisive fossa at its back part to the interval between the lateral incisor and canine teeth a suture is always present in early life, and may persist in the adult, which is said to indicate the line of junction of the maxillary portion proper and the premaxilla or intermaxillary bone, the latter representing the part which bears the central and lateral incisor teeth. This intermaxillary portion forms an independent bone in many animals. Sometimes a rough, antero-posterior elevation is seen in the mid-line, behind the incisive fossa, known as the torus palatinus. It may be mistaken for a bony tumour or exostosis.

The **maxillary sinus** is situated within the body of the bone, and is of large size, its capacity in health being equal to about 2 drachms. It has the shape of a four-sided pyramid, and is lined with mucous membrane continuous with that of the nasal fossa. The *apex* corresponds to the zygomatic process, and the *base* represents the nasal aspect. The *superior wall* or *roof* is formed by the orbital plate. The *inferior wall* or *floor* is formed by that portion of the alveolar border which contains the molar and second premolar sockets, and, in some cases, the first premolar socket also. It is often very irregular, due to projections of the upper ends of the sockets, and in some cases the root of the first molar, and, it may be, that of the second, projects into the antral cavity. The *antero-lateral wall* is formed by the facial surface, and is thin and translucent over the region of the canine fossa. It contains the anterior, and the lower part of the middle, dental canals. The *postero-lateral wall* is formed by the zygomatic surface, and it contains the upper part of the middle dental canal. The **opening** of the sinus, which is large and irregular, is situated on the base or nasal aspect. In the articulated skull its size is considerably diminished by

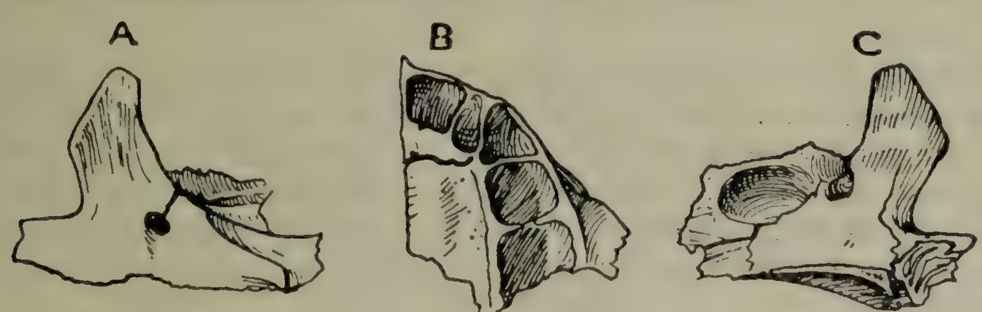


FIG. 139.—THE FŒTAL MAXILLA.

A, lateral aspect, showing the infra-orbital groove and foramen, with fissure; B, inferior view, showing the incisive fissure and sockets; C, medial aspect, showing the maxillary sinus and incisive fissure.

the perpendicular plate of the palatine bone behind, the maxillary process of the inferior nasal concha below, and above this by the uncinate process of the ethmoid. The opening is further curtailed by the adjacent mucous membrane. Under these circumstances it is reduced to a small aperture, situated near the upper part, which opens into the middle meatus of the nasal fossa. The sinus is usually unilocular, but it may be partially divided into compartments.

The bone derives its blood-supply from many sources, such as posterior superior dental, infra-orbital, anterior superior dental, facial, supratrochlear, greater palatine, and spheno-palatine arteries.

Articulations.—The maxilla articulates with nine bones as follows: zygomatic, nasal, frontal, lacrimal, ethmoid, inferior nasal concha, palatine, vomer, and its fellow of the opposite side. In addition to these it may articulate with the pterygoid process and greater wing of the sphenoid.

Structure.—The bone contains the maxillary sinus. For the most part cancellated tissue is absent, except in the alveolar process around the sockets.

Ossification.—The maxilla is ossified in membrane. According to Mall and Fawcett it has **two centres**—maxilla proper and premaxilla—which appear about the *sixth week*, and join about the *third month*. The centre referred to as *maxilla proper* appears in the region of the future canine socket, and from it ossification proceeds backwards into the zygomatic process, upwards into the *posterior half* of the nasal process, inwards into the *posterior* three-quarters of the palatine process, and downwards into the alveolar border, excluding the incisor portion.

The *premaxilla centre* gives rise to the premaxilla, which lies on the medial side of the maxilla proper and bears the upper incisor teeth. It also gives rise to (1) the *anterior fourth* of the palatine plate, and (2), according to Fawcett, the *anterior half* of the nasal process It is to be noted that, whilst the *anterior half* of the nasal process is ossified from the premaxilla centre, the *posterior half* of that process (bearing the lacrimal groove) is ossified from the maxilla proper centre.

Besides the premaxilla centre there is an *infravomerine centre*, according to Rambaud and Renault. This centre lies beneath the anterior part of the vomer, and it gives rise to the infravomerine part of the bone, which forms the medial wall of the incisive canal. The line of union between the premaxilla and maxilla proper is indicated by the *premaxillary suture* on the palatine surface of young bones, which may, though somewhat rarely, persist in adult life. This suture extends outwards and forwards from a point directly behind the lower end of the incisive canal to the alveolar border between the lateral incisor and canine sockets.

The premaxilla of each side forms an independent bone in many animals. It may be developed in two parts from separate centres of ossification—an inner for the portion bearing the central incisor socket, and an outer for the portion containing the lateral incisor socket, and these two portions may remain separate. The inner portion is known as the *endognathion*, and the outer portion as the *mesognathion*, whilst the remainder and greater part of the bone is referred to as the *ectognathion*.

The varieties of alveolar cleft palate are explained by a reference to these conditions of the bone. In **medial cleft palate** the two premaxillæ (right and left) are separated by a medial cleft. **Lateral cleft palate** may occur in two forms—the maxilla proper or ectognathion and the entire premaxilla may fail to unite, and the cleft is situated between them, and invades the alveolar border between the lateral incisor and canine sockets; or the premaxilla may exist in two parts, inner or endognathion, and outer or mesognathion, and the cleft may be between these two, in which case it invades the alveolar border between the central and lateral incisor sockets. These conditions may occur on one or both sides.

In the earlier stages of intra-uterine life there is no trace of the maxillary sinus, and the alveolar border lies close to the infra-orbital border. In the course of the *fourth month*, however, the sinus makes its appearance as a shallow depression on the inner aspect of the bone, and, as this increases, it gradually separates the orbital, alveolar, and palatine portions. In the process of development the alveolar border first presents an elongated furrow, called the **dental groove**, on either side of which a plate grows downwards, forming the labial and lingual plates. The groove is thus converted into a trench with these ramparts on either side. Subsequently these plates are connected by a number of septa, which intersect the trench and break it up into sockets. At this stage these are only five in number for each bone, and the canine socket is the first to be partitioned off. In early life the bone contains the temporary teeth, which are five in number on either side, but in the adult, as stated, it contains eight alveoli for the eight permanent teeth.

The Zygomatic Bones.

The **zygomatic bone** is situated between the zygomatic process of the frontal and zygoma of the temporal on the one hand, and the zygomatic process of the maxilla on the other, where it separates the orbit from the temporal fossa. It is quadrilateral, and presents two surfaces, four processes, and four borders. The *lateral surface* is convex, and near its centre there is the **zygomatic tuberosity.** Above this is the **zygomatic foramen** for the passage of the zygomatico-facial branch of the zygomatic nerve. The portion of this surface close to the zygomatic process gives origin to the zygomaticus major, and the lower and anterior part to the zygomaticus minor. The *medial surface,* which is concave, looks into the temporal fossa above and zygomatic fossa

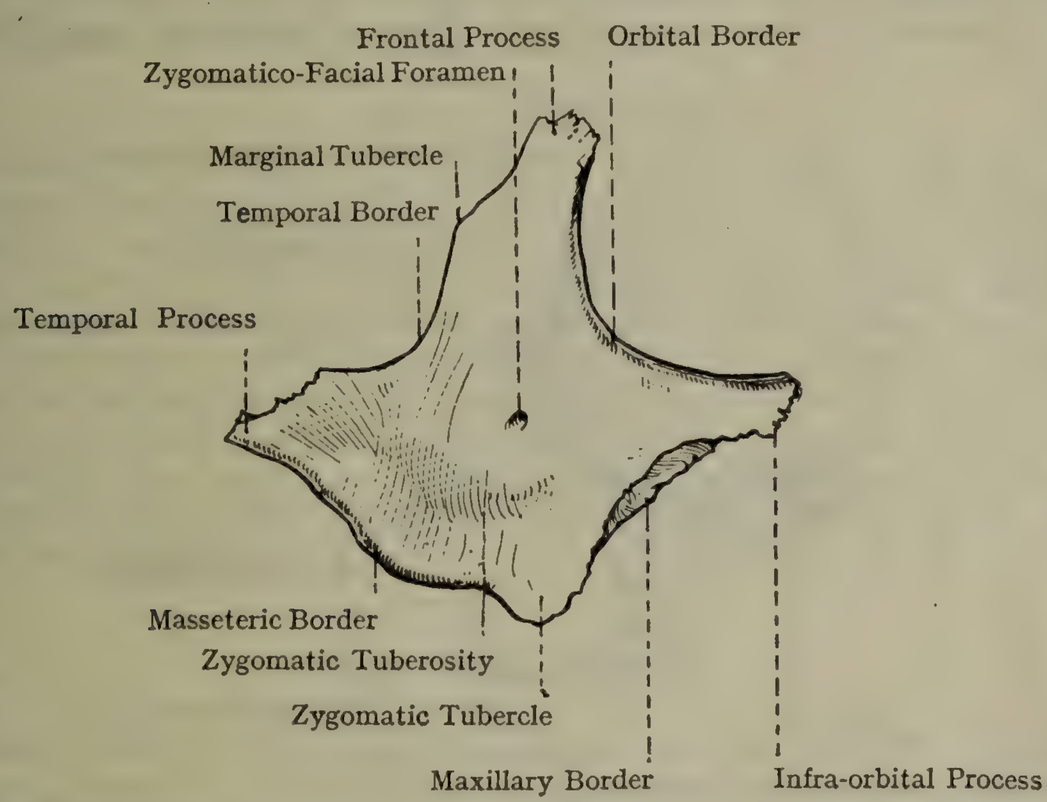


FIG. 140.—THE RIGHT ZYGOMATIC BONE (LATERAL SURFACE).

below, and it is overhung superiorly by a curved plate of bone, called the orbital process. Anteriorly it presents a rough, slightly serrated, triangular area for the zygomatic process of the maxilla. The **orbital process** projects backwards and inwards, in a curved manner, from the upper part of the medial surface on a level with the orbital border. It is triangular, and its superior or orbital surface presents a sweeping concavity, which enables it to form the front part of the outer wall of the orbit, and a portion of the floor. This surface is pierced by one or, it may be, two openings. If there is one, it ultimately leads to two canals—**zygomatico-facial,** which opens on the lateral surface; and **zygomatico-temporal,** which opens on the temporal division of the medial surface, as a rule near the frontal process. These canals transmit the zygomatico-facial and zygomatico-temporal branches of the zygomatic nerve. If there are two, each leads to its own canal.

The inferior surface of the orbital process, which is convex, forms the anterior part of the temporal fossa. The rough margin of the process articulates by its superior part with the anterior border or zygomatic crest of the greater wing of the sphenoid, and below with a part of the orbital plate of the maxilla. The part of this border between the sphenoidal and maxillary portions usually closes the anterior and outer extremity of the inferior orbital fissure, and thus intervenes between the greater wing of the sphenoid and the superior maxilla.

The **processes** are four in number—superior, posterior, inferior, and anterior. The *superior* or **frontal process** is stout and prominent. Its direction is vertically upwards, and it terminates in a thick serrated extremity for the zygomatic process of the frontal. The *posterior* or **temporal process** is short and usually blunt. Its direction is backwards, and it terminates in a serrated extremity which is mortised into the zygomatic process of the temporal. The *inferior* or **maxillary process**

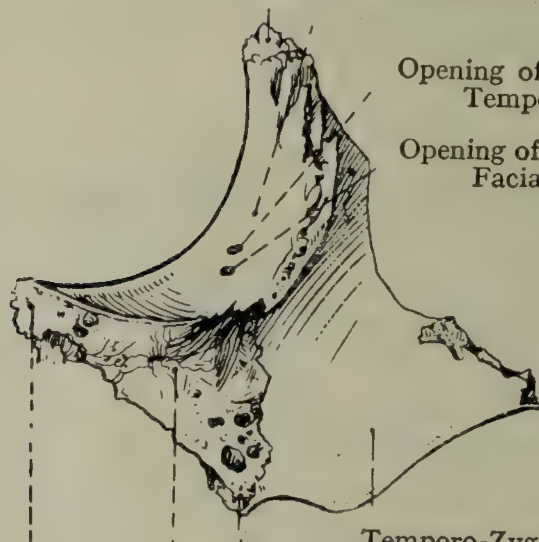


FIG. 141.—THE RIGHT ZYGOMATIC BONE (MEDIAL SURFACE).

is blunt and truncated. Its direction is downwards, and it articulates with part of the zygomatic process of the maxilla. The *anterior* or **infra-orbital process** is slender and pointed. Its direction is forwards, and it articulates with the maxilla near the infra-orbital foramen.

The **borders** are four in number—temporal, masseteric, maxillary, and orbital. The *temporal border* extends from the frontal process to the temporal process, and is directed backwards. It is sinuous, and continuous with the upper border of the zygomatic, and it gives attachment to the temporal fascia. Near the frontal process it usually presents a slight prominence, called the *marginal tubercle*, to which a stout slip of the temporal fascia is attached. The masseteric border extends from the temporal process to the maxillary process, and looks downwards. It is thick, rough, and continuous with the lower border of the zygomatic arch, and it gives origin to the anterior fibres of the superficial part of the masseter. The maxillary border extends from

the maxillary process to the infra-orbital process, and it looks forwards and slightly downwards. It is rough and slightly concave, and, together with the rough, slightly serrated, triangular area on the medial surface adjacent to it, articulates with the zygomatic process of the maxilla. The *orbital border* extends from the infra-orbital process to the frontal, and is smooth, round, and concave. Its direction is outwards and upwards, and it forms a large part of the circumference of the orbit.

The bone derives its blood-supply from the lacrimal, deep temporal, and transverse facial arteries.

Articulations.—The zygomatic bone articulates with four bones, as follows: *superiorly* with the frontal and sphenoid, *posteriorly* with the temporal, and *anteriorly* with the maxilla.

Structure.—The bone is mainly composed of compact tissue, the amount of cancellous tissue being small.

Varieties.—The bone may persist in two parts connected by a suture, which may be horizontal or vertical It sometimes persists in three parts.

Ossification.—The zygomatic is developed in membrane from **three centres,** which appear in the *eighth week* of intra-uterine life, and they unite at the end of the *fourth month.* These centres are called **prezygomatic, postzygomatic,** and **hypozygomatic.** If all three centres should fail to unite, then a tripartite zygomatic is the result. If the prezygomatic and postzygomatic unite, and the hypozygomatic remains separate, a bipartite zygomatic persists with a horizontal suture. If the postzygomatic and hypozygomatic unite, and the prezygomatic remains separate, the suture is vertical. A bipartite zygomatic occurs with great frequency amongst the Japanese, and from this circumstance the bone is known as the **os Japonicum.**

The Nasal Bones.

The **nasal bone,** which articulates with its fellow by its medial border, forms with it the bridge of the nose. It lies in front of the frontal process of the maxilla, where it enters into the formation of the face and nasal fossa. The bone is elongated from above downwards, and presents two surfaces and four borders. The *anterior* or *facial surface* is smooth, concavo-convex from above downwards, and convex from side to side. Near its centre it usually presents a minute foramen for the passage of a small vein from the nose to the commencement of the facial vein. The *posterior* or *nasal surface* is rough superiorly, where it articulates with the nasal spine of the frontal. Elsewhere it is smooth and concave from side to side, and in the recent state is covered by the nasal mucous membrane. It is traversed longitudinally near the centre by the **ethmoidal sulcus** for the anterior ethmoidal nerve.

The *superior border* is short, thick, and serrated for the nasal spine of the frontal. The *inferior border* is thin and expanded for the lateral nasal cartilage. It usually presents the *nasal notch,* which is situated near its inner end. The *medial border* articulates with its fellow. It is usually rather shorter and thicker than the lateral, and projecting

backwards from it is a ledge of bone which, with its fellow, forms the **nasal crest** for articulation with the nasal spine of the frontal and the anterior border of the perpendicular plate of the ethmoid. The *lateral border,* long and thin, is finely serrated for the frontal process of the maxilla.

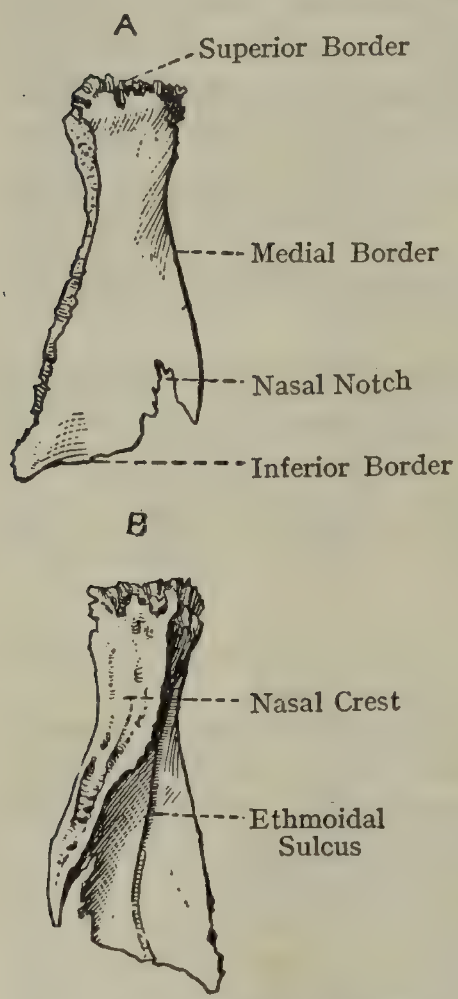


FIG. 142.—THE RIGHT NASAL BONE.

A, anterior view; B, posterior view.

The bone receives its blood-supply from the angular branch of the facial, and the dorsal nasal and anterior ethmoidal branches of the ophthalmic arteries.

Articulations.—The nasal articulates with four bones, as follows: *superiorly* with the frontal, *laterally* with the maxilla, *medially* with its fellow, and *posteriorly* with the ethmoid and again with the frontal.

Structure.—The bone is composed of compact tissue, and is therefore dense.

Ossification.—The nasal is developed in membrane from **one centre,** which appears about the *eighth week* of intra-uterine life.

The Lacrimal Bones.

The **lacrimal bone** is situated at the anterior part of the inner wall of the orbit, where it lies behind the frontal process of the maxilla, and in front of the orbital plate of the ethmoid. It is very thin and scale-like. From its resemblance in this sense to a finger-nail, it is known as the *os unguis.* It is quadrilateral and presents two surfaces and four borders, the inferior border being recognized by its presenting a hamular and a descending process. The *lateral* or *orbital surface* is traversed by the **lacrimal crest,** which is nearer the anterior than the posterior border, and divides the surface into two unequal parts. The *anterior division,* representing one-third, completes the **lacrimal groove,** which lodges the lacrimal sac and the commencement of the naso-lacrimal duct. The lower end of this division is prolonged into the **descending process,** which takes part in the wall of the lacrimal canal, and articulates with the lacrimal process of the inferior nasal concha. The *posterior division,* representing two-thirds, is smooth and forms part of the inner wall of the orbit. The **lacrimal crest** gives origin to the lacrimal part of orbicularis oculi, and inferiorly terminates in a hook-like projection, called the **lacrimal hamulus.** This process is curved in a forward direction, and is received into the lacrimal notch at the front part of the medial border of the orbital plate of the maxilla, where it bounds laterally the superior orifice of the lacrimal canal. It articulates with the lacrimal tubercle of the maxilla. The *medial surface* presents a vertical furrow corresponding with the position of

the lacrimal crest on the lateral surface. Superiorly it articulates with the front part of the labyrinth of the ethmoid, where it helps to close ethmoidal sinuses and forms part of the infundibulum. Inferiorly it forms part of the outer wall of the nasal fossa, and looks into the middle meatus.

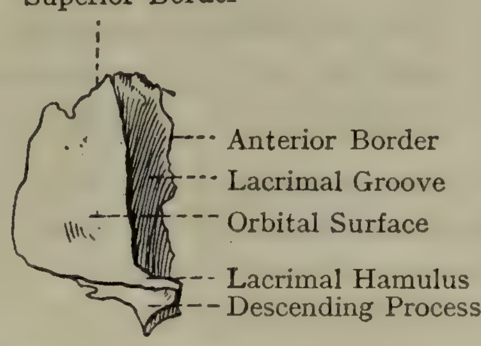


FIG. 143.—THE RIGHT LACRIMAL BONE (EXTERNAL VIEW).

The *superior border* is short, and articulates with the frontal. The *inferior border*, behind the lacrimal crest, articulates with the medial border of the orbital surface of the maxilla, whilst in front of the crest it forms, as stated, the descending process, and articulates with the lacrimal process of the inferior nasal concha. The *anterior border* articulates with the posterior border of the frontal process of the maxilla. The *posterior border* articulates with the anterior border of the orbital plate of the ethmoid.

Articulations.—The lacrimal articulates with four bones: *superiorly* with the frontal, *anteriorly* with the maxilla, *inferiorly* with the inferior nasal concha, and again with the maxilla, and *posteriorly* with the ethmoid.

Structure.—The bone consists of a thin translucent plate.

Varieties.—Very occasionally the bone may extend beyond the margin of the orbit on to the face.

Ossification.—The lacrimal is developed in membrane usually from **one centre,** which appears during the *third month* of intra-uterine life.

The Inferior Nasal Conchæ.

The **inferior nasal concha** is situated on the outer wall of the nasal fossa, where it overhangs the inferior meatus, and is in series with the middle nasal concha of the ethmoid. It is elongated from before backwards, and presents two surfaces, two borders, and two extremities. The *lateral surface* is concave, and is overhung above, over about its middle third, by the maxillary process. It looks towards the outer wall of the nasal fossa. The *medial surface* is irregularly convex, pitted, and marked by a few antero-posterior grooves. It bulges into the nasal fossa, and limits inferiorly the middle meatus.

The *superior border*, which is attached, slopes downwards and forwards in front, where it articulates with the conchal crest of the maxilla. Behind this it presents a slight concavity, limited in front by the **lacrimal process,** which articulates with the descending process of the lacrimal, and forms part of the lacrimal canal. Behind the concavity is the **ethmoidal process** for the uncinate process of the ethmoid. The portion of the superior border between these two processes is folded downwards and outwards into a thin plate, called the **maxillary process,** which forms part of the inner wall of the maxillary sinus below the opening of that cavity. Behind the ethmoidal process the superior

border slopes downwards and backwards, and articulates with the conchal crest of the palatine bone. The *inferior border* is convex, thick, pitted, and free. The *anterior extremity* is short and stunted, whilst the *posterior* is long, slender, and pointed.

Articulations.—The inferior nasal concha articulates with the following four bones: maxilla, lacrimal, ethmoid, and palatine.

Structure.—The bone is light and porous.

Ossification.—The inferior nasal concha is developed in *cartilage* from **one centre,** which appears in the *fifth month* of intra-uterine life.

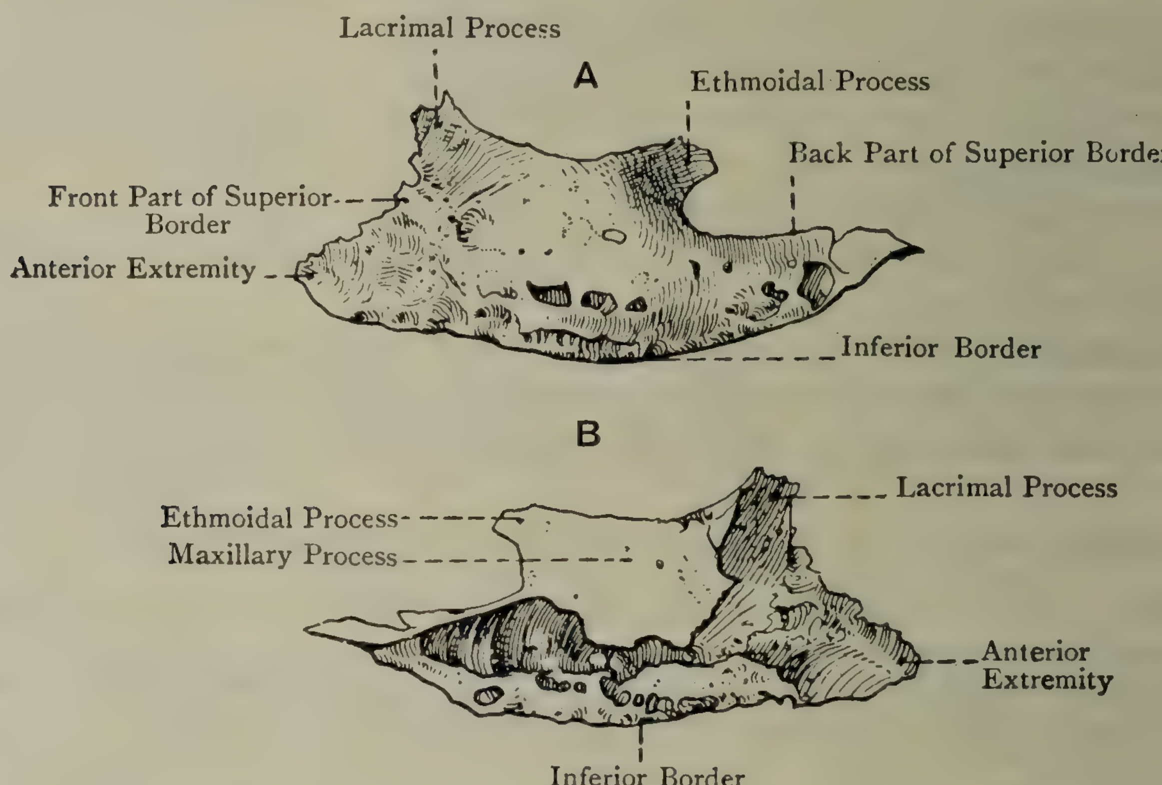


FIG. 144.—THE RIGHT INFERIOR NASAL CONCHA.
A, medial aspect; B, Lateral aspect.

The Palatine Bone.

The **palatine bone** enters into the formation of the hard palate, the outer wall of the nasal fossa, and the floor of the orbit. It consists of a horizontal and perpendicular plate, which meet at a right angle, and of four processes: the tubercle, situated at the meeting of the two plates posteriorly; and orbital and sphenoidal processes, situated at the upper extremity of the perpendicular plate, where they are separated by the spheno-palatine notch; and the maxillary process in front.

The **horizontal plate** is quadrate, and presents two surfaces and four borders. The *superior* or *nasal surface* is smooth and concave from side to side. It forms the posterior fourth of the floor of the nasal fossa, and is covered in the recent state by the nasal mucous membrane. The *inferior* or *palatal surface* forms the posterior fourth of one-half of the hard palate, and near its posterior border it presents a short transverse ridge, which serves to divide the palatine glands into two groups, and gives insertion to a portion of the tendon of the tensor

palati. The anterior border is serrated for the posterior border of the palatine process of the maxilla. The posterior border is concave and sharp. It gives attachment to one-half of the soft palate, and at its inner extremity it forms a backward projection, which, with its fellow, constitutes the **posterior nasal spine,** for the attachment of the musculus uvulæ. The lateral border is attached, and meets the perpendicular plate at a right angle. On its outer aspect posteriorly it is excavated by the lower part of the greater palatine canal. The medial border is thick and serrated, and articulates with its fellow, forming an upward elevation, called the **nasal crest.** This crest is continuous with that of the palatine processes of the maxillæ, and, like it, is grooved superiorly for a portion of the inferior border of the vomer.

The **perpendicular plate** rises upwards from the outer border of the horizontal plate. It is long and thin, and presents two surfaces and four borders. The *medial surface* forms part of the outer wall of the

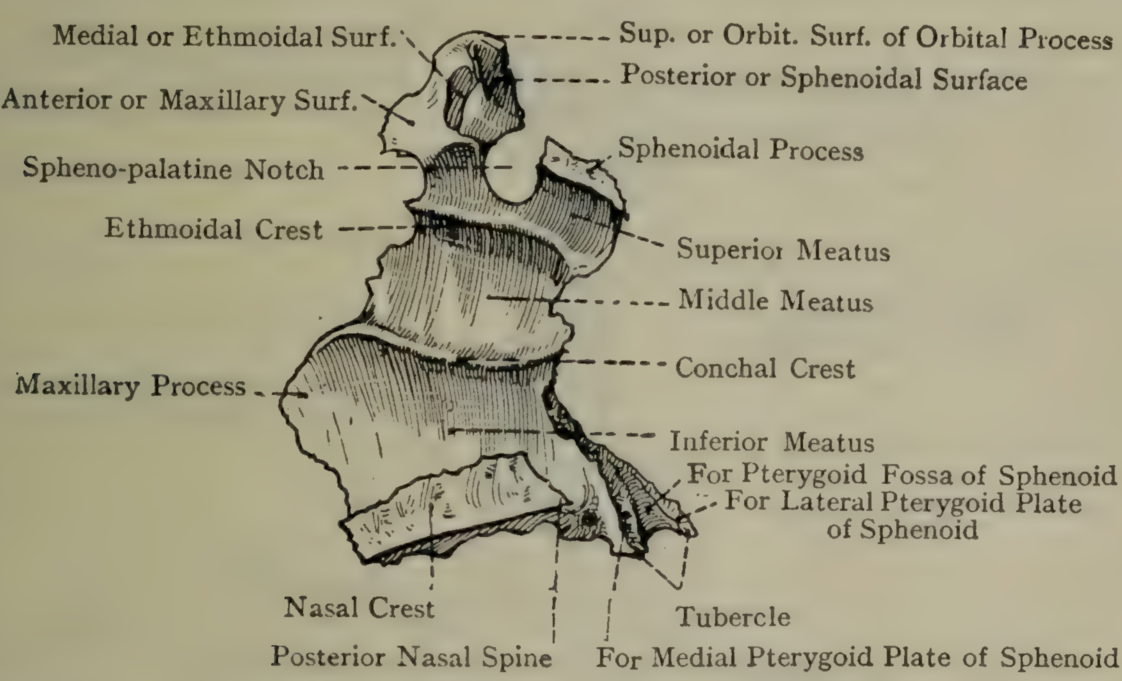


FIG. 145.—THE RIGHT PALATINE BONE (MEDIAL ASPECT).

nasal fossa, and is crossed from before backwards by two ridges. The lower ridge is called the **conchal crest,** and articulates with the posterior sloping part of the superior border of the inferior nasal concha. The upper ridge, which crosses the roots of the orbital and sphenoidal processes, is called the **ethmoidal crest,** and it articulates with the middle nasal concha of the ethmoid. Below the conchal crest is a smooth groove, which forms part of the inferior meatus of the nose; between the conchal and ethmoidal crests is another groove, which forms part of the middle meatus; and above the ethmoidal crest there is a third groove, which forms part of the superior meatus. The lateral surface is divided into three vertical strips, of which the anterior and posterior overlap and articulate with the maxilla and medial pterygoid plate respectively. The middle strip forms the inner wall of the pterygo-palatine fossa, and is prolonged below into a groove which completes the greater palatine canal for the greater palatine nerve and its accompanying artery.

The anterior border of the perpendicular plate presents, just below the conchal crest, a leaf-like projection, called the **maxillary process,** which closes the lower and back part of the opening of the maxillary sinus. Superiorly it articulates with the ethmoid, and inferiorly with the maxilla. The posterior border articulates superiorly with the anterior border of the medial pterygoid plate of the sphenoid, and inferiorly it is prolonged into the tubercle. The inferior border is attached, and meets the horizontal plate. The superior border presents the orbital and sphenoidal processes and the spheno-palatine notch, to be presently described.

The **tubercle** of palatine bone projects backwards, downwards, and outwards from the meeting of the horizontal and perpendicular plates, and is received into the pterygoid fissure of the sphenoid. Posteriorly it presents three grooves. The central groove forms part of the pterygoid fossa, and gives origin to fibres of the medial pterygoid. The

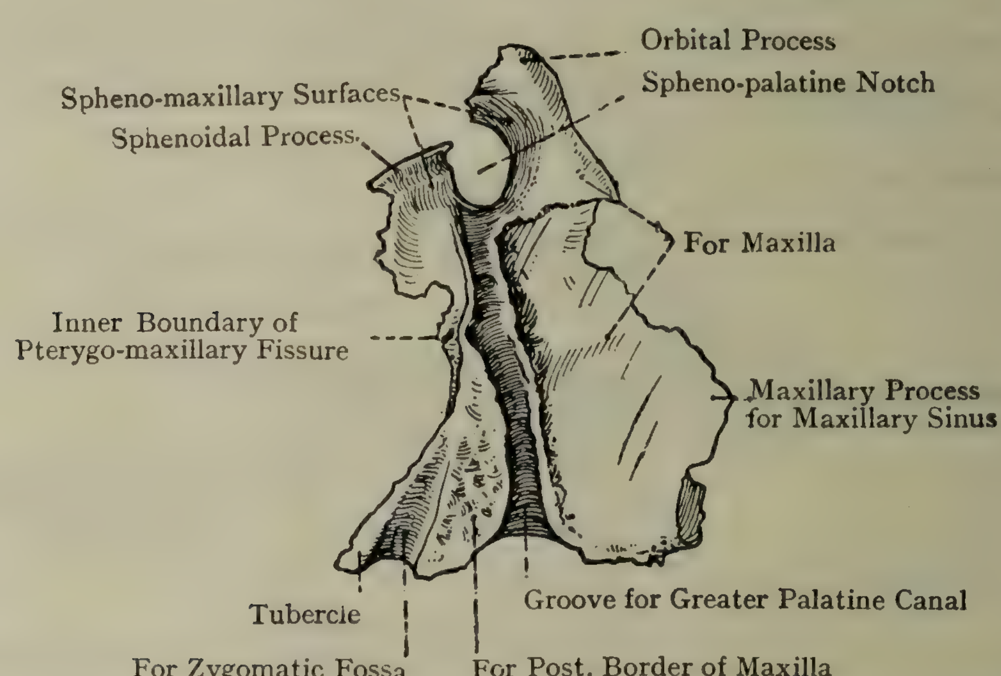


FIG. 146.—THE RIGHT PALATINE BONE (LATERAL ASPECT).

grooves on either side are rough, and articulate with the anterior borders of the corresponding pterygoid plates. The tubercle on its inferior aspect, close to the horizontal plate, presents two small openings, which are the orifices of the **greater** and **lesser palatine foramina,** the latter being the smaller of the two, and inconstant. These canals transmit the greater and lesser palatine nerves and arteries. Medially the tubercle gives origin to a few fibres of the superior constrictor muscle of the pharynx. Laterally there is a small free surface, which looks into the zygomatic fossa, between the pterygoid process of the sphenoid and the tubercle of the maxilla.

The orbital process is the larger and more anterior of the two superior processes, and is often considered the most difficult piece of bone in the body to describe and to understand. First it must be realized as an inverted pyramid, attached to the top of the palatine bone by its apex, having four sides and a base. Then, in the inner wall of the orbit, it should be noticed that the orbital plate of the

ethmoid, the sphenoid, and the maxilla, where they meet in the lower and back part of the orbit, each have a little piece bevelled off to enclose three sides of a diamond-shaped space, the fourth side being free in the pterygo-palatine fossa. It is into this diamond-shaped space that the orbital process of the palatine bone is wedged, so that one surface, looking forwards and inwards, rests against the orbital plate of the ethmoid and forms the ethmoidal surface.

Another, the sphenoidal, is directed backwards and inwards against the sphenoid; a third, forwards and outwards against the maxilla; a fourth, looking backwards and outwards, known as the spheno-maxillary (zygomatic) surface, has no bone to rest against, but lies free in the pterygo-palatine fossa; while the fifth or orbital surface, which is the base of the pyramid, makes a lozenge-shaped tile at the junction of the inner wall and floor of the back of the orbit.

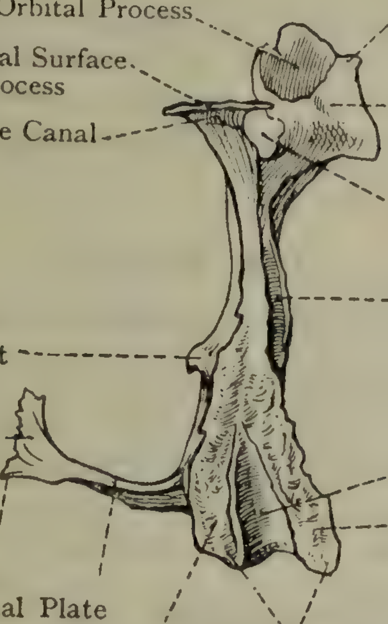


FIG. 147.—THE RIGHT PALATINE BONE (POSTERIOR VIEW).

Lastly, it must be realized that the process is a hollow pyramid, and that the air space which it contains communicates with the posterior ethmoidal sinus either on the ethmoidal or, where the sinus is completed, on the sphenoidal surface.

The **sphenoidal process** surmounts the posterior border of the perpendicular plate, and is an incurved flange. It has two surfaces and three borders. The *superior* or *sphenoidal surface*, which is grooved, articulates with the inferior surface of the body and the vaginal process of the sphenoid. The groove on this surface, with that on the under surface of the vaginal process of the medial pterygoid plate, forms the **pterygo-palatine canal** for the greater and lesser palatine vessels and nerves. The *inferior* or *nasal surface* is scooped out, and forms part of the outer wall and roof of the nasal fossa. The anterior border bounds the spheno-palatine notch posteriorly, and may be projected over it to join the orbital process. The posterior border articulates with the medial pterygoid plate of the sphenoid. The internal border articulates with the ala of the vomer.

The **spheno-palatine notch** is situated between the orbital and sphenoidal processes, and is converted into a foramen usually by the inferior surface of the body of the sphenoid, representing the part formed by a sphenoidal concha. It leads from the pterygo-palatine fossa behind the superior meatus of the nose, and transmits the medial branches of the spheno-palatine ganglion and spheno-palatine artery.

Articulations.—The palate bone articulates with six bones, as follows: the maxilla, inferior nasal concha, ethmoid, vomer, sphenoid, and its fellow.

Structure.—The bone is very thin, especially over the upper part of the perpendicular plate.

Varieties.—(1) The groove for the greater palatine canal may be bridged over. (2) The lesser palatine canal may be absent. (3) The spheno-palatine notch may be converted into a foramen by a forward extension of the sphenoidal process.

Ossification.—The palatine bone is ossified in membrane from **one primary centre.** The **primary centre** appears about the *seventh week*, at the angle of junction between the horizontal and perpendicular plates, or in the perpendicular plate (Fawcett). There may be a **secondary centre** for the orbital process.

The Vomer.

The **vomer** is situated in the median plane, and forms part of the septum of the nose. It presents two surfaces, four borders, and an anterior extremity. The surfaces are disposed laterally, and each looks into the corresponding nasal fossa. Traversing each there is

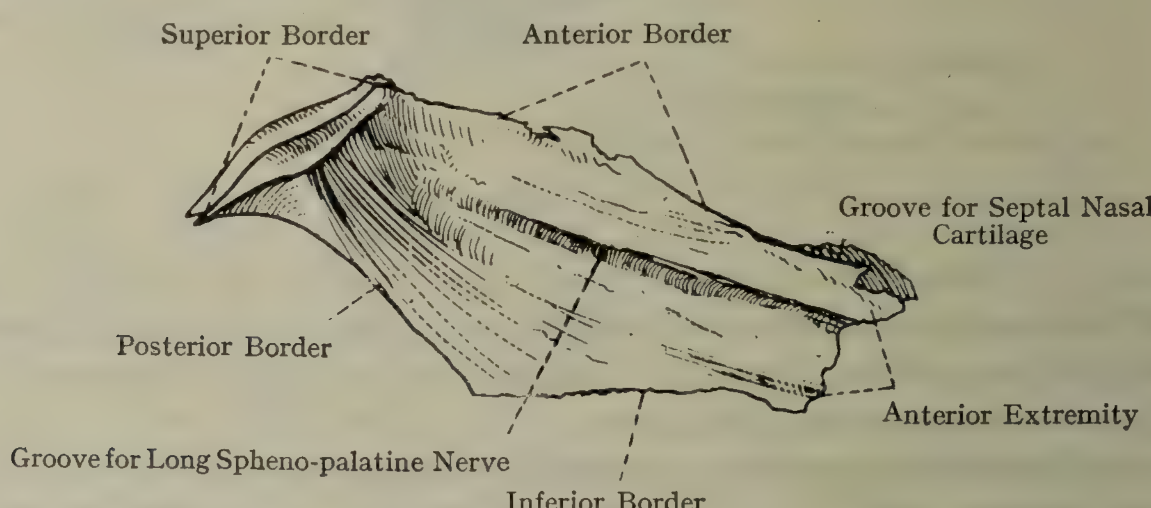


FIG. 148.—THE VOMER (LATERAL VIEW).

a groove, directed forwards and downwards, for the long spheno-palatine nerve.

The *superior border* is characterized by two thick, everted alæ, separated by a groove, which receives the rostrum of the sphenoid. Each ala by its upper aspect fits against the inferior surface of the body of the sphenoid, and the lateral margin of each meets the vaginal process of that bone, and also articulates with the medial border of the sphenoidal process of the palatine bone. The *inferior border* is irregular, and is received into the groove which marks the nasal crests

of the palatine processes of the maxillæ and palatine bones. The *anterior border* is sloped downwards and forwards, and it may present two alæ, but these are very thin, and lie near each other, being separated by a narrow cleft. These characters are always more pronounced in earlier life. The cleft in its lower part receives the septal nasal cartilage, and superiorly the perpendicular plate of the ethmoid fits into it, being usually ankylosed with one or both alæ. In many cases, however, the anterior border is simply grooved. The *posterior border* is sharp and almost vertical, and lies between the posterior nares. The *anterior extremity* forms a short irregular lip, which touches the back parts of the incisive crests of the maxillæ.

Articulations.—The vomer articulates with six bones, as follows: the sphenoid, two palatine bones, ethmoid, and maxillæ. In addition to these, it articulates with the septal nasal cartilage.

Structure.—The vomer is composed of two thin plates of compact bone, which are blended into one, except superiorly, and, it may be, to a certain extent anteriorly.

Varieties.—The bone is often much deflected to one or other side, more frequently the left, and so it may curtail the cavity of the nasal fossa to which it is deflected.

Ossification.—The vomer is developed in membrane from **two centres,** which appear about the *eighth week* of intra-uterine life. The centres unite below in the *third month,* and form a groove in which the septal nasal cartilage lies. The laminæ forming the lips of the groove continue to grow upwards and forwards and subsequently fuse, the enclosed cartilage becoming absorbed. Ultimately there are left the alæ on the superior border, and, it may be, on the anterior border, which are permanent indications of the original bilaminar condition of the bone.

The Mandible.

The **mandible** supports the lower teeth, and articulates at either side with the anterior part of the articular fossa of the temporal in a freely movable manner. It has the shape of a horse-shoe, and consists of a central horizontal portion, called the body, and two upright portions, called the rami.

The **body** is arched, being convex in front and concave behind, and it presents two surfaces and two borders. The *lateral surface* presents a slight median vertical ridge over its upper two-thirds, which marks the **symphysis** or place of union of the two halves of which the bone is originally composed. This ridge bifurcates at the lower third, and its two divisions, diverging, pass to the lower border, where each terminates in the **mental tubercle.** Between these diverging divisions there is a triangular elevated surface, called the **mental protuberance** or chin, a feature only found in man. On either side of the symphysis is the **incisive fossa,** which gives origin to the mentalis and a deep slip of the orbicularis oris. A little lateral to this fossa is the **mental foramen,** which opens outwards and backwards from the inferior dental canal, and transmits the mental nerve and vessels. This foramen is in line with the septum between the two premolar sockets, and in the

adult it is midway between the superior and inferior borders. Below it is the **oblique line,** which extends from the mental tubercle to the lower extremity of the anterior border of the ramus. This line gives origin to the depressor anguli oris. The lower part of the lateral surface, from near the symphysis to about the level of the mental foramen, gives origin to the depressor labii inferioris.

The *medial surface* presents a slight median groove over about its upper two-thirds, which coincides with the symphysis. Lower down there are four small projections, called collectively the **genial tubercles,** which are arranged in pairs on either side of the middle line. The *upper* spine gives origin, at either side, to the genio-glossus, and the

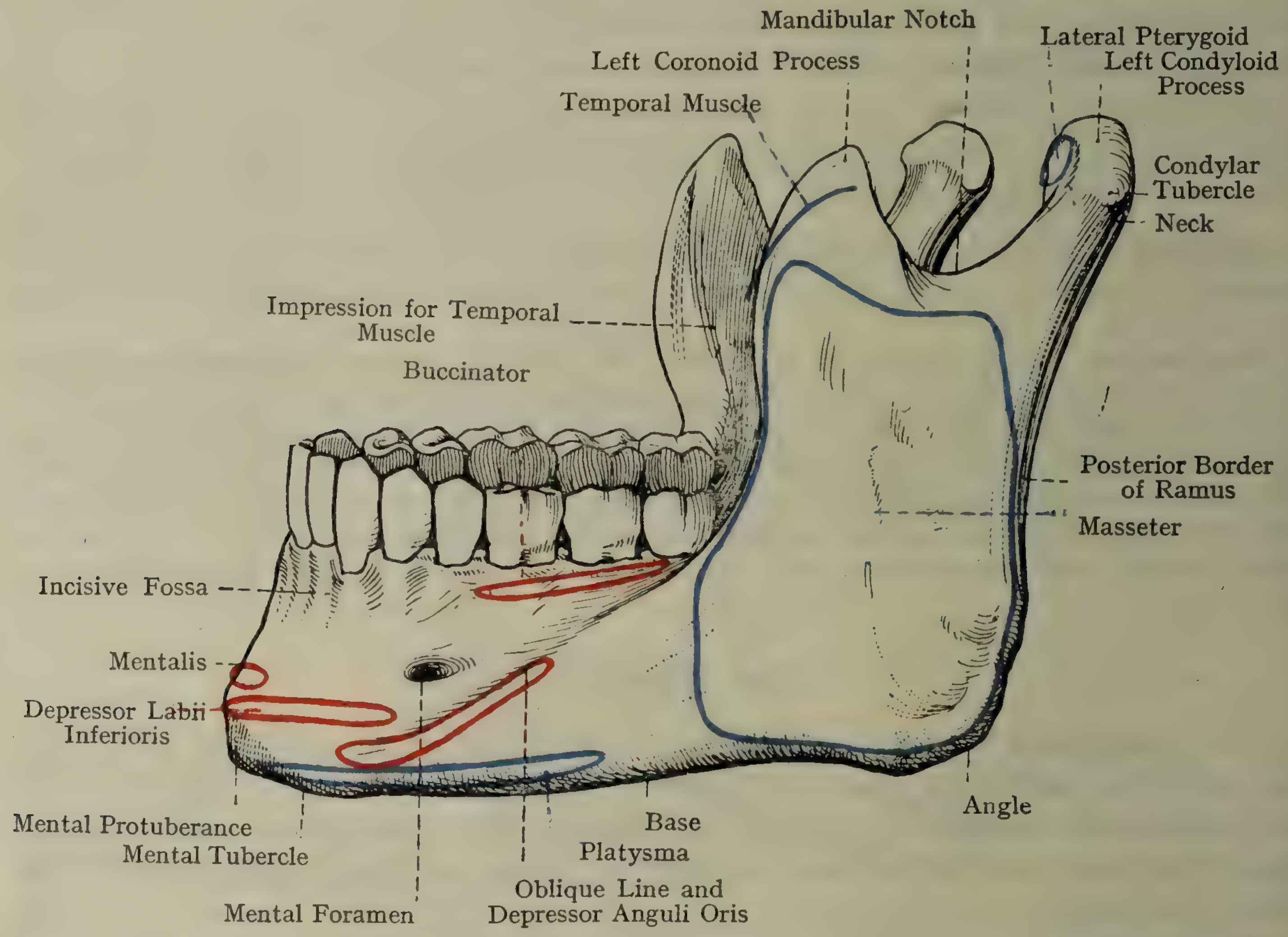


FIG. 149.—THE LEFT HALF OF THE MANDIBLE (LATERAL ASPECT).

lower to the genio-hyoid. Close to the lower border, at either side of the symphysis, is the oval **digastric fossa,** which gives origin to the anterior belly of the digastric. Coinciding with the position of the oblique line there is the **mylo-hyoid line.** This commences near the symphysis below the lower genial tubercle, and, passing obliquely backwards and upwards, it terminates a little behind the last molar socket. It gives origin to the mylo-hyoid muscle over its whole length, whilst at its upper and back part it gives attachment to some fibres of the superior constrictor muscle of the pharynx and the pterygo-mandibular ligament. Below the posterior part of this ridge is the **submandibular fossa** for the submandibular gland, and above its anterior part is the **sublingual fossa** for the sublingual gland.

The *superior* or *alveolar border* is excavated into sixteen sockets, eight in each half of the bone, which correspond with those in each maxilla. The outer surface of the alveolar arch, over the extent of the three molar sockets at either side, gives origin to some fibres of the buccinator. The *inferior border* or **base** terminates, at either side, on a level with the anterior border of the ramus. It projects more than the superior border, and gives insertion on its outer aspect to a portion of the platysma. Near its termination it is marked by a short vertical groove for the facial artery.

The **ramus** rises, at either side, from the extremity of the body. It is compressed from without inwards, and presents two surfaces and

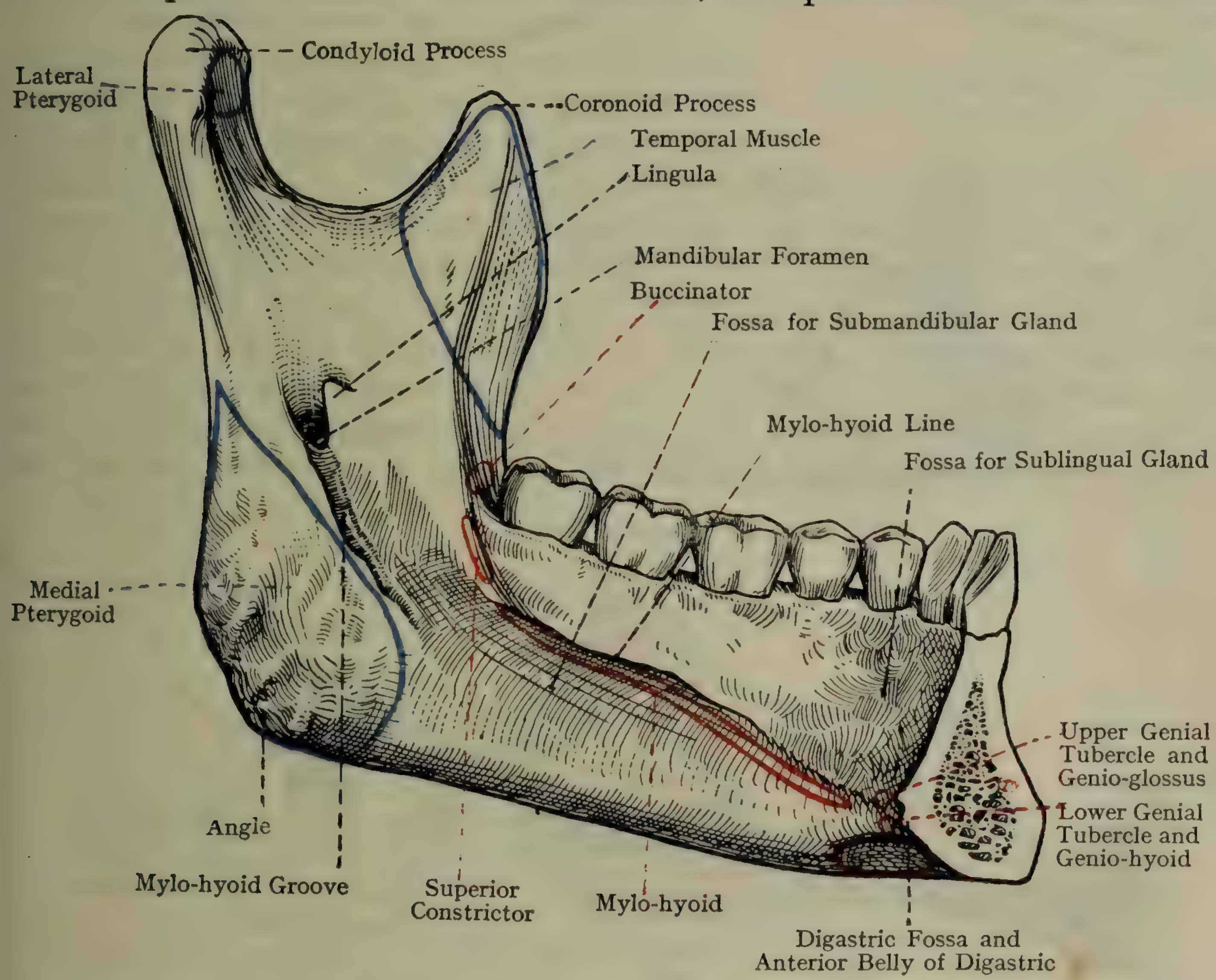


FIG. 150.—THE LEFT HALF OF THE MANDIBLE (MEDIAL ASPECT).

four borders. The *lateral surface* gives insertion to the masseter, and, in the vicinity of the angle, it presents a few oblique ridges for the tendinous bands of that muscle. The *medial surface* presents, a little below its centre, the **mandibular foramen,** which is on a level with the summit of the crown of the third molar tooth. This foramen leads to the **mandibular canal,** which traverses the bone to near the symphysis, and from which, near its anterior part, the mental foramen opens on the lateral surface. This canal lodges the inferior dental nerve and vessels, and communicates with the foramina which open on the extremities of the fangs of the teeth. The mandibular foramen presents anteriorly and medially a thin, sharp plate of bone, called the **lingula.**

Behind the lower end of the latter is a short crescentic margin on the inner aspect of the foramen, and proceeding downwards and forwards from this is the **mylo-hyoid groove,** which terminates a little below the posterior extremity of the mylo-hyoid line, and transmits the mylo-hyoid nerve and artery. The spheno-mandibular ligament is attached to the lingula and to the crescentic margin behind it. Between the mandibular foramen and the angle there is a rough impression, often strongly ridged, which gives insertion to the medial pterygoid.

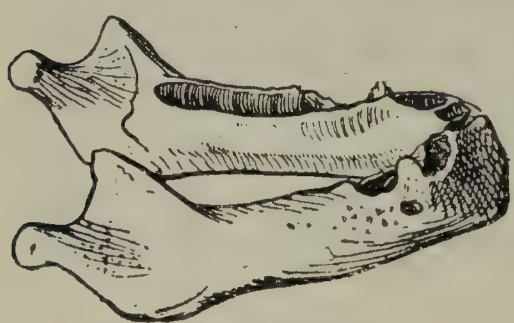


FIG. 151.—THE MANDIBLE AT BIRTH.

The *anterior border* is continuous with the oblique line opposite the third molar socket, and is shorter than the posterior. The *posterior border* meets the inferior border, thus forming the **angle,** which, in muscular subjects, is strongly marked and slightly everted. Laterally and medially it presents rough impressions for portions of the masseter and medial pterygoid respectively, and between these muscles it gives attachment to the stylo-mandibular ligament. The angle is obtuse, and in the adult amounts on an average to 120 degrees. In early infancy it is as much as 150 degrees, and in old age it amounts to about 140 degrees. The *inferior border* is continuous with the inferior border or base of the body. The *superior border* presents the mandibular notch, the coronoid process, and the condyloid process.

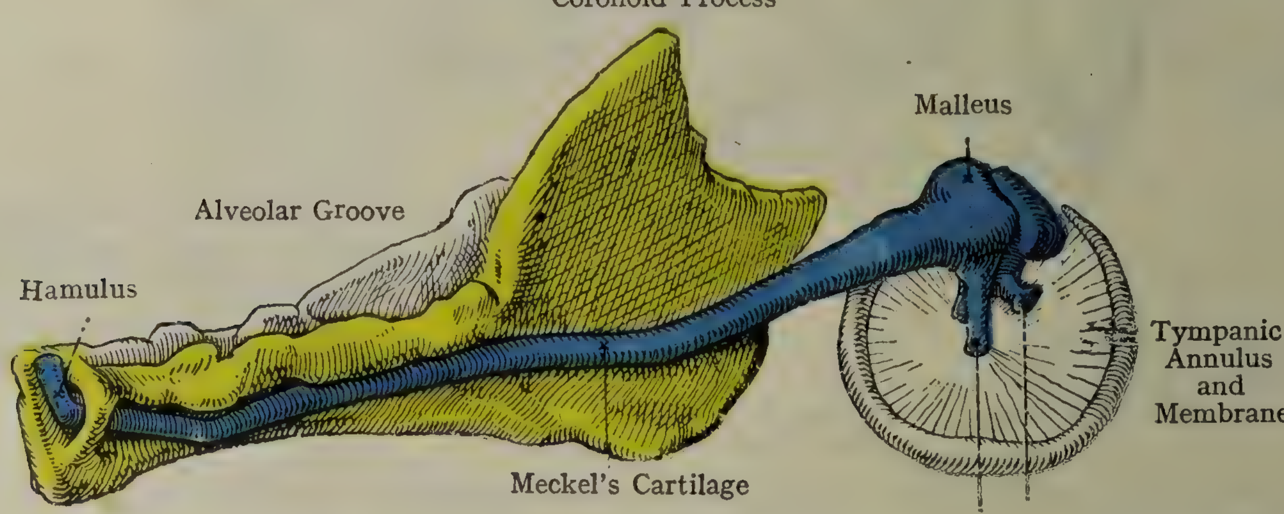


FIG. 152.—CARTILAGE OF MANDIBULAR ARCH (MECKEL'S). (FROM KEIBEL AND MALL, AFTER KOLLMANN.)

The **mandibular notch** communicates with the zygomatic fossa, and transmits the masseteric nerve and artery to the deep surface of the masseter.

The **coronoid process** surmounts the anterior border of the ramus, and is triangular and compressed from without inwards. Its lateral surface gives insertion to fibres of the masseter, and its medial surface, as well as the superior and anterior borders, to part of the temporal

muscle. The medial surface is marked by a ridge which extends downwards on the medial surface of the ramus, not far from the anterior border, to a point on the inner side of the last molar socket, where it becomes continuous with the mylo-hyoid line. The temporal muscle

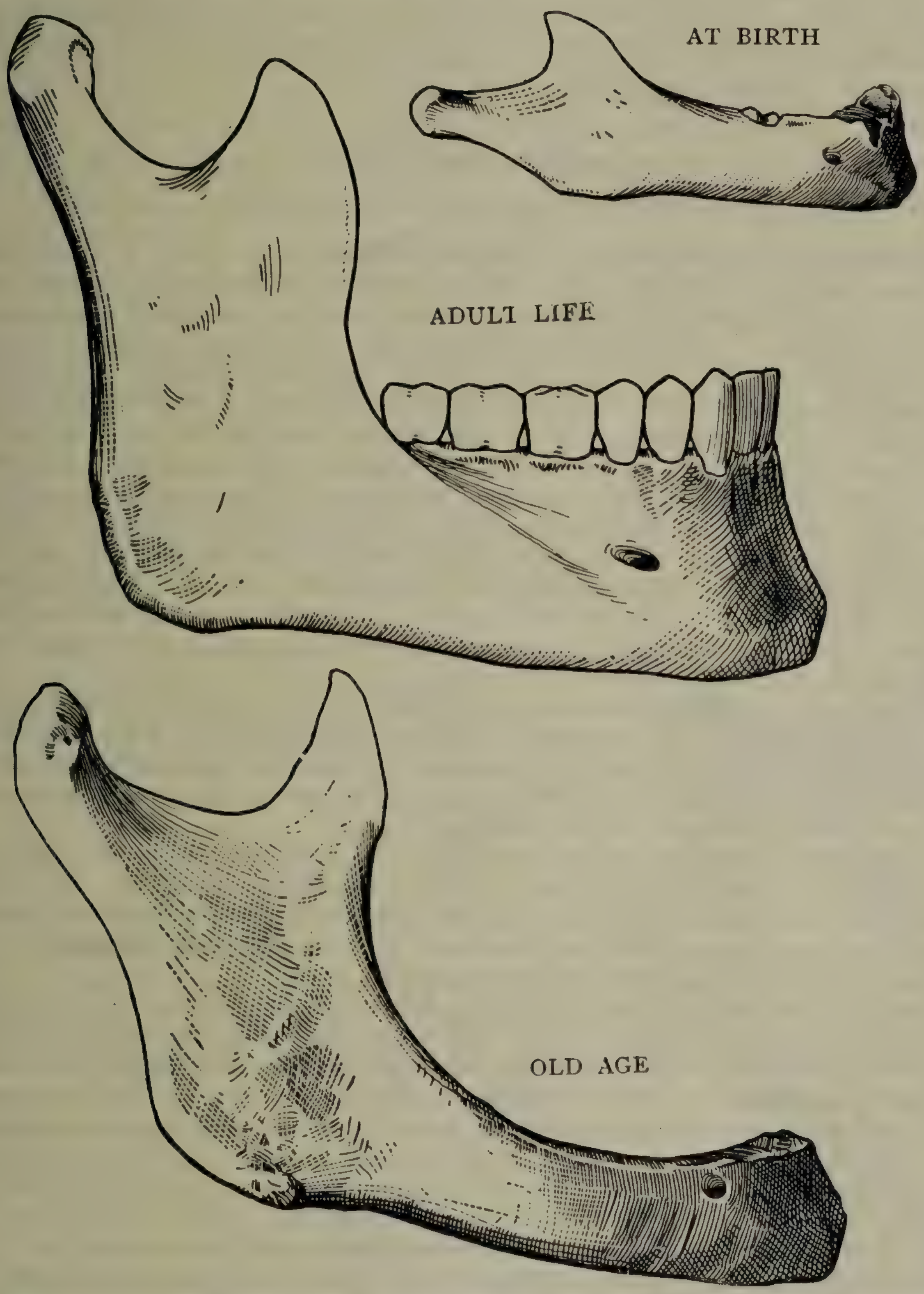


FIG. 153.—THE MANDIBLE AT DIFFERENT PERIODS OF LIFE.

continues to take insertion into this ridge, as well as into the elongated triangular depression between it and the anterior border of the ramus.

The **condyloid process** surmounts the posterior border of the ramus. It is oval and convex, and it articulates with the anterior part of the articular fossa of the temporal, an interarticular fibro-cartilage intervening. Its long axis is oblique, so that the axes of the two condyles,

if sufficiently prolonged inwards and slightly backwards, would meet near the anterior margin of the foramen magnum. Laterally the condyloid process presents a projection, called the **condylar tubercle,** for the temporo-mandibular of the mandibular joint. Below the condyloid process is the **neck,** which presents anteriorly a depression for the insertion of the greater part of the lateral pterygoid muscle.

Articulations.—With the articular fossæ of the temporal bones.

Structure.—The mandible is composed of two dense plates of compact bone, which are particularly strong in the region of the base, but become thinner superiorly at the alveolar border. Between these plates there is cancellous tissue with wide meshes.

Ossification.—The mandible is a **mixed bone,** being chiefly a *membrane bone,* but in part also a *cartilage bone.* It is ossified in connection with Meckel's cartilage and its fibrous investment. Each half of the bone has **one centre** (Low and Fawcett), which appears about the *sixth week* of intra-uterine life, being only preceded by the primary centres for the clavicle. It is deposited in the membrane which covers the *outer surface* of Meckel's cartilage in the region of the future mental foramen. From this centre one-half of the bone is ossified, chiefly in membrane, but also in cartilage—namely, the medial end of Meckel's cartilage, and certain other *accessory cartilages.* The original centre gives membranous origin to (1) the walls of the sockets and mandibular canal, (2) the basilar border and angle, and (3) the ramus as high as the mandibular foramen. The medial part of Meckel's cartilage is invaded by osseous extension from the primordial membrane bone formed from the single centre, the medial part of Meckel's cartilage becoming incorporated with the bone so formed and constituting the *incisive portion* of the mandible.

The *accessory cartilages,* which are distinct from Meckel's cartilage, are as follows: (1) Condyloid, (2) coronoid, and (3) symphysial. All these accessory cartilages become surrounded and invaded by osseous extension from the primordial membrane bone formed from the single centre, and they become incorporated with the parts of the mandible so formed.

The **condyloid cartilage** gives rise to (1) the condyloid process, and (2) the posterior part of the ramus *as low as the mandibular foramen.* The **coronoid cartilage** gives rise to (1) the coronoid process, and (2) the anterior part of the ramus *as low as the mandibular foramen.* The **symphysial cartilage** gives rise to the limited symphysial part of the mandible.

At birth the mandible consists of *two halves,* connected at the symphysis by fibrous tissue. In the course of the *first year* osseous union takes place, which is completed towards the end of the first year or beginning of the second year.

Meckel's cartilage, which represents a large part of the first visceral arch, extends on either side downwards and forwards from the periotic cartilaginous capsule to the median line, where it meets its fellow. It is surrounded by a fibrous investment. The proximal end of the cartilage gives rise to the malleus and incus, two of the three ossicles of the tympanic cavity. The part of the cartilage between the periotic cartilaginous capsule and the mandibular foramen disappears, and the membranous investment of this part persists as the *spheno-mandibular ligament.* The part of the cartilage between the mandibular foramen and the mental foramen also disappears, and its membranous investment undergoes ossification from a *single centre,* and gives rise to (1) the greater part of one-half of the body of the mandible (incisive and symphysial parts excepted), and (2) the lower half of the ramus as high as the mandibular foramen. The medial part of Meckel's cartilage, when ossified, becomes the *incisive part* of the mandible.

At birth the inferior border is but little developed, and the body is consequently shallow. The rami are very short, so that each condyloid process is nearly on a level with the upper border of the symphysis, and the coronoid

process is rather longer than the condyloid process. The mental foramen is nearer the inferior than the superior border, and the angle amounts to 150 degrees or more. Subsequently the body increases in depth, the rami lengthen, the angle decreases, and the mental foramen gradually assumes a position midway between the superior and inferior borders. In old age, after the bone becomes edentulous, the alveolar border undergoes absorption, the body consequently becomes shallower, the mental foramen lies near the superior border, the rami droop backwards, and each angle becomes increased to about 140 degrees. For the development of the alveolar arch, and its relation to the milk-teeth, see the maxilla.

The Hyoid Bone.

The **hyoid bone** is situated in the median line of the neck, between the chin and the thyroid cartilage of the larynx, with which latter it is connected by means of the thyro-hyoid membrane and thyro-hyoid ligaments. It is closely connected with the base of the tongue, and is hence known as the *os linguæ*. In its development it is associated with the skull, and it is suspended from the lower ends of the styloid processes of the temporal bones by two fibrous bands, called the stylo-hyoid ligaments (epi-hyals). It consists of a central portion or body and two pairs of horns (cornua), greater and lesser.

The **body** is elongated transversely, compressed from before backwards, and quadrilateral. Its surfaces, which are anterior and posterior, occupy an oblique plane, being sloped downwards and forwards. The *anterior surface* is convex, and is crossed transversely by a curved ridge, which divides it into an upper and a lower part, and is continuous with the roots of the lesser horns. At the middle line this is intersected at right angles by a vertical ridge, which, however, is often incomplete, being sometimes confined to the upper half, and sometimes to the lower. At the place of intersection of the two ridges there is a slight projection, called the **hyoid tubercle.** Each half of the anterior surface is thus mapped out into an upper and a lower irregular muscular division. The upper division, provided the upper border is not very thick, gives attachment to the genio-hyoid and genio-glossus, and the lower division to the digastric, stylo-hyoid, and mylo-hyoid. The *posterior surface* is concave, and is covered by the thyro-hyoid membrane as it ascends to be attached to the superior border, a synovial bursa intervening. This surface is related to the epiglottis. The *superior border* is somewhat thick, and occasionally is really a surface, in which cases it gives attachment to the genio-glossus, whilst its posterior lip gives attachment to the thyro-hyoid membrane. The *inferior border* is sharp, and gives insertion to the sterno-hyoid, superior

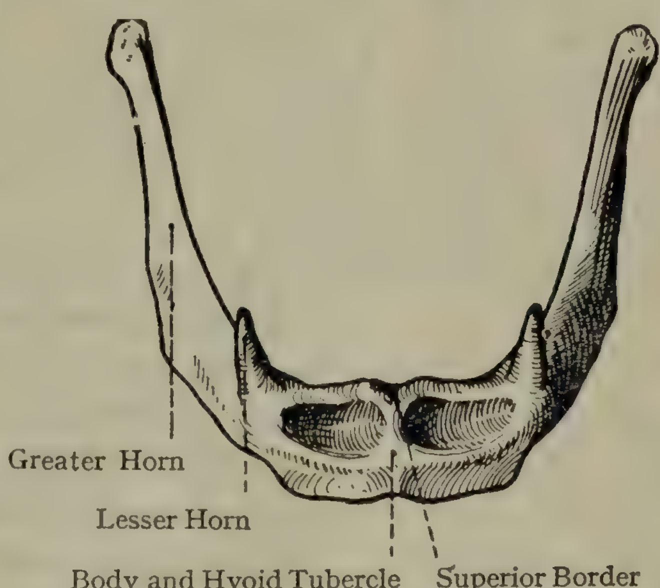


Fig. 154.—The Hyoid Bone (Anterior View).

belly of the omo-hyoid, and thyro-hyoid muscles. Each *lateral border* is connected with a greater horn.

The **greater horns** project upwards, backwards, and outwards from the lateral borders of the body. Each is compressed from above downwards, and gradually diminishes in size to its termination, where it ends in a small tubercle for the attachment of the thyro-hyoid ligament. It gives attachment to fibres of the thyro-hyoid, hyo-glossus, middle constrictor muscle of the pharynx, and the thyro-hyoid membrane.

The **lesser horns** are short conical nodules, each of which projects upwards and backwards from the junction between the body and greater horn. Its tip gives attachment to the stylo-hyoid ligament, which is sometimes ossified, a possible condition to be borne in mind during digital examination of the upper part of the pharynx. Elsewhere it gives attachment to the middle constrictor muscle of the

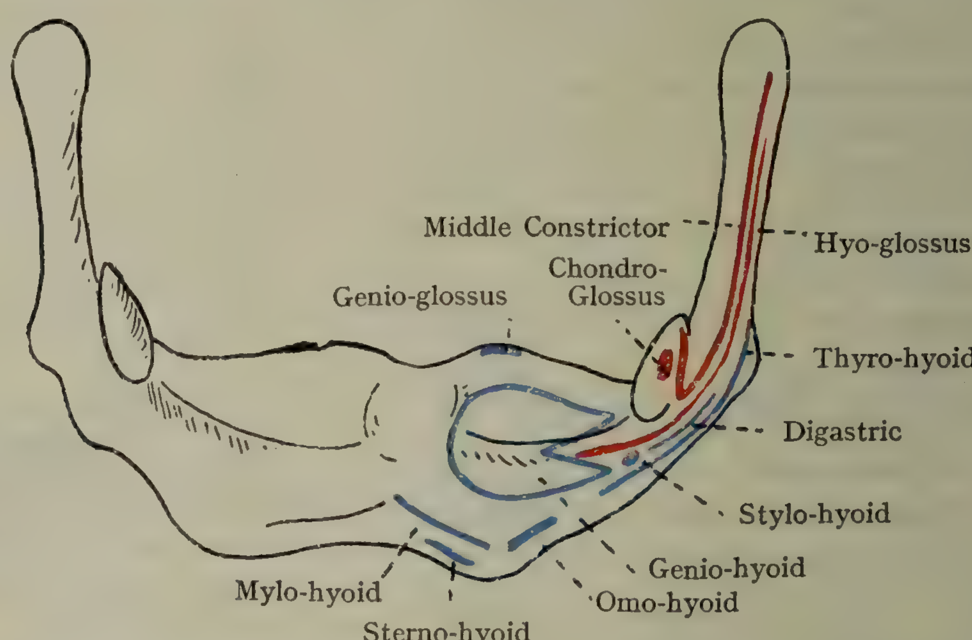


FIG. 155.—THE HYOID BONE, SHOWING ITS MUSCULAR ATTACHMENTS.

pharynx, and sometimes to the chondro- and cerato-glossus. The lesser horns may be wholly or partially cartilaginous, and they articulate with the body by a synovial joint, unless in advanced life, when ankylosis usually takes place.

Ossification.—The hyoid bone is developed in connection with the second and third visceral arches. The cartilaginous bar of the second visceral arch is known as the hyoid bar, and is continuous with its fellow at the median line. It is represented by the curved ridge, already described, joining the bases of the lesser horns. The cartilaginous bar of the third visceral arch is known as the thyro-hyoid bar, and at the median line it blends with the junction of the hyoid bars. With the foregoing proviso, the hyoid bone is developed from **five** or, it may be, **six centres.** One or, it may be, two are deposited during the last month of intra-uterine life at the place of fusion of the two hyoid bars. If there are two centres they soon join, and give rise to the greater part of the body of the hyoid bone or **basi-hyal.** About the same time a centre appears at either side in the thyro-hyoid bar of the third visceral arch, and from these centres are developed the greater horns or **thyro-hyals,** and the adjacent portions of the body. Centres for the lesser horns (**cerato-hyals**) do not appear till shortly

before puberty. About this time centres have been described for tips of greater horns, as epiphyses. The greater horns join the body in middle life, but the lesser horns do not join until advanced life. The stylo-hyoid ligaments may become ossified more or less completely, and so represent the epi-hyal bones of many animals.

THE SKULL AS A WHOLE.

Sutures.

The only bone of the skull which has movable articulations is the mandible. Each condyloid process of that bone articulates with the anterior part of the articular fossa of the corresponding temporal bone, with the intervention of an interarticular fibro-cartilage, the articulation so formed being called the **mandibular joint.**

The other bones of the skull, for the most part, are in close contact with each other, a small amount of fibrous tissue being interposed, which is continuous with the periosteum. These articulations are called **sutures.** Certain cranial bones, however, are separated at first by a plate of hyaline cartilage, the articulation being called **synchondrosis.** This, however, is a temporary joint, inasmuch as synostosis takes place after a certain period of life. It applies to (1) the articulation between the basilar process of the occipital and the body of the sphenoid, and (2) the articulation between the jugular process of the occipital bone and the jugular notch on the inferior surface of the petrous portion of the temporal bone.

The **lambdoid suture** connects the superior lateral borders of the squamous portion of the occipital bone with the posterior borders of the two parietal bones. The two limbs of the suture, right and left, become continuous with each other at the superior angle of the squamous portion of the occipital bone, from which point each limb passes outwards and downwards. The margins of the bones are strongly serrated, and along the course of the suture supernumerary ossicles, called **sutural bones** (Wormian bones), are frequently present.

The **occipito-mastoid suture,** on either side, connects the inferior lateral border of the squamous portion of the occipital bone with the posterior border of the mastoid part of the temporal bone. It is one of the bifurcations of the lower end of the corresponding limb of the lambdoid suture, the other bifurcation being the parieto-mastoid suture. Its direction is downwards and forwards.

The **sagittal suture** (interparietal) connects the superior borders of the two parietal bones. It is serrated, and occupies the median line, its direction being from behind forwards. Posteriorly it meets the lambdoid suture, the place of meeting constituting the **lambda,** which indicates the situation of the *posterior fontanelle* of early life. From the lambda three sutures radiate—namely, the sagittal suture and the two limbs of the lambdoid suture. Anteriorly the sagittal suture meets the coronal suture, the place of meeting constituting the **bregma,** which indicates the situation of the *anterior fontanelle* of early life. The part of the sagittal suture in the region of the

two parietal foramina is usually less serrated than elsewhere, and is the first part to show signs of obliteration. It constitutes the **obelion,** which indicates the situation of the sagittal fontanelle of early intra-uterine life.

The **coronal suture** connects the frontal bone with the two parietal bones. It crosses the superior surface of the skull in an arched manner, extending on either side as low as the superior border of the greater wing of the sphenoid. As it crosses the median line it is joined by the anterior end of the sagittal suture. The place of junction is, as stated, called the **bregma,** which indicates the position of the anterior fontanelle of early life. From the bregma three sutures radiate—the sagittal, and the two limbs, right and left, of the coronal suture. Each limb of the coronal suture is serrated, but more so over the central part than the upper and lower parts, and more so over the upper part near the median line than over the lower part,

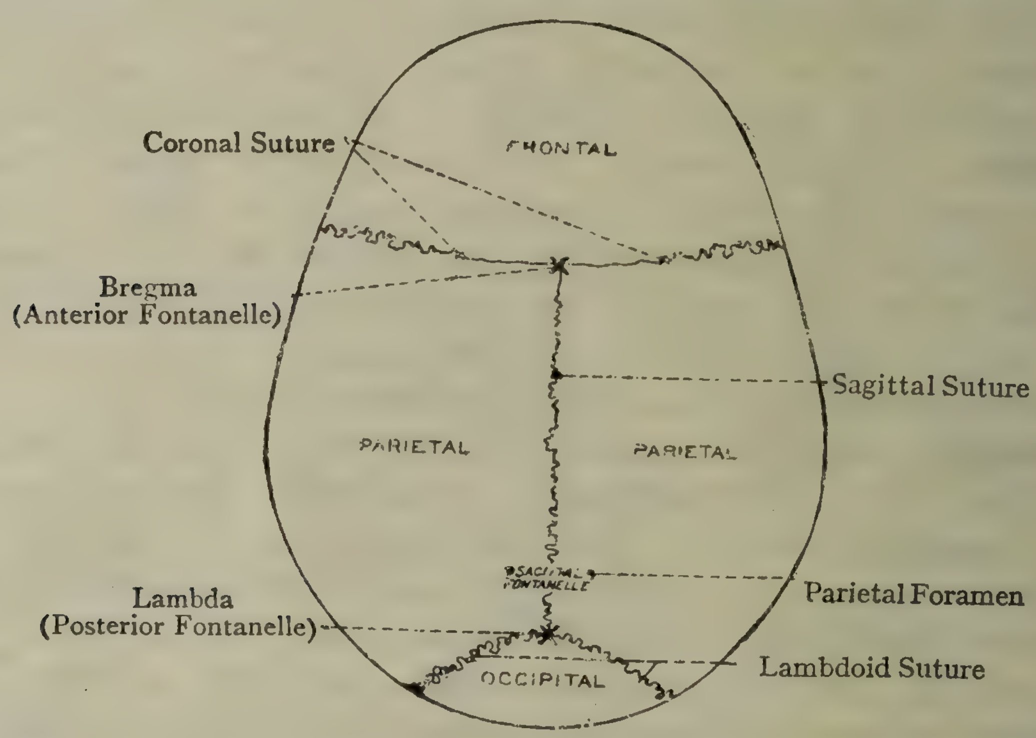


FIG. 156.—SUTURES OF SUPERIOR SURFACE OF SKULL.

in which two latter situations overlapping takes place. *Superiorly* the frontal bone slightly overlaps the parietal bone, and *inferiorly* the parietal bone distinctly overlaps the frontal bone, the opposed bevelled surfaces in the latter region being ridged. This latter portion of the coronal suture is spoken of as a **limbous suture.**

The **metopic** or **frontal suture,** which connects the two halves of the frontal bone during the first year of life, may persist throughout life. Under these circumstances, it extends in the median line from the bregma to the centre of the nasal notch of the frontal bone. Superiorly it is continuous with the sagittal suture, and inferiorly with the internasal suture. Even though the suture may not persist entirely, traces of it may be present inferiorly. As a rule, however, the suture is entirely obliterated by the end of the second year of life.

The **parieto-mastoid suture** is serrated, and anteriorly is continuous with the posterior end of the squamosal suture. It is on a level with

the upper border of the zygomatic arch. Its posterior extremity is the **asterion,** which indicates the situation of the *postero-lateral* or *mastoid fontanelle* of early life. From this point three sutures radiate—the lambdoid, the parieto-mastoid, and the occipito-mastoid.

The **squamosal suture** is arched, the convexity being directed upwards, and after having descended posteriorly, it becomes continuous with the parieto-mastoid suture. Anteriorly it is continuous with the spheno-parietal suture. The squamosal suture presents a marked contrast to the foregoing serrated sutures, inasmuch as it is a squamous suture, the squamous part of the temporal overlapping the lower border of the parietal bone.

The **spheno-parietal suture** connects the posterior part of the superior border of the greater wing of the sphenoid with the antero-inferior angle of the parietal bone. Its direction is from behind forwards. Posteriorly it is continuous with the squamosal suture,

FIG. 157.—SUTURES OF RIGHT LATERAL SURFACE OF SKULL.

S.P., spheno-parietal; S.F., spheno-frontal; P.S., parieto-squamosal; X, pterion; C., coronal; S.S., spheno-squamosal.

and anteriorly with the spheno-frontal suture. The spheno-parietal suture, like the parieto-squamosal, is a squamous suture. The region of the spheno-parietal suture coincides with the **pterion.** The spheno-parietal suture may be very short, or entirely absent, in which latter case the lower and posterior part of the frontal bone articulates directly with the squamous part of the temporal bone, thus excluding the antero-inferior part of the parietal bone from any articulation with the greater wing of the sphenoid. In such cases the **pterion** is situated at the posterior end of the spheno-frontal suture. In all cases the guide to it is the lower end of the posterior border of the zygomatic process of the frontal bone, the pterion being situated about $1\frac{1}{2}$ inches behind it, and about 2 inches above the zygomatic arch. The pterion indicates the situation of the *antero-lateral* or *sphenoidal fontanelle* of early life. In this region a sutural bone, called the **epipteric bone,** is sometimes met with.

The **fronto-squamosal suture** is quite rare, but is the normal arrangement in monkeys.

The **spheno-frontal suture,** which is squamous, connects the superior border of the greater wing of the sphenoid bone with the lower part of the lateral aspect of the frontal.

In studying the sutures of the vault of the skull it will be noticed that they are much simpler intracranially than on the surface, and that they close internally much earlier than they do externally, except in two places. It has been found that, in English people, the internal obliteration begins soon after thirty, and is fairly complete by forty years of age. The two exceptions on the surface are at the obelion, between the parietal foramina, and in the coronal suture below the point where the temporal crest crosses it. At these two places obliteration is as early as it is inside the skull.

There are two other spheno-frontal sutures. One connects the rough triangular surface on the antero-superior part of the greater wing of the sphenoid bone with the rough triangular surface on the frontal bone behind the zygomatic process. This is a harmonic suture. The other spheno-frontal suture (orbito-spheno-frontal suture) will be described under the orbital sutures. It also appears, however, in the anterior fossa of the internal surface of the base of the skull.

The **spheno-squamosal suture** connects the lateral border of the greater wing of the sphenoid bone with the antero-inferior border of the squamous part of the temporal bone, its direction being downwards and backwards as far as the inner end of the squamo-tympanic fissure. Its upper part forms a squamous suture, but its lower part is serrated.

The **zygomatico-temporal suture** connects the extremity of the zygomatic process of the temporal bone with the temporal process of the zygomatic bone by an oblique or else by a right-angled junction.

The **fronto-maxillary suture,** which is serrated, connects the lateral part of the nasal notch of the frontal bone with the superior border of the frontal process of the maxilla. It lies almost transversely.

The **fronto-nasal suture** connects the medial part of the nasal notch of the frontal bone with the superior border of the nasal bone. It lies transversely, and is serrated. Across the median line it is continuous with its fellow of the opposite side, and laterally it is continuous with the fronto-maxillary suture. The point corresponding to the meeting of the two fronto-nasal sutures coincides with the **nasion.**

The **internasal suture** is vertical, and it is a harmonic suture. The lower end of the suture coincides with the **rhinion.**

The **naso-maxillary suture** is almost vertical, and it is finely serrated.

The **zygomatico-maxillary suture** connects the rough triangular area at the anterior part of the medial surface of the zygomatic bone with the rough superior surface of the zygomatic process of the maxilla.

The **intermaxillary suture** is only partially seen on the facial surface of the skull. This part extends from the centre of the anterior nasal spine to the point of meeting of the alveolar arches of the maxillæ.

The palatine part of the suture connects the medial borders of the palatine processes of the maxillæ. Its direction is antero-posterior, and it is a harmonic suture.

The **interpalatine suture** connects the medial borders of the horizontal plates of the palatine bones. It is continuous with the intermaxillary suture, and is a harmonic suture.

The *transverse* **palato-maxillary suture** connects the anterior border of the horizontal plate of the palatine bone with the posterior border of the palatine process of the maxilla.

The *vertical* **palato-maxillary suture** connects the lower part of the anterior border of the perpendicular plate of the palatine bone with the medial surface of the maxilla behind the opening of the maxillary sinus. It is a harmonic suture.

The **premaxillary suture** is described on p. 216.

The **petro-squamosal suture** connects the petrous and squamous parts of the temporal bone, and is situated on the inner or cerebral surface of the bone. Its direction is antero-posterior, and it extends from the petro-squamosal angle anteriorly to the parietal notch (entomion) on the superior border of the *mastoid part* posteriorly, where it meets the squamo-mastoid suture. It is a harmonic suture, and ankylosis usually takes place in the course of the *first year* of life. The suture, however, may persist until puberty, or later. Even though ankylosis takes place at the normal period of time, it may occur in such an imperfect manner that the suture is drilled by several channels. Under the foregoing circumstances pyogenic infection may extend from the tympanic cavity to the cerebral meninges and brain. The *petro-squamosal venous sinus* of fœtal life extends along the petro-squamosal suture.

The **squamo-mastoid suture** connects the mastoid and squamous parts of the temporal bone, and is situated on the outer surface of the bone. Its direction is almost vertical, and it extends from the parietal notch (entomion) on the superior border of the *mastoid part* anteriorly to a point behind the posterior limb of the tympanic ring. The lower part of the suture intervenes between the contiguous part of the *mastoid part* and the post-meatal plate of the *squamous part*, which latter forms the suprameatal triangle and outer wall of the antrum. Superiorly it meets the petro-squamosal suture. The squamo-mastoid suture is a harmonic suture, and ankylosis usually takes place in the course of the *first year* of life. The suture, however, may persist until puberty, or even throughout life. Even though ankylosis takes place at the normal period of life, it may occur in such an imperfect manner that the suture is drilled by several channels. Under these circumstances, pus may find an exit from the tympanic cavity to the exterior.

The **petro-sphenoidal suture** connects a portion of the anterior border of the petrous part of the temporal bone with the outer portion of the posterior border of the greater wing of the sphenoid. It lies obliquely, its direction being inwards and forwards.

The **petro-basilar suture** connects the inner half of the posterior border of the petrous portion of the temporal bone with the lateral border of the basilar portion of the occipital bone. Its direction is forwards and slightly inwards, and it is a harmonic suture. Superiorly it is grooved for the inferior petrosal venous sinus.

Schindylesis.—There are only a few examples of this variety of synarthrosis, or immovable joint, in the skull. These are as follows: (1) The articulation between the inferior border of the vomer and the cleft which lies along the nasal crests of the palatine processes of the maxillæ and palatine bones; (2) the articulation between the rostrum of the sphenoid and the cleft on the superior border of the vomer between the two thick, everted alæ; and (3) the articulation between the inferior border of the perpendicular plate of the ethmoid with the narrow cleft on the anterior border of the vomer.

Gomphosis.—This variety of synarthrosis is illustrated in the impaction of the roots of the teeth within the sockets of the maxillæ and mandible.

Synchondroses.

The following are examples of this temporary form of synarthrosis:

Spheno-occipital Synchondrosis.—This is situated between the posterior surface of the body of the sphenoid and the anterior surface of the basilar part of the occipital bone.

Petro-occipital Synchondrosis.—This is situated between the jugular notch on the inferior surface of the petrous part of the temporal bone and the extremity of the jugular process of the occipital.

Spheno-petrosal Synchondrosis.—This is situated between the posterior border of the greater wing of the sphenoid and the anterior part of the petrous portion of the temporal bone.

There are also intra-occipital and intra-sphenoidal synchondroses until the ossification of these bones is completed.

SKULL AS A WHOLE: REGIONS.

Before comparing the different aspects of two or more skulls it is obvious that they must be placed in the same position, or, to be more definite, orientated in the same plane. Craniologists have now agreed to accept what is known as the 'Frankfurt plane of orientation,' which is obtained by drawing a horizontal line from the lower margin of the orbit through the upper margin of the external auditory meatus.

1. The Posterior Aspect of the Skull.

The **posterior aspect** (norma occipitalis) is formed by the posterior parts of the parietal bones, the upper or interparietal division of the squamous part of the occipital, and the mastoid part of the temporal bones. A little above the centre it presents the **lambda,** which is the place where the sagittal meets the lambdoid suture in the situation

of the posterior fontanelle of early life. Radiating from the lambda there are three sutures. One passes upwards and forms the posterior part of the sagittal suture. The other two, diverging, pass outwards and downwards, and form together the lambdoid or occipito-parietal suture. About 1 inch above the lambda, at either side of the sagittal suture, is the **parietal foramen,** and the point where the horizontal line connecting the parietal foramina intersects the sagittal suture is known as the **obelion,** the interval between coinciding with the situation of the sagittal fontanelle of early fœtal life, and sometimes being regarded as the remnant of the median orbit for the pineal eye. This part of the sagittal suture is less serrated than elsewhere, and is the first to show signs of obliteration. At the lower part of the posterior region in the middle line is the external occipital protuberance, which is known as the **inion.** A little above this is the **occipital point,** which is the part in the median plane at the greatest distance from the glabella of the frontal. The squamous part of the occipital may present an occipital suture if the interparietal division persists as a separate bone.

2. The Skull viewed from Above.

The **skull viewed from above** (norma verticalis) varies in shape. It may be oval with its long axis antero-posterior, and broader behind than in front. Such skulls are called **dolicocephalic,** and in them the zygomatic arches are usually visible at either side from above, a condition known as **phenozygous.** In other cases the superior region assumes a more circular shape, due to the broadening of its anterior part. Such skulls are called **brachycephalic,** and in them the zygomatic arches are usually concealed from above, a condition known as **cryptozygous.** Some skulls are intermediate between the dolicocephalic and brachycephalic, and are known as **mesaticephalic.** The bones which enter into the superior region are the upper part of the frontal, the anterior parts of the parietals, and a very little of the occipital. Its limits will vary with the shape of the skull, which must, of course, be orientated on the Frankfurt plane. Sometimes the supraciliary arches are seen, sometimes they are hidden by the frontal eminences. The highest point is situated in the course of the sagittal suture, and is called the **vertex.** The sutures in this region are three in number—coronal, sagittal, and lambdoid; but there is sometimes a fourth—namely, the metopic. The skull, viewed from above, reveals certain parts of the posterior region—namely, the posterior portions of the parietals, with the parietal foramina and obelion, the lambda, the interparietal portion of the occipital, and the lambdoid suture.

3. The Anterior Aspect of Skull.

The **anterior aspect** (norma frontalis) is formed by a portion of the frontal, the nasals, maxillæ, zygomatics, and the mandible. It is subdivided into two regions, frontal and facial.

The **frontal region** presents the frontal eminences, superciliary arches,

zygomatic and medial angular processes, supra-orbital notches, or it may be foramina, all on either side of the median line, and the nasal eminence or **glabella** at the median line, between the two superciliary arches. The meeting of the two fronto-nasal sutures is known as the **nasion.** The centre of a line drawn from one temporal line to the other across the narrowest part of the frontal region is the **ophryon.**

The upper part of the **facial region** presents the openings of the orbits. These apertures are quadrilateral, with the angles rounded off, and the long axes directed outwards and a little downwards. Their vertical height varies a good deal, and is sometimes an important racial characteristic. They are separated at the median line by the bridge of the nose, which is formed by the nasal bones and the frontal processes of the maxillæ, whilst laterally each orbit is limited by the zygomatic bone and the zygomatic process of the frontal. The point at the inner angle of the orbit where the horizontal fronto-maxillary suture meets the vertical lacrimo-maxillary suture is known as the **dachryon,** and the lower part of the internasal suture is known as the **rhinion.** Below the nasal bones is the anterior bony aperture of nose. It is bounded on either side by the nasal notch on the medial border of the maxilla, and above by the inferior borders of the nasal bones, whilst inferiorly in the median line is the anterior nasal spine in two halves. The central point of the base of this spine is known as the **subnasal point.** The anterior nasal aperture is the common external opening of the two nasal fossæ, which are separated by a septum composed of bones and cartilage. Just below the aperture, on each side of the subnasal spine, a small depression, called the subnasal fossa, is sometimes seen. An inspection of each nasal fossa will reveal two bulging prominences on its outer wall, the lower of which is formed by the inferior nasal concha, and the upper by the middle nasal concha. Below the former is the inferior meatus, whilst between the two is the middle meatus. The outer wall, from its irregularity, thus presents a marked contrast to the floor, which is smooth and unbroken. The osseous septum is, as a rule, deflected to one side, most commonly the left, thus diminishing the capacity of the left fossa. Below the anterior nasal aperture are the alveolar arches of the maxillæ, which lodge the upper teeth. The point where the anterior margins of these two borders meet in the median line is known as the **alveolar point.** Below these borders is the entrance to the buccal cavity, and below this is the alveolar arch of the mandible which lodges the lower teeth. The middle point of the anterior lip of the lower border of the mandible is known as the **mental point** or **gnathion.**

The maxillæ having a wider range than the mandible, the upper teeth slightly overlap the lower. According to the degree of projection of the maxillary bones, skulls are spoken of as **orthognathous, prognathous,** or **mesognathous.**

The chief small foramina of the anterior region are as follows, from above downwards at either side: **supra-orbital,** at the junction of the outer two-thirds and inner third of the supra-orbital margin

of the frontal (which in most cases is a notch); **infra-orbital,** in the maxilla near the infra-orbital margin; **mental,** in the mandible in line with the septum between the premolar sockets; and **zygomatico-facial,** situated above the zygomatic tuberosity. The supra-orbital, infra-orbital, and mental foramina are in the same perpendicular line, and transmit the following important sensory nerves, in order from above downwards: supra-orbital, infra-orbital, and mental, which are branches of the ophthalmic, maxillary, and mandibular divisions of the trigeminal ganglion on the sensory root of the fifth cranial nerve. The zygomatico-facial foramen transmits the zygomatico-facial branch of the zygomatic nerve from the maxillary division of the fifth.

The sutures in the anterior region are: zygomatico-frontal, fronto-maxillary, lacrimo-maxillary, fronto-nasal, internasal, naso-maxillary, zygomatico-maxillary, and intermaxillary.

The Orbits.—The **orbits** have the shape of four-sided pyramids, their bases being directed forwards and outwards, and their apices backwards and inwards. The inner walls are nearly parallel, and occupy an antero-posterior plane, but the outer walls diverge, the plane of each being directed forwards and outwards, so that they almost form a right angle with each other. Each orbit is lined with periosteum, which is continuous with the dura mater through the superior orbital fissure, and it contains the eyeball, with the ocular muscles, nerves, and bloodvessels, the lacrimal gland, and a large amount of fat. It presents an apex, a base, and four sides or walls. The **apex,** which is directed backwards and inwards, is formed by the bar of bone separating the optic foramen from the superior orbital fissure, and just above and internal to this is the **optic foramen.** The **base** is free, and is directed forwards and outwards. Its circumference presents the zygomatico-frontal suture laterally, the zygomatico-maxillary inferiorly, and the fronto-maxillary medially. The walls are superior, inferior, lateral, and medial.

The **superior wall** or **roof,** which is thin and brittle, is formed mainly by the orbital plate of the frontal, and behind this by the lesser wing of the sphenoid. It is smooth and concave. Within the zygomatic process it presents the **fossa for lacrimal gland,** and near the medial angular process the **trochlear fossa,** which gives attachment to the fibrous pulley of the superior oblique muscle of the eyeball.

The **inferior wall** or **floor** is formed by three bones—namely, the orbital surface of the maxilla, lateral to which is a part of the orbital surface of the zygomatic, whilst posteriorly is the orbital process of the palatine bone. The floor is thin, and separates the orbit from the subjacent maxillary sinus. It is traversed from behind forwards by the **infra-orbital canal,** which posteriorly is a groove. At its anterior and inner part is the upper orifice of the **lacrimal canal,** and lateral to this is a small depression which gives origin to the inferior oblique muscle of the eyeball.

The **outer wall** looks forwards and inwards, and is formed mainly by the orbital surface of the greater wing of the sphenoid, and in

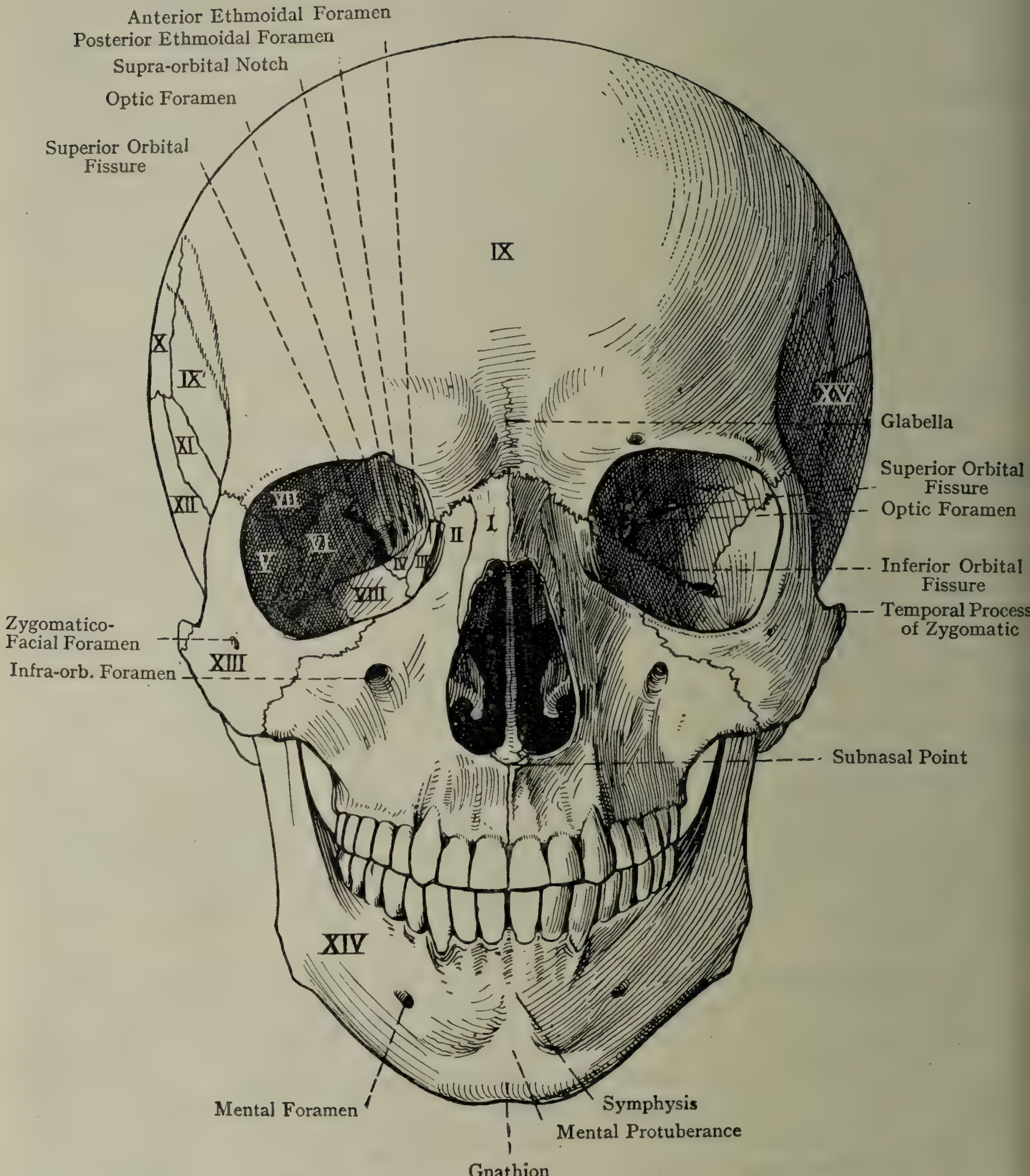


FIG. 158.—THE ANTERIOR ASPECT OF THE SKULL (NORMA FRONTALIS ET FACIALIS).

I, nasal; II, nas. proc. of maxilla; III, lacrimal; IV, ethmoid (orbital plate); V, orbital surface of zygomatic; VI, orb. surf. of greater wing of sphenoid; VII, orb. plate of frontal; VIII, orb. surf. of maxilla; IX, frontal; IX′, temp. div. of frontal; X, parietal; XI, greater wing of sphenoid; XII, squam. port. of temporal; XIII, zygomatic; XIV, mandible; XV, temporal fossa.

front of this by a part of the orbital surface of the zygomatic. Between the outer wall and the floor is the **inferior orbital fissure,** the front part of which communicates with the infratemporal fossa, and the back part with the pterygo-palatine fossa. Between the outer wall and the roof, towards the posterior part, is the outer portion of the **superior orbital fissure.** The part of the orbital process of the zygomatic which forms the front part of this wall presents two foramina (sometimes one) leading to the **zygomatico-facial** and **zygomatico-temporal foramina.**

The **inner wall** is almost vertical, and looks directly outwards. It is formed by four (sometimes five) bones, in the following order from before backwards: (1) the frontal process of the maxilla; (2) the lacrimal; (3) the orbital plate of the ethmoid; and (4) the anterior part of the lateral surface of the body of the sphenoid. If there are five bones, the fifth is a portion of the sphenoidal concha, which would lie behind the orbital plate of the ethmoid. Between the inner wall and roof, in the fronto-ethmoidal suture, are the openings of the **anterior** and **posterior ethmoidal** or **internal orbital foramina.** At the anterior part of this wall is the **lacrimal groove,** which lodges the lacrimal sac, and behind this is the lacrimal crest, which gives origin to the lacrimal part of orbicularis oculi.

The orbital sutures are as follows: superiorly, the spheno-frontal; inferiorly, the zygomatico-maxillary and palato-maxillary; laterally, the spheno-zygomatic; and medially, from before backwards, the lacrimo-maxillary, lacrimo-ethmoidal, and spheno-ethmoidal, all of which three are disposed vertically, and fronto-ethmoidal, which is antero-posterior.

The orbit has ten (sometimes nine) openings communicating with it. (1) The **superior orbital fissure,** the wide inner end of which forms the apex of the cavity, whilst the narrow outer part lies between the roof and the outer wall. This fissure transmits (*a*) the third nerve, the sympathetic filament to the ciliary ganglion, the fourth, the three branches (frontal, lacrimal, and naso-ciliary) of the ophthalmic division of the fifth and the sixth cranial nerves; (*b*) the superior ophthalmic vein; (*c*) the orbital branch of the middle meningeal artery; and (*d*) a portion of the dura mater. (2) The **optic foramen,** situated above and medial to the apex, for the optic nerve and the ophthalmic artery, along with a plexus of sympathetic nerve fibres. (3) The **supra-orbital notch** (or it may be foramen), on the supra-orbital margin, for the supra-orbital nerve and vessels. (4) The opening of the **infra-orbital canal,** on the floor, transmitting the infra-orbital nerve and vessels. (5) The opening of the **zygomatico-temporal foramen,** and (6) the opening of the **zygomatico-facial foramen,** both on the outer wall, for the branches of the zygomatic nerve from the maxillary division of the fifth cranial nerve. (The temporal and zygomatic openings may be combined into one.) (7) The **inferior orbital fissure,** at the junction of the outer wall and floor, which transmits the maxillary nerve to become the infra-orbital, and the infra-orbital artery and

inferior ophthalmic vein. (8) The **naso-lacrimal canal,** at the anterior part of the inner wall, for the naso-lacrimal duct. (9) The **anterior ethmoidal foramen,** and (10) the **posterior ethmoidal foramen,** both situated on the inner wall, the former transmitting the anterior ethmoidal vessels and nerve, and the latter the posterior ethmoidal vessels and nerve.

Eight muscles take their origin within each orbit. The four recti arise from a fibrous ring surrounding the optic foramen. The levator palpebræ superioris arises above and in front of the optic foramen, and the superior oblique arises medial to the last named. The inferior oblique arises from the depression at the anterior and inner part of the floor, lateral to the orifice of the naso-lacrimal canal, and the lacrimal part of orbicularis oculi arises from the lacrimal crest behind the lacrimal groove.

The Nasal Fossæ.—The **nasal fossæ** are two in number, right and left, and they lie on either side of the median plane. They extend horizontally from before backwards, opening on the face by means of the anterior bony aperture of nose, and communicating posteriorly with the naso-pharynx by the posterior bony aperture of nose. The vertical and antero-posterior dimensions of each fossa greatly exceed the transverse. The two fossæ are separated from each other by a partition, called the nasal septum, which is partly osseous and (in the recent state) partly cartilaginous. Each fossa presents a roof, floor, and two walls, inner and outer.

The **roof** over its central part is horizontal, but in front and behind it is inclined downwards. Six bones enter into its formation. The central portion is formed by one-half of the cribriform plate of the ethmoid. The sloping anterior part is formed by the grooved nasal margin of the frontal bone, by the side of the nasal spine, and the posterior surface of the nasal bone. The sloping posterior part is formed by portions of the anterior and inferior surfaces of the body of the sphenoid, the ala of the vomer, and a part of the sphenoidal process of the palatine bone. The central part of the roof is perforated by the foramina of one-half of the cribriform plate, including the nasal slit, and, at its back part, the aperture of the sphenoidal sinus opens into the spheno-ethmoidal recess.

The **floor** is smooth and concave from side to side. Over its anterior three-fourths it is formed by the palatine process of the maxilla, and over its posterior fourth by the horizontal plate of the palatine bone. Near its anterior extremity, close to the incisive crest of the maxilla, is the upper opening of the **incisive canal.**

The **inner wall** is known as the **nasal septum.** The osseous septum is formed by ten bones, in the following order, as nearly as possible from below upwards; the nasal crests of the palatine processes of the maxillæ and palatine bones; the vomer; the perpendicular plate of the ethmoid; the rostrum of the sphenoid; the nasal crest of the nasal bones; and the nasal spine of the frontal. The anterior border of the osseous septum presents a triangular deficiency, which is occupied in

the recent state by the septal cartilage. The posterior border is formed by the posterior border of the vomer, which lies between the posterior bony apertures of the nose. As previously stated, the septum is usually deflected to one side, most commonly the left.

The **outer wall** is characterized by great irregularity, and is formed by seven bones, in the following order, as nearly as possible from before backwards: (1) the nasal; (2) the frontal process of the maxilla;

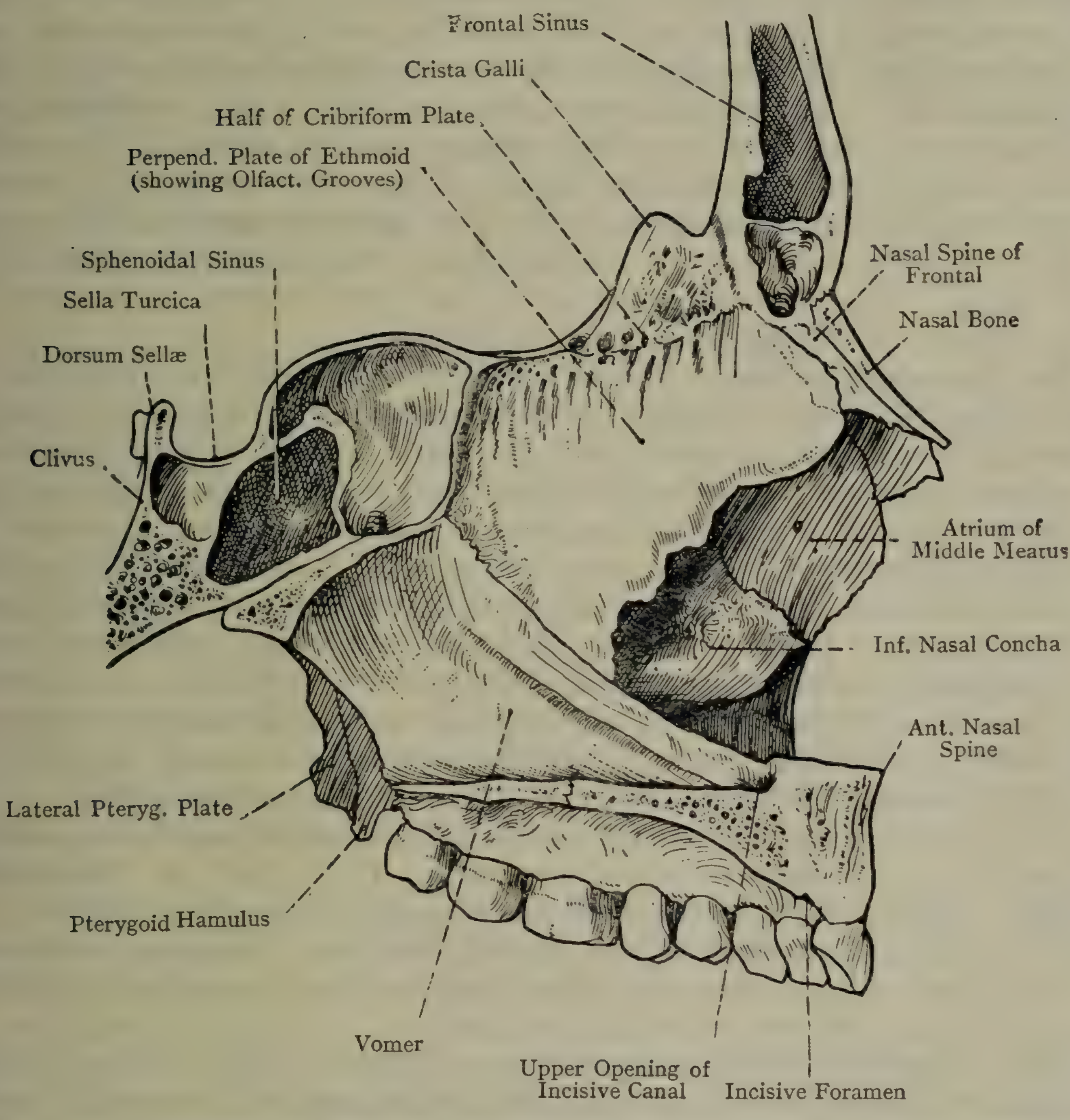


FIG. 159.—SAGITTAL SECTION OF THE ANTERIOR PART OF THE SKULL TO THE RIGHT OF THE NASAL SEPTUM.

(3) the lacrimal; (4) the medial surface of the labyrinth of the ethmoid, presenting the superior and middle nasal conchæ; (5) the inferior nasal concha, which lies below the last named; (6) the perpendicular plate of the palatine bone, together with parts of its orbital and sphenoidal processes; and (7) the medial pterygoid plate of the pterygoid process of the sphenoid.

The bulging projections on this wall are produced by the superior, middle, and inferior nasal conchæ, in this order from above downwards,

and the deep channels thereby formed are known as the *meatus*. These are three in number—superior, middle, and inferior. The **superior meatus** is situated towards the back part of the outer wall, where it lies between the superior and middle nasal conchæ. It is comparatively short, and is directed obliquely forwards and upwards. The posterior ethmoidal sinus opens into it anteriorly, and the spheno-palatine foramen opens just below and behind the superior nasal concha. The **middle meatus,** which is longer than the superior, lies between the middle and inferior nasal conchæ. At its anterior part it turns upwards, and is continued into the passage known as the **infundibulum,** which communicates with the frontal sinus of its own side. The ascending part also communicates with the anterior ethmoidal sinus. The middle portion communicates with the middle ethmoidal sinus, and presents the opening of the maxillary sinus. The **inferior meatus,** the longest of the three, lies between the inferior nasal concha and the floor of the nasal fossa. Near its anterior part is the lower orifice of the lacrimal canal, which lodges the naso-lacrimal duct.

The Paranasal Sinuses.—These are hollow cavities lined with mucous membrane, which are contained within the following bones: the frontal, sphenoid, ethmoid, maxillæ, and mastoid portions of the temporals. They communicate directly with the nasal fossæ, except the mastoid air cells, which at either side are in communication, through the tympanic antrum, with the tympanic cavity, that in turn being connected by means of the pharyngo-tympanic tube with the nasal part of pharynx, at a point lateral to the posterior bony aperture of nose. The maxillary sinus appears about the fourth month of intra-uterine life, but the other sinuses do not appear until childhood, and they do not show much development until the period of puberty (see the individual bones). In old age they all tend to become enlarged.

The frontal sinus (by means of the infundibulum) and the anterior ethmoidal sinus open into the ascending front part of the middle meatus. The middle ethmoidal sinus and the maxillary sinus open into the central portion of the middle meatus. The posterior ethmoidal sinus opens into the superior meatus, and the sphenoidal sinus opens into the spheno-ethmoidal recess.

The foramina which perforate the cribriform plate of the ethmoid transmit the filaments of the olfactory bulb, and are arranged in three sets, as follows: a middle set, which are simple perforations, and a lateral and medial set, which lead into small canals. These canals descend on the inner surface of the labyrinth and corresponding part of the perpendicular plate respectively, branching and opening out as they descend. The nasal slit transmits the anterior ethmoidal artery and nerve.* The spheno-palatine foramen leads from the pterygo-palatine fossa, and transmits the spheno-palatine nerves from the spheno-palatine ganglion and the spheno-palatine artery.

The nasal fossæ open on the face through means of the anterior

* There is often a separate foramen for the anterior ethmoidal nerve in front of, and lateral to, the nasal slit.

bony aperture of nose. Each bony aperture is semipyriform, and is bounded above by the lower border of the nasal, laterally by the nasal notch of the maxilla, and inferiorly by the premaxillary portion of that bone.

The **posterior bony apertures of nose** are situated at the posterior extremities of the nasal fossæ, between the pterygoid processes of the sphenoid, and they communicate in the recent state with the nasal part of the pharynx. They are oblong from above downwards, and their plane is oblique, being directed downwards and slightly forwards. Each bony aperture is bounded laterally by the medial pterygoid plate of the sphenoid, medially by the posterior border of the vomer, which separates the two apertures, inferiorly by the posterior border of the horizontal plate of the palatine bone, and superiorly by the vaginal process of the sphenoid, ala of the vomer, and sphenoidal process of the palatine bone.

4. The Lateral Aspect of Skull.

The **lateral aspect of skull** (norma lateralis) is formed by portions of most of the skull bones. This region presents the zygomatic arch, and, from behind forwards, are seen the mastoid process, opening of the external auditory meatus and suprameatal triangle, condyloid process of the mandible, lying in the anterior part of the articular fossa, articular eminence, and the mandibular notch and coronoid process of the mandible, the latter lying within the front part of the zygomatic arch. The central point of the orifice of the external auditory meatus is known as the **auricular point,** and the outer side of the angle of the mandible is known as the **gonion.** The point, situated at the angle which the posterior border of the frontal process of the zygomatic makes with the superior border of its temporal process, is known as the **jugal point.**

The sutures in this region are the zygomatico-frontal, spheno-zygomatic, spheno-frontal, spheno-parietal, spheno-squamosal, coronal, squamosal, zygomatico-temporal, parieto-mastoid, and a portion of the occipito-mastoid.

The point where the superior temporal line crosses the coronal suture is known as the **stephanion,** and the point where the parieto-mastoid, occipito-mastoid, and lambdoid sutures meet is the **asterion.** The latter coincides with the position of the postero-lateral fontanelle in early life. The point near the anterior part of the parieto-mastoid suture, where a process of the parietal is received into the parietal notch of the mastoid, is known as the **entomion.**

The lateral region is divided by the zygomatic arch into the temporal and infratemporal fossæ, the former being above the arch, and the latter within and below it.

The **temporal fossa** is bounded above by the superior temporal lines of the frontal and parietal, and below by the upper border of the zygomatic arch laterally, and the infratemporal crest of the greater

wing of the sphenoid medially. It is formed by five bones: in front by the orbital process of the zygomatic, above by the lower portions of the frontal and parietal, and below by the temporal division of the

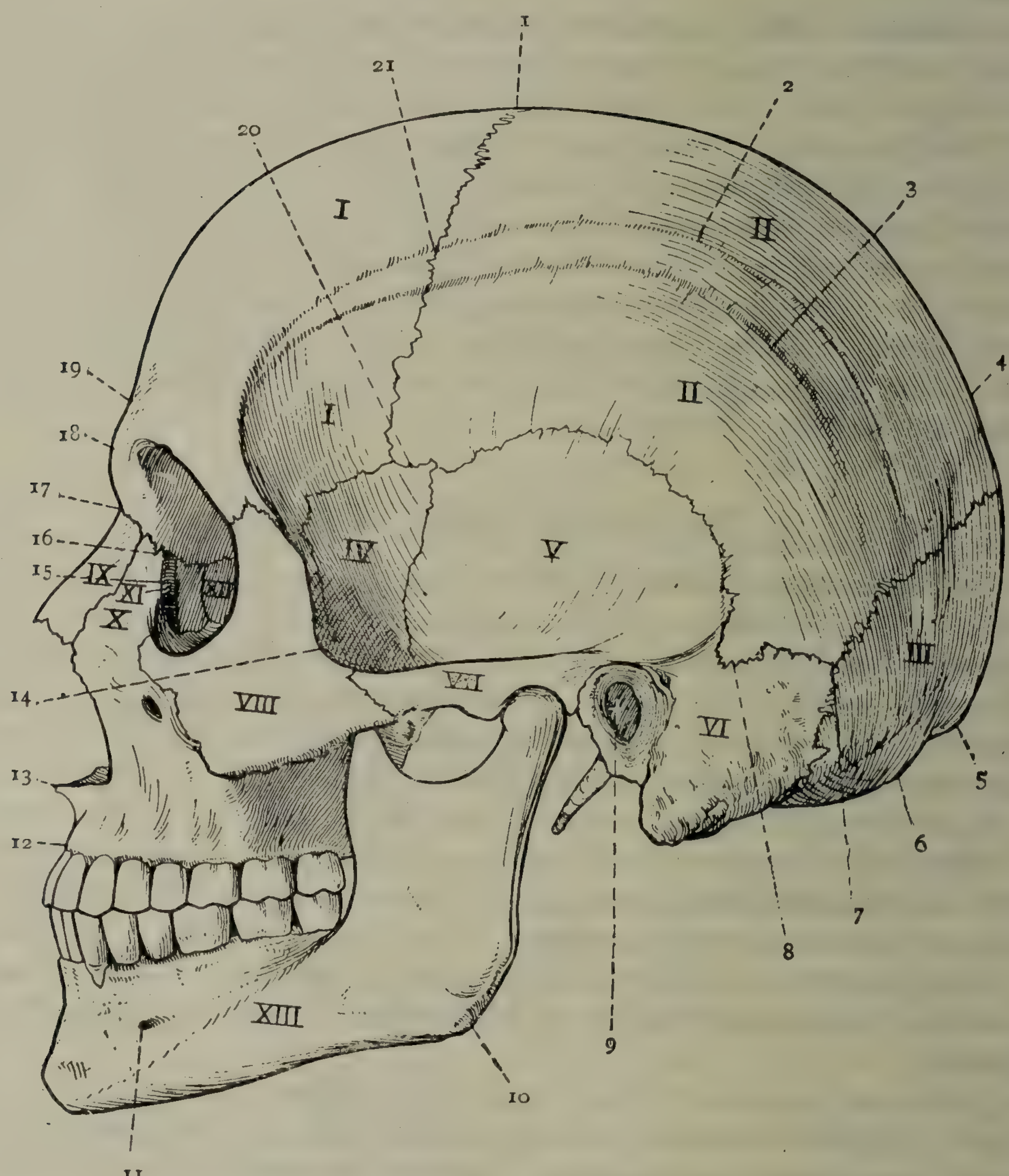


FIG. 160.—THE LATERAL ASPECT OF THE SKULL (NORMA LATERALIS).

I, I, frontal; II, II, parietal; III, occipital; IV, greater wing of sphenoid; V, squamous portion of temporal; VI, mastoid portion of temporal; VII, zygomatic arch; VIII, zygomatic; IX, nasal; X, maxilla (frontal process); XI, lacrimal; XII, ethmoid (orbital plate); XIII, mandible.

1, bregma; 2, superior temporal line; 3, inferior temporal line; 4, obelion; 5, occipital point; 6, inion; 7, asterion; 8, entomion; 9, auricular point; 10, gonion; 11, mental foramen; 12, alveolar point; 13, subnasal point; 14, jugal point; 15, lacrimal groove; 16, dachryon; 17, nasion; 18, glabella; 19, ophryon; 20, pterion; 21, stephanion.

outer surface of the greater wing of the sphenoid and the squamous portion of the temporal. The place where the parietal, frontal, greater wing of the sphenoid, and squamous portion of the temporal are related to one another, and more particularly the region of the

spheno-parietal suture, is known as the **pterion,** which coincides with the position of the antero-lateral fontanelle of early life. In this situation a sutural bone is sometimes present, called the **epipteric bone.** The temporal fossa gives origin to the temporal muscle as high as the inferior temporal line, and the temporal fascia, which covers that muscle, is attached to the superior temporal line.

The **inferior temporal fossa** is situated below the level of the infratemporal crest of the sphenoid. It is bounded laterally by the ramus of the mandible and the inner surface of the zygomatic arch, and, between the two, it communicates with the exterior by means of the mandibular notch. Medially it is bounded by the lateral pterygoid plate of the sphenoid. Superiorly it is limited by the infratemporal surface of the greater wing of the sphenoid below the infratemporal crest, where it presents the foramen ovale and foramen spinosum, and by a small part of the squamous portion of the temporal. Anteriorly its wall is formed by the lower portion of the medial surface of the zygomatic bone and the infratemporal surface of the maxilla, which latter presents the openings of the dental canals. Its superior limit is the infratemporal crest of the sphenoid, the inferior limit being the molar portion of the alveolar arch of the maxilla and the lower border of the lateral pterygoid plate.

The contents of the fossa are as follows: the coronoid process of the mandible with the insertion of the temporal muscle; the lateral and medial pterygoid muscles; the first and second parts of the maxillary artery, and the pterygoid plexus of veins; the maxillary division of the fifth cranial nerve and its branches, together with the otic ganglion; the chorda tympani nerve; and the spheno-mandibular ligament.

The foramina which communicate with the fossa are: the **foramen ovale**; the **foramen spinosum**; the openings of the **dental canals**; and the **inferior dental foramen.**

The fossa presents two fissures—infra-orbital and pterygo-maxillary.

The **infra-orbital** fissure lies horizontally between the greater wing of the sphenoid and the maxilla. Laterally it is closed, as a rule, by the zygomatic, but sometimes by the greater wing of the sphenoid, which may here articulate with the maxilla. Medially it is bounded by the infratemporal surface of the orbital process of the palatine bone. The fissure leads into the orbit, and transmits the maxillary nerve to become the infra-orbital, the infra-orbital vessels, the zygomatic branch of the maxillary nerve, the orbital branches of the spheno-palatine ganglion, the inferior ophthalmic vein, and numerous lymphatic vessels draining the orbit.

The **pterygo-maxillary** fissure lies vertically between the anterior border of the pterygoid process of the sphenoid and the posterior border of the maxilla, at their upper ends. Inferiorly the fissure is closed by the approximation of the bones forming its lips, a part of the tubercle of the palatine bone usually intervening between them, though direct articulation sometimes takes place between the pterygoid process and

the maxilla. Medially the fissure is bounded by the perpendicular plate of the palatine bone. It transmits the maxillary artery to the pterygo-palatine fossa. The pterygo-maxillary fissure meets the infra-orbital fissure at a right angle, and situated deeply within this angle is the pterygo-palatine fossa.

The boundaries of the **pterygo-palatine fossa** are as follows: *anteriorly*, the infratemporal surface of the maxilla at its inner and back part superiorly; *posteriorly*, the base of the pterygoid process of the sphenoid, and the lower and inner part of the anterior surface of its greater

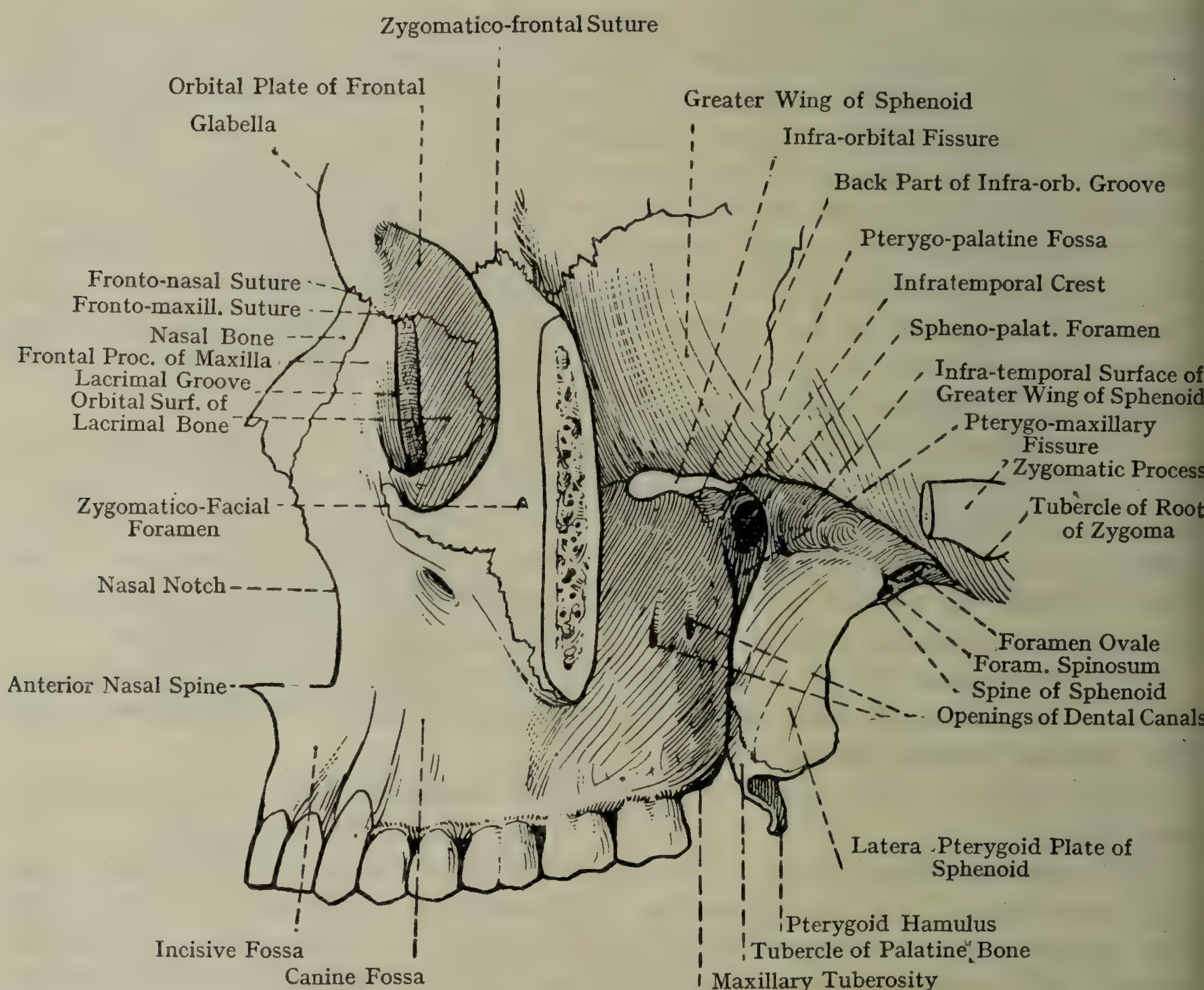


FIG. 161.—THE INFRATEMPORAL AND PTERYGO-PALATINE FOSSÆ.

wing; *medially*, the perpendicular plate of the palatine bone, with its orbital and sphenoidal processes; and *superiorly*, the under surface of the body of the sphenoid. The contents of the fossa are the third part of the maxillary artery, the maxillary nerve, and the spheno-palatine ganglion, along with their branches. Two fissures communicate with this fossa: the infra-orbital, leading into the orbit, and the pterygo-maxillary, opening into the infratemporal fossa. It also communicates with the superior meatus of the nose by means of the spheno-palatine foramen on its inner wall.

The foramina which open into the pterygo-palatine fossa are three n the *posterior wall,* in the following order from above downwards, nd from without inwards: the **foramen rotundum** for the maxillary erve, the **pterygoid canal** for the artery and nerve of pterygoid canal, nd the **palatino-vaginal canal** for the pharyngeal artery and the pharyn-eal branch of the spheno-palatine ganglion. On the *medial wall* is he **spheno-palatine foramen** for the spheno-palatine branches of spheno-alatine ganglion and the spheno-palatine artery. *Inferiorly* is the pening of the **greater palatine canal** for the greater palatine nerve nd the greater palatine artery. In this situation there may also be he openings of the **lesser palatine canals** for the lesser palatine arteries nd nerves, but these openings usually branch off from the main canal. *nteriorly* is the infra-orbital fissure. *Laterally* the fossa communi-ates with the infratemporal fossa through the pterygo-maxillary fissure.

5. The Lower Surface of Base of Skull.

The **external surface of the base of the skull** (norma basilaris), from vhich the mandible is excluded, is very irregular, and presents three livisions—anterior, middle, and posterior.

The **anterior division** forms the hard palate, and resembles a horse-hoe. It is bounded in front and laterally by the alveolar arches of he maxillæ, and behind by the posterior borders of the horizontal lates of the palatine bones. The posterior border presents in the niddle line the posterior nasal spine in two halves, from which the nusculus uvulæ arises. At either side of this it is sharp and concave or the attachment of the soft palate. The bones forming the hard alate are the palatine processes of the maxillæ over the anterior three-ourths, and the horizontal plates of the palatine bones over the pos-erior fourth. The surface is vaulted, and is intersected by two sutures, niddle palatine and transverse palatine. The middle palatine suture xtends from the alveolar point to the posterior nasal spine, and indi-ates the meeting of the palatine processes of the maxillæ and palatine ones of opposite sides. The transverse palatine suture crosses the niddle one at right angles about $\frac{1}{2}$ inch in front of the posterior border, nd laterally it turns backwards to end at the greater palatine foramen. t indicates the meeting of the palatine process of the maxilla and the orizontal plate of the palatine bone of either side.

In young skulls two additional sutures are present, called maxillo-remaxillary, each of which extends from the posterior part of the ncisive fossa to the interval between the lateral incisor and canine eeth. Each of these sutures corresponds with the place of junction f the maxilla proper and the premaxilla.

The hard palate presents several openings. At the anterior ex-remity of the middle palatal suture is the diamond-shaped **incisive ossa.** Within this are four openings, two being placed laterally, one t either side, called the **lateral incisive foramina,** and two in the median ine in the intermaxillary suture, called the **median incisive foramina,**

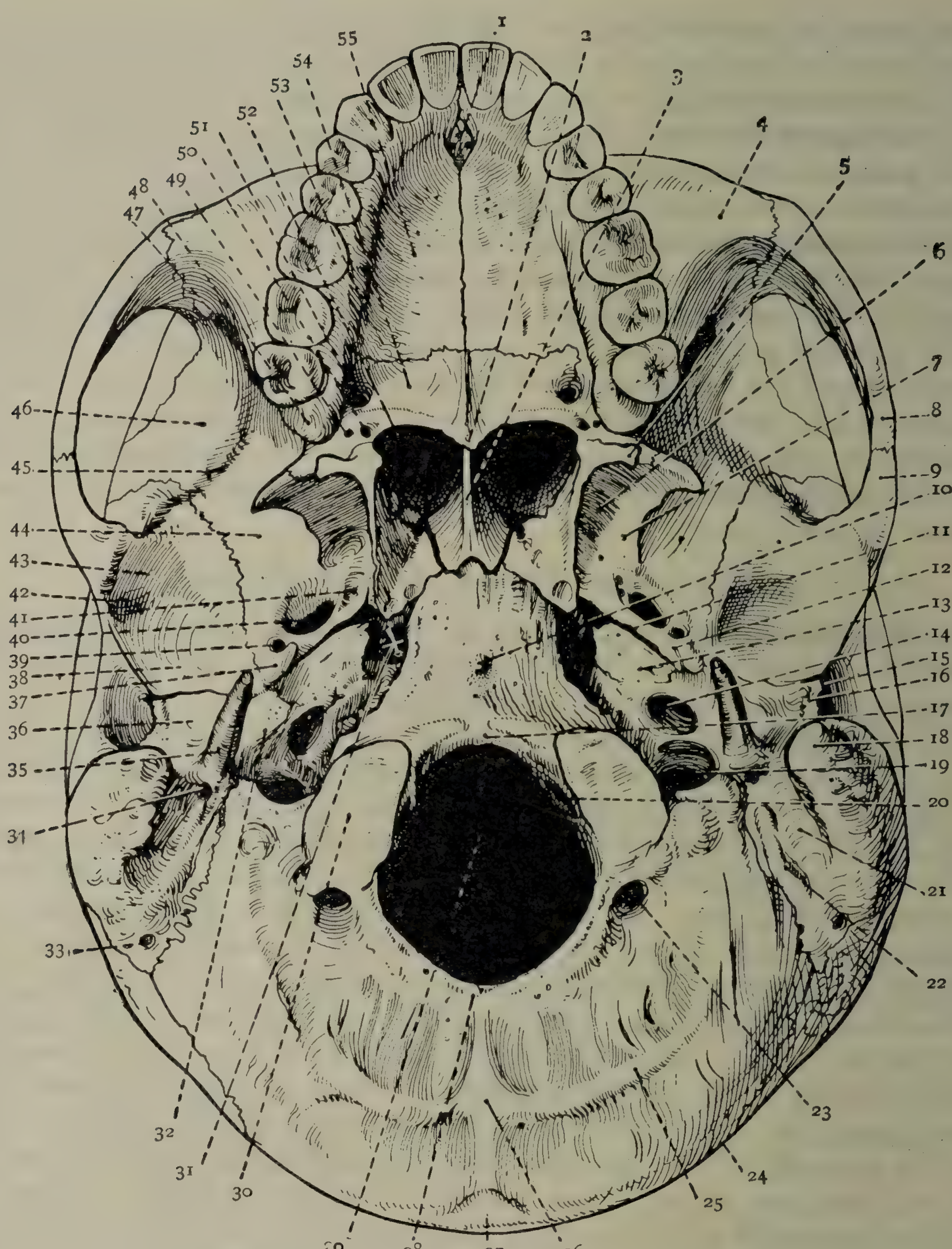


FIG. 162.—THE EXTERNAL SURFACE OF THE BASE OF THE SKULL.

1. Incisive Fossa
2. Post. Nasal Spine
3. Post. Border of Vomer
4. Facial Surf. of Maxilla
5. Pterygoid Hamulus of Medial Pterygoid Plate of Sphenoid
6. Pterygoid Fossa
7. Lateral Pterygoid Plate
8. Temporal Process of Malar
9. Zygomatic Process of Temporal
10. Pharyngeal Tubercle (pointer crosses Foramen Lacerum)
11. Groove for Pharyngo-Tympanic Tube
12. Groove for Chorda Tympani Nerve
13. Petrous Portion of Temporal (Origin of Levator Palati)
14. Carotid Canal
15. Ext. Auditory Meatus
16. Ext. Auditory Process
17. Basion
18. Mastoid Process
19. Jugular Foramen
20. Anterior Condylar Canal
21. Mastoid Notch
22. Occipital Groove
23. Posterior Condylar Canal
24. Superior Nuchal Line
25. Inferior Nuchal Line
26. Ext. Occipital Crest
27. Ext. Occipital Protuberance
28. Opisthion
29. Foramen Magnum
30. Right Occipital Condyle
31. Foramen Lacerum
32. Vaginal Proc. of Tymp. Plate
33. Mastoid Foramen
34. Stylo-Mastoid Foramen
35. Styloid Process
36. Tympanic Plate (Post. part of Articular Fossa)
37. Spine of Sphenoid
38. Ant. part of Articular Fossa
39. Foramen Spinosum
40. Foramen Ovale
41. Emissary Sphenoidal Foramen
42. Tubercle of Root of Zygoma
43. Articular Eminence
44. Infratemporal Fossa
45. Infratemporal Crest
46. Temporal Division of Greater Wing of Sphenoid
47. Infra-Orbital Fissure.
48. Maxillary Tuberosity
49. } Lesser Palatine Foramina
50. }
51. Greater Palatine Foramen
52. Right Posterior Bony Aperture of Nose (pointer crosses ridge for Tensor Palati)
53. Groove for Greater Palat. Artery
54. Horiz. Plate of Palatine Bone
55. Palat. Proc. of Maxilla

anterior and posterior respectively. Each of the former transmits a branch of the greater palatine vessels from the palate to the nasal fossa, whilst each of the latter transmits the long spheno-palatine nerve from the nasal fossa to the hard palate, the *anterior*, which usually opens from the *left* nasal fossa, containing the left nerve, and the *posterior*, which usually opens from the *right* nasal fossa, containing the right nerve. Medial to the last molar socket at either side is the **greater palatine foramen,** which is the outlet of the greater palatine canal, and through which the greater palatine nerve and the greater palatine vessels pass. Leading forwards from this foramen there is a groove for the transmitted structures. A little behind the greater palatine foramen are the lesser palatine foramina for the lesser palatine nerves. There are usually two such foramina, medial and lateral, but the latter one is inconstant. Besides the foregoing openings, there are a number of nutrient foramina. Over its posterior third the hard palate presents several depressions for the palatine mucous glands, and extending inwards from the back part of the greater palatine foramen at either side is a transverse ridge, which divides the palatine gland and gives partial insertion to the tensor palati muscle. In addition to these the torus palatinus, described on p. 216, may occasionally be seen.

The **middle division** extends from the posterior border of the hard palate to a transverse line on a level with the anterior margin of the foramen magnum. Laterally it is limited by a line extending from the tuberosity of the maxilla to the styloid process of the temporal. It is on a higher level than the anterior division, and its central or basilar part is sometimes termed the **guttural fossa.** The bones forming it at either side are the tubercle of the palatine bone, the pterygoid process, and a small part of the greater wing of the sphenoid, and the inferior surface of the petrous portion of the temporal. The central part is formed by the basilar process of the occipital, the body and vaginal processes of the sphenoid, the superior border and alæ of the vomer, and the sphenoidal processes of the palatine bones.

Anteriorly it presents the posterior bony apertures of the nose, already described, and at either side of these openings is the **pterygoid fossa,** which is bounded medially by the medial, and laterally by the lateral, pterygoid plate of the sphenoid, the fossa being completed inferiorly by the tubercle of the palatine bone.

In a line extending backwards and outwards from the lateral pterygoid plate to the styloid process the following parts are seen, in order from before backwards: **foramen ovale; foramen spinosum; spine** of the sphenoid; medial border of the tympanic plate of the temporal, forming posteriorly the **vaginal process;** and **styloid process.** Inside the foregoing line anteriorly is the **groove for pharyngo-tympanic tube,** which lies obliquely between the greater wing of the sphenoid and the apical part of the petrous portion of the temporal. This groove lodges the cartilaginous part of the pharyngo-tympanic tube, and, when followed outwards and backwards, it leads to the pharyngo-tympanic

canal in the angle between the squamous and petrous portions of the temporal.

On either side of the basilar process of the occipital is the **foramen lacerum.** It lies between the basilar process, the apex of the petrous portion of the temporal, and the greater wing of the sphenoid near the root of the pterygoid process. In the recent state it is closed below by cartilage, which is pierced by a meningeal branch of the ascending pharyngeal artery, one or more emissary veins from the cavernous sinus, and partly by the greater superficial petrosal nerve and internal carotid artery, which lie in the space but do not traverse it completely.

In a line extending backwards and outwards from the foramen lacerum are the following markings on the inferior surface of the petrous portion of the temporal: the rough surface from which the levator palati and tensor tympani arise; the **carotid canal,** which transmits the internal carotid artery and the ascending branch of the superior cervical ganglion of the sympathetic; a minute foramen, on the posterior wall of the vertical portion of the carotid canal, for the carotico-tympanic branch of the carotid sympathetic plexus and carotico-tympanic branch of the internal carotid artery; the **jugular fossa,** which forms part of the jugular foramen; the **tympanic canaliculus,** on the ridge between the carotid canal and jugular fossa, for the tympanic branch of the glosso-pharyngeal and the tympanic branch of the ascending pharyngeal artery; and the **mastoid canaliculus,** on the outer wall of the jugular fossa, for the auricular branch of the vagus. Between the petrous portion of the temporal and the jugular process of the occipital is the **jugular foramen,** which lodges the commencement of the internal jugular vein, and transmits the following structures: the glosso-pharyngeal, vagus, and accessory nerves; the inferior petrosal sinus; and meningeal branches of the ascending pharyngeal and occipital arteries.

Lateral to the front of the occipital condyle is the **anterior condylar canal** for the hypoglossal nerve and a meningeal branch of the ascending pharyngeal artery. The under surface of the basilar process of the occipital presents the **pharyngeal tubercle.**

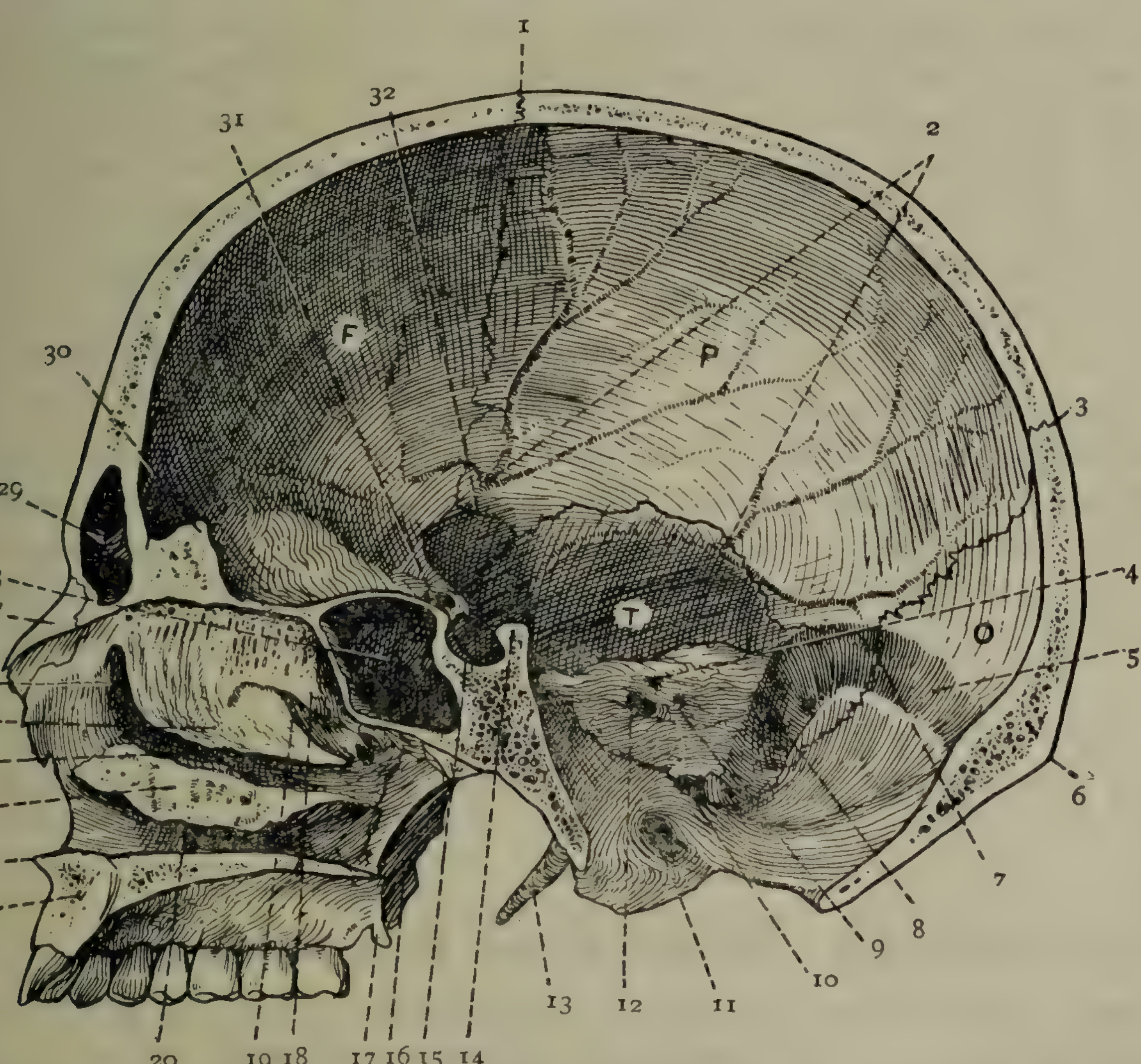
The **posterior division** is limited in front by a transverse line on a level with the anterior margin of the foramen magnum, and behind by the external occipital protuberance and the superior nuchal line at either side. It is formed by the supra- and ex-occipital portions of the occipital, and the mastoid portions of the temporal bones.

In the middle line is the **foramen magnum,** which transmits the central nervous axis and its membranes, the accessory nerves, the vertebral arteries, the anterior spinal and posterior meningeal arteries, parts of the cerebellar amygdalæ, and the membrana tectoria. The centre of the anterior margin of the foramen magnum is known as the **basion,** and the centre of the posterior margin as the **opisthion.** Proceeding outwards from this foramen are the **occipital condyle, jugular process, occipital groove** for the occipital artery, **mastoid notch** for the posterior belly of the digastric, and the mastoid process. Behind the occipital condyle is the **condylar fossa,** in which there may be a posterior

ondylar canal for the passage of an emissary vein from the sigmoid inus. Behind the foramen magnum is the supra-occipital portion of he occipital, which presents the **external occipital crest** in the median ine, and the **inferior nuchal line** extending outwards on either side from ts centre; while in or close to the suture between the mastoid and upra-occipital bones there may be a mastoid foramen transmitting an missary vein from the transverse sinus and a meningeal branch of the ccipital artery.

The Interior of the Cranium.

A sagittal or antero-posterior section of the skull a little to one ide of the median plane shows the nasal septum already described.



IG. 163.—SAGITTAL SECTION OF THE SKULL TO THE RIGHT OF THE MEDIAN PLANE.

F, frontal; P, parietal; O, occipital; T, temporal.

1. Coronal Suture
2. Anterior and Posterior Meningeal Grooves
3. Lambdoid Suture
4. Subarcuate Fossa
5. Sigmoid Groove
6. Inion (External Occipital Protuberance)
7. Asterion
8. Sigmoid Groove
9. Aqueduct of Vestibule
o. Jugular Foramen
11. Anterior Condylar Canal
12. Internal Auditory Meatus
13. Styloid Process
14. Dorsum Sellæ
15. Sella Turcica
16. Lateral Pterygoid Plate
17. Pterygoid Hamulus
18. Superior Nasal Concha
19. Superior Meatus
20. Inferior Meatus
21. Right Maxilla
22. Anterior Nasal Spine
23. Inferior Nasal Concha
24. Middle Meatus
25. Middle Nasal Concha
26. Infundibulum
27. Nasal Bone
28. Right Sphenoidal Sinus
29. Right Frontal Sinus
30. Crista Galli
31. Optic Foramen
32. Pterion

long, and at either side of, the vault of the cranium is the groove for he superior sagittal venous sinus, which extends from before back-

wards, and on either side of its parietal portion are the pits for arachnoid granulations. The internal openings of the parietal foramina may be seen, as well as the branching system of meningeal grooves and impressions for cerebral gyri. The basi-cranial, basi-facial, and basi-bregmatic axes are to be studied from this section. The **basi-cranial axis** represents a line drawn upwards and forwards from the basion to the spheno-ethmoidal suture. The **basi-facial axis** corresponds with a line drawn from the spheno-ethmoidal suture to the subnasal point. The angle formed by these two axes is known as the **cranio-facial angle.** The **basi-bregmatic axis** represents a line drawn vertically from the basion to the bregma.

The most instructive coronal or transverse section is one made in the plane of the basi-bregmatic axis. Such a section gives important views of the parts within the petrous portion of the temporal, such as the external auditory meatus, tympanic cavity, and vestibule.

When a horizontal section has been made on a level with the occipital point and the most prominent part of the glabella, the vaulted roof of the cranium is removed. This is called the **calvaria,** or skull-cap, and it is formed by portions of the frontal, parietals, squamous portions of the temporals, and occipital. The outer plate is strong, except over the temporal region, but the inner is brittle and readily cracked, from which circumstance it is known as the vitreous (glassy) plate. Between the two plates there is cancellated tissue, here called **diploë.** The interior of the calvaria presents branching meningeal grooves, impressions for cerebral gyri, and along the middle line the groove for the superior sagittal venous sinus, with depressions at either side for the arachnoid granulations. The openings of the parietal foramina may be noted. The simple structure of the sutures of the vault when seen from the intracranial aspect has been called attention to already.

The Intracranial Surface of the Base of the Skull.

The **base** forms the floor of the cranial cavity, and is of very irregular outline and thickness. The thickest and densest parts are the petrous portions of the temporals. The mastoid portion of the temporal and the basilar part of the occipital are also thick. The thinnest parts are the cribriform plate of the ethmoid and the orbital plates of the frontal, but the central portions of the cerebellar fossæ of the occipital are also thin, sometimes remarkably so. The interior of the base is divided into three fossæ—anterior, middle, and posterior.

Anterior Fossa.—The floor of this fossa is formed by the orbital plates of the frontal, the cribriform plate of the ethmoid, and the lesser wings, jugum sphenoidale, and ethmoidal spine of the sphenoid. It is limited posteriorly by the posterior border of the lesser wing of the sphenoid at either side, and by the limbus sphenoidalis in the centre. It is subdivided into a central and two lateral parts.

The **central portion,** which is depressed, is formed by the cribriform

plate of the ethmoid and the ethmoidal spine and jugum of the sphenoid. In the middle line it presents the **crista galli,** which gives attachment to the falx cerebri. In front of this is the **foramen cæcum,** which, when pervious, transmits an emissary vein passing between the intracranial superior sagittal sinus and the veins of the roof of the nose. At each side of the crista galli are the **nasal slit** for the anterior ethmoidal artery and nerve; the **olfactory foramina** for the filaments of the olfactory bulb; the cranial opening of the **anterior ethmoidal foramen** for the anterior ethmoidal artery and nerve; and the cranial opening of the **posterior ethmoidal foramen** for the posterior ethmoidal artery and nerve. The last two openings are situated at the outer side of the cribriform plate, lateral to the olfactory groove which marks it. Directly beneath each half of the cribriform plate is the corresponding nasal fossa.

Each **lateral portion** of the anterior fossa is irregularly convex, and forms the roof of the orbit. It is formed by the orbital plate of the frontal and the lesser wing of the sphenoid. It is very thin, and, except over the lesser wing of the sphenoid, it presents digitate impressions for the convolutions of the orbital surface of the frontal lobe of the cerebrum, which it supports. The sutures in the anterior fossa are the fronto-ethmoidal, fronto-sphenoidal, and spheno-ethmoidal.

Middle Fossa.—This fossa is on a lower level than the anterior. It is bounded in front by the posterior border of the lesser wing of the sphenoid at either side, and by the limbus sphenoidalis in the centre. Behind, it is limited by the superior border of the petrous portion of the temporal at either side, and by the dorsum sellæ of the sphenoid in the centre. It presents a central and two lateral divisions. The central division is formed by the superior surface of the body of the sphenoid, posterior to the limbus sphenoidalis. Each lateral division, which is much depressed, is formed anteriorly by the superior surface of the greater wing of the sphenoid, laterally by part of the squamous portion of the temporal, and posteriorly by the superior surface of the petrous portion of that bone. It lodges the temporal lobe of the cerebrum, and it presents the following sutures: the spheno-parietal; squamous; squamo-sphenoidal; and petro-sphenoidal.

The **central division** presents the following parts: the **optic groove** and **tuberculum sellæ ;** the **optic foramen** of each side for the optic nerve and ophthalmic artery; the **anterior clinoid process** of each side; the **sella turcica** or **hypophysial fossa** for the hypophysis; the **carotid groove,** at either side of the sella turcica, for the cavernous venous sinus and internal carotid artery, the latter being accompanied by the cavernous sympathetic plexus of nerves, and having the sixth cranial nerve on its outer side; the **middle clinoid process** of each side (sometimes connected with the anterior, which it faces); the **dorsum sellæ ;** the **posterior clinoid process** of each side, at either lateral angle of the dorsum sellæ; and the **groove** for the inferior petrosal sinus, on each side of the dorsum sellæ a little below the posterior clinoid process. The central division corresponds with the interpeduncular region at the base of the cerebrum.

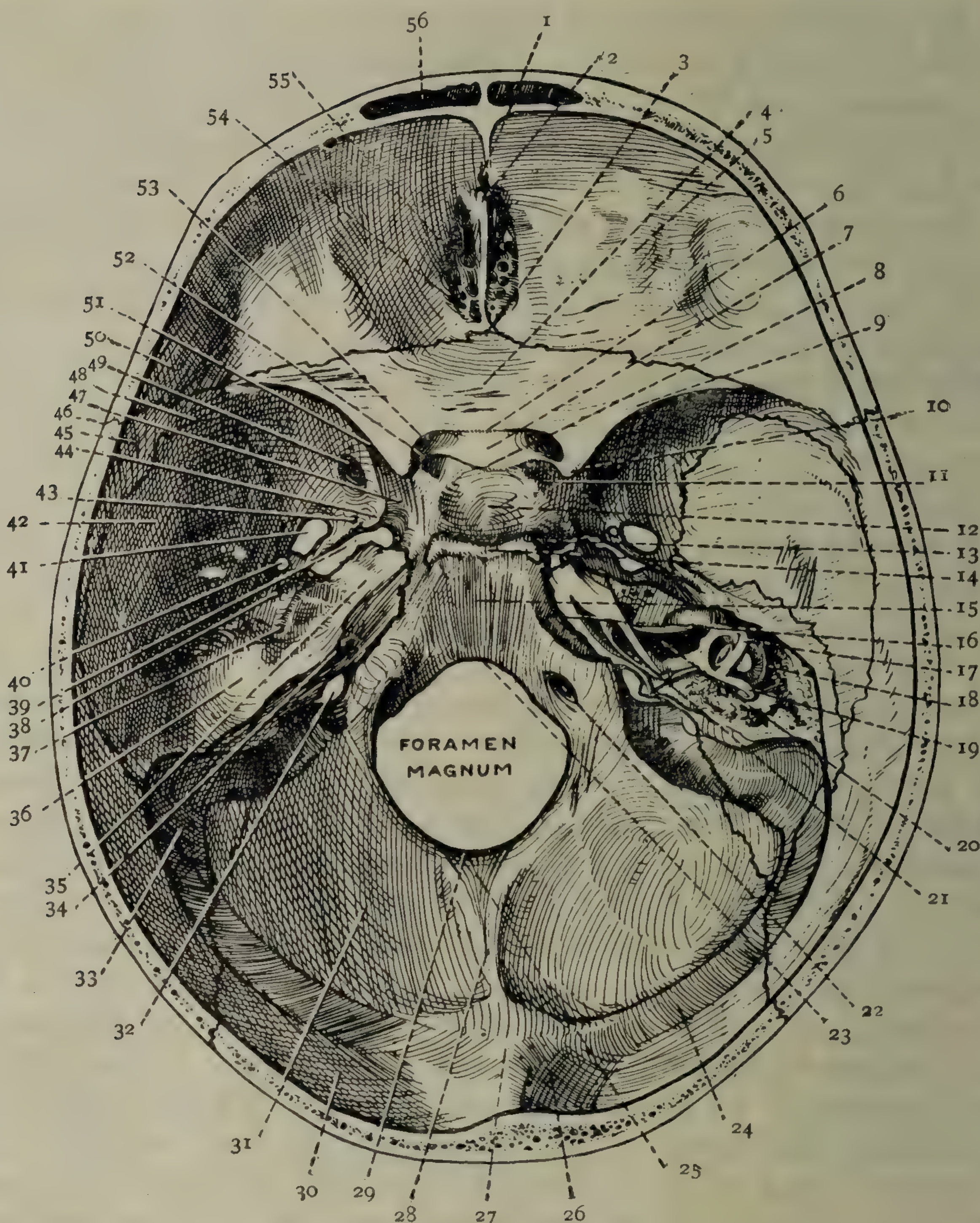


FIG. 164.—THE INTRACRANIAL BASE OF THE SKULL.

The superior surface of the petrous portion of the right temporal bone has been removed to expose the internal auditory meatus and semicircular canals.

1. Foramen Cæcum
2. Crista Galli
3. Ethmoidal Spine of Sphenoid
4. Jugum Sphenoidale
5. Anterior Fossa
6. Limbus Sphenoidalis
7. Optic Groove
8. Tuberculum Sellæ
9. Posterior Border of Lesser Wing of Sphenoid
10. Anterior Clinoid Process
11. Middle Clinoid Process
12. Sella Turcica
13. Posterior Clinoid Process
14. Dorsum Sellæ
15. Clivus
16. Groove for Inf. Petrosal Sinus
17. Superior Semicircular Canal
18. Lateral Semicircular Canal
19. Posterior Semicircular Canal
20. Internal Auditory Meatus (laid open)
21. Opening of Internal Auditory [Meatus
22. Anterior Condylar Canal
23. Basion
24. Groove for Transverse Sinus
25. Vermian Fossa
26. Confluence of the Sinuses
27. Int. Occipital Protuberance
28. Internal Occipital Crest
29. Opisthion
30. Cerebral Fossa
31. Cerebellar Fossa
32. Jugular Foramen
33. Sigmoid Groove
34. Internal Auditory Meatus
35. Trigeminal Impression
36. Arcuate Eminence
37. Hiatus for Greater Superficial Petrosal Nerve
38. Hiatus for Lesser Superficial Petrosal Nerve
39. Foramen Lacerum
40. Foramen Spinosum
41. Foramen Ovale
42. Middle Fossa
43. Emissary Sphenoidal Foramen
44. Lingula of Sphenoid
45. Parietal Bone
46. Coronal Suture
47. Carotid Groove
48. Pterion
49. Foramen Rotundum
50. Orbital Plate of Frontal
51. Superior Orbital Fissure
52. Carotid Notch
53. Optic Foramen
54. Posterior Ethmoidal Foramen
55. Anterior Ethmoidal Foramen
56. Left Frontal Sinus

Each **lateral division** is marked by meningeal grooves and impressions for cerebral gyri, and presents the following openings: the **superior orbital fissure** for the third cranial nerve, the fourth, the three branches of the ophthalmic division of the fifth (namely, frontal, lacrimal, and naso-ciliary), and the sixth cranial nerves, the sympathetic root of the ciliary ganglion, the superior ophthalmic veins, the orbital branch of the middle meningeal artery, and a portion of the dura mater to form the orbital periosteum; the **foramen rotundum,** leading to the pterygo-palatine fossa, and transmitting the maxillary division of the fifth cranial nerve; the **foramen ovale,** leading to the infratemporal fossa, and transmitting the mandibular division and the motor root of the fifth cranial nerve, the accessory meningeal artery, the middle meningeal vein, an emissary vein from the cavernous sinus, and occasionally the lesser superficial petrosal nerve; the **accessory sphenoidal foramen** (inconstant), leading to the scaphoid fossa at the root of the medial pterygoid plate, or to the pterygoid fossa lateral to the scaphoid fossa, and transmitting an emissary vein from the cavernous sinus; the **foramen spinosum,** leading to the infratemporal fossa, and transmitting the middle meningeal artery and the nervus spinosus branch of the mandibular nerve; and the **foramen lacerum,** situated between the basilar process of the occipital, the apex of the petrous portion of the temporal, and the greater wing of the sphenoid near the root of the pterygoid process. The posterior opening of the **pterygoid canal,** which leads to the pterygo-palatine fossa and transmits the nerve and artery of pterygoid canal, is to be found on its anterior wall, while the **carotid canal** for the internal carotid artery, with a plexus of sympathetic nerve fibres, opens on its lateral wall.

The anterior surface of the petrous portion of the temporal presents, in addition to the impressions produced by the overlying convolutions of the temporal lobe of the brain, the following markings: the **trigeminal impression,** near the apex, for the trigeminal ganglion; the **hiatus for greater superficial petrosal nerve,** to which a groove conducts the greater superficial petrosal nerve and the petrosal branch of the middle meningeal artery (within this opening there may be a small one for the external superficial petrosal nerve); the **hiatus for lesser superficial petrosal nerve,** to which a groove conducts the lesser superficial petrosal nerve; the **arcuate eminence,** which coincides with the position of the superior semicircular canal of the internal ear; and the **tegmen tympani.**

Posterior Fossa.—This fossa is on a lower level than the middle. It is limited in front by the dorsum sellæ of the sphenoid in the centre, and the superior border of the petrous portion of the temporal at either side. Behind it is limited by the internal occipital protuberance and the groove at either side for the transverse venous sinus, which groove also marks its lateral extent. It lodges the pons, medulla oblongata, and cerebellum. The bones which form it are as follows: the dorsum sellæ of the sphenoid; the basilar, condylar, and supra-occipital portions of the occipital; the petrous and mastoid portions of the temporal; and the postero-inferior angle of the parietal. It

presents the following sutures: the occipito-mastoid; parieto-mastoid; and petro-basilar. The following parts are to be noted: the **clivus,** the upper part of which lodges the pons and basilar artery, whilst the lower part contains the medulla oblongata; the **foramen magnum,** which transmits the medulla oblongata and its membranes, the accessory nerves, and the vertebral, anterior spinal, and posterior spinal arteries; the **anterior condylar canal,** on either side of the foramen magnum, for the hypoglossal nerve and a meningeal branch of the ascending pharyngeal artery; the **internal occipital crest,** which gives attachment to the falx cerebelli, and is occasionally grooved for the occipital venous sinus (near the foramen magnum this crest presents the **vermian fossa,** which receives a part of the vermiform process of the cerebellum); the **cerebellar fossæ,** which lodge the hemispheres of the cerebellum; the opening of the **internal auditory meatus,** on the posterior surface of the petrous portion of the temporal, for the motor and sensory roots of the facial nerve and the auditory nerve, and the internal auditory artery; the **aqueduct of vestibule,** about $\frac{1}{4}$ inch lateral to the preceding, for a small artery and vein, and the endolymphatic duct, the **subarcuate fossa,** representing the parafloccular fossa of early life, situated close to the superior border of the petrous portion, about midway between the opening of the internal auditory meatus and aqueduct of vestibule; and the **jugular foramen,** between the jugular process of the occipital and petrous portion of the temporal.

The **jugular foramen** is divided into three compartments, which lie obliquely from behind forwards and inwards. The postero-lateral compartment transmits the transverse venous sinus to become the internal jugular vein, and a meningeal branch of the ascending pharyngeal artery; the middle compartment transmits the glosso-pharyngeal, vagus, and accessory nerves; and the antero-medial compartment gives passage to the inferior petrosal venous sinus. The antero-medial compartment may be more or less completely isolated by means of the intrajugular process passing between the occipital and the petrous portion of the temporal.

The posterior fossa is grooved by the following venous sinuses: the transverse sinus, which extends from the internal occipital protuberance to the jugular foramen, grooving in its sinuous course the squamous part of the occipital, the postero-inferior angle of the parietal, the mastoid portion of the temporal, and the jugular process of the occipital (opening from which there is usually the mastoid foramen, and occasionally the posterior condylar canal); in its descending course it is often spoken of as the sigmoid sinus, and it is worth noticing that a hole drilled from outside the skull, 1 inch behind the middle of the top of the external auditory meatus, will just strike the groove for the sinus as it is making its turn downward; the superior petrosal sinus, which grooves the superior border of the petrous bone; the inferior petrosal sinus, along the course of the petro-basilar suture; and the occipital sinus, which sometimes grooves the internal occipital crest.

Sutural Bones.

The **sutural bones** (originally named after Wormius) are accessory bones which are frequently met with in the course of the cranial sutures, and occasionally in the face, as in the region of the lacrimal bones, and at the outer extremity of each inferior orbital fissure. From their position in the course of sutures they are known as *ossa suturarum.* They are for the most part of small size and triangular outline, and are hence sometimes spoken of as *ossa triquetra.* They are usually due to the appearance of special ossific centres. Their most common situation is along the course of the lambdoid suture, where they may form a regular chain. The superior angle of the occipital sometimes persists as a sutural bone, called **pre-interparietal,** which may be double. One is often found between the antero-inferior angle of the parietal and greater wing of the sphenoid in the region of the pterion, and it is known as the **epipteric bone.** If the metopic or frontal suture is persistent, one or more sutural bones may be present along its course, and if at the upper part, they may give rise by their persistence and union to a **bregmatic bone.** In the condition known as chronic hydrocephalus sutural bones of large size are present in great numbers along the cranial sutures.

The Skull at Birth.

The skull at birth is remarkable for its large size, and for the great development of the cranium as compared with the face. The face is equal to one-eighth of the cranium, whereas in the adult it is equal to one-half. The occipital, parietal, and frontal regions are well developed, the parietal and frontal eminences are very conspicuous, and the mastoid processes are absent. The bones are not united by sutures, but are connected by fibrous tissue, continuous with the periosteum externally and dura mater internally. Membranous intervals exist between the angles of certain bones, these being called **fontanelles,** from the pulsation, or welling-up sensation, which can be felt there. They are six in number, two being placed in the median line, anterior and posterior, and two at either side, antero-lateral and postero-lateral. The **anterior fontanelle** is situated between the antero-superior angles of the parietals and the superior angles of the two halves of the frontal. It is large and diamond-shaped, and it is

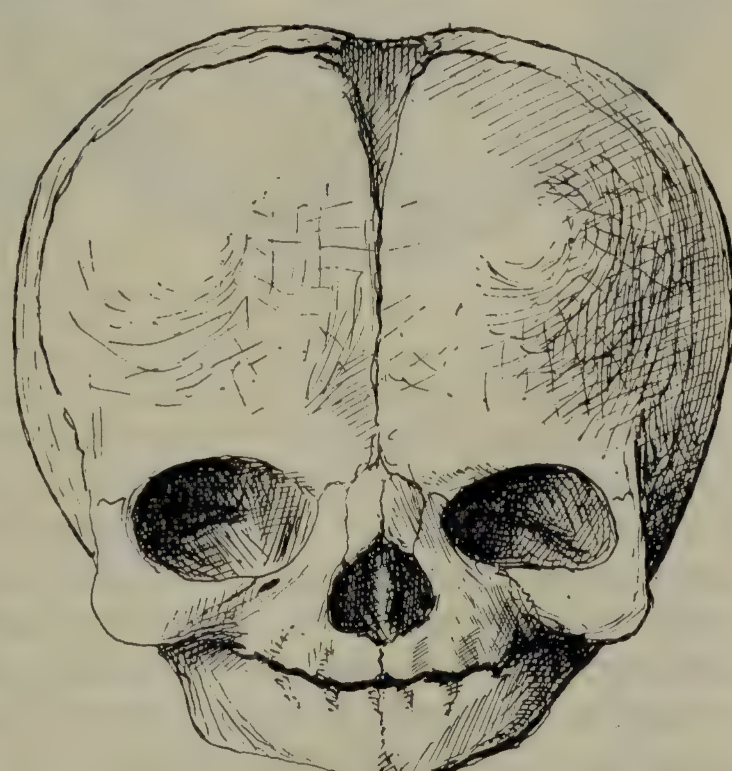


Fig. 165.—Skull at Birth (Anterior Aspect).

not completely closed, as a rule, until towards the end of the second year. The **posterior fontanelle** is situated between the postero-superior angles of the parietals and the superior angle of the occipital. It is small and triangular, and is usually closed at, or shortly after, birth, but the surrounding bones are still movable. The antero-lateral and postero-lateral fontanelles correspond with these angles of the parietal. The **antero-lateral** is situated between the parietal, sphenoid, frontal, and squamous portion of the temporal, whilst the **postero-lateral** is situated between the parietal, occipital, and mastoid portion of the temporal. For the **sagittal fontanelle** of the earlier part of fœtal life, see Parietal Bone.

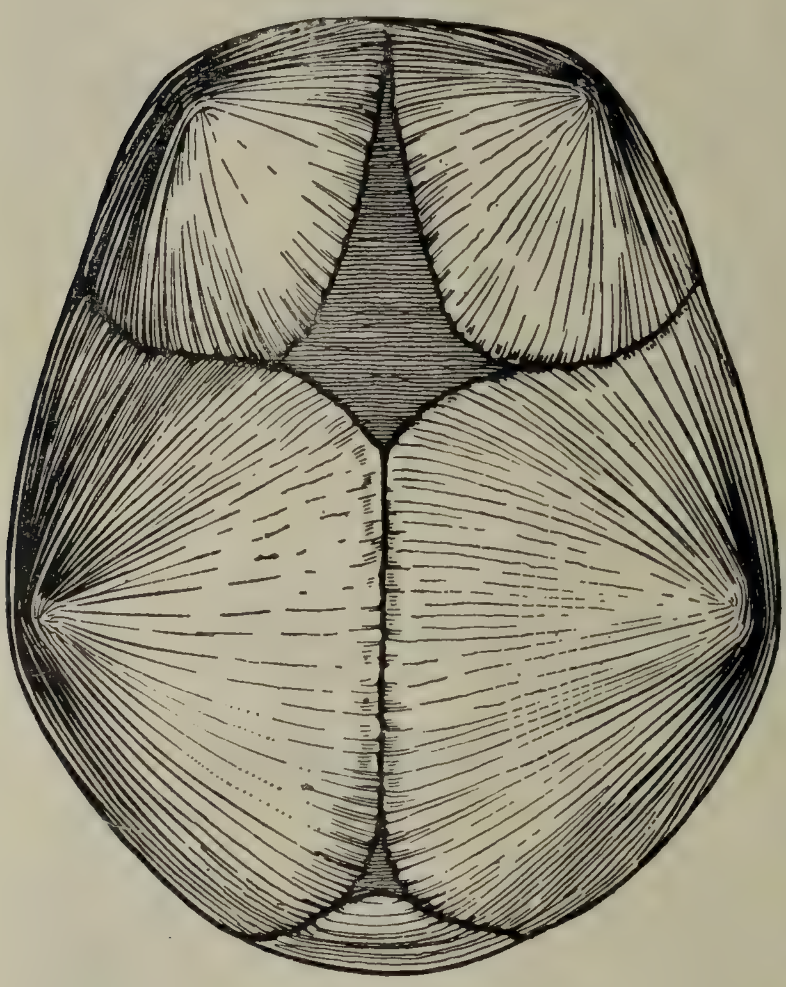


Fig. 166.—The Skull at Birth, showing the Anterior and Posterior Fontanelles, and the Parietal Eminences.

The facial appearances in the fœtal skull are the results of the conditions of the upper and lower jaws, and of the rudimentary teeth carried by them: these last are within the jaws, so that their height (when erupted) is lost to the face. The maxillæ are flattened, the maxillary sinus being present only as a very small cavity near the mesial part of the body of the bone. It follows from this that the palate level is not much below that of the orbital floor, and the lower part of the nasal cavity on each side is small. The ethmoidal portion of the cavity, on the other hand, is of proper proportionate size. Associated with the maxillary condition is a low height for the perpendicular part of the palatine bone, and for the vomer. The mandible does not possess a definite angle, and is in two halves, meeting at the symphysis. The maxillary height increases markedly with the temporary dentition, and especially with the permanent dentition; the increase is associated with growth of the sinus and eruption of teeth, lowering of the level of the nasal floor, with relative increase in nasal height, growth in depth of palatine and vomer, and a more oblique plane of the posterior nasal openings.

The lateral aspect of the fœtal skull shows the maxillary and mandibular conditions mentioned above, the low level of the zygomatic bone and arch being associated with these. In addition the temporal bone is seen to possess neither mastoid process nor tympanic part: this latter plate is represented here by a ring, to which the membrane

s attached. The absence of a mastoid process leads to the exposure n the lateral aspect of the digastric groove and the foramen for the xit of the facial nerve. The process begins to project during the econd year: the tympanic ring begins its extension into a 'plate' luring the first year.

The tympanic membrane, being attached to a ring, with no proection of bone from this, is therefore visible on the side of the skull. t must not be imagined, however, that it is visible in that way in the omplete head, for the external auditory meatus is as long proporionately in the child as in the grown-up person: it is only in the *bony* art of its floor that it is deficient.

The skull increases rapidly in size during the first six years, and further marked increase commences on the approach of puberty, vhich is associated with the development of the cranal air sinuses.

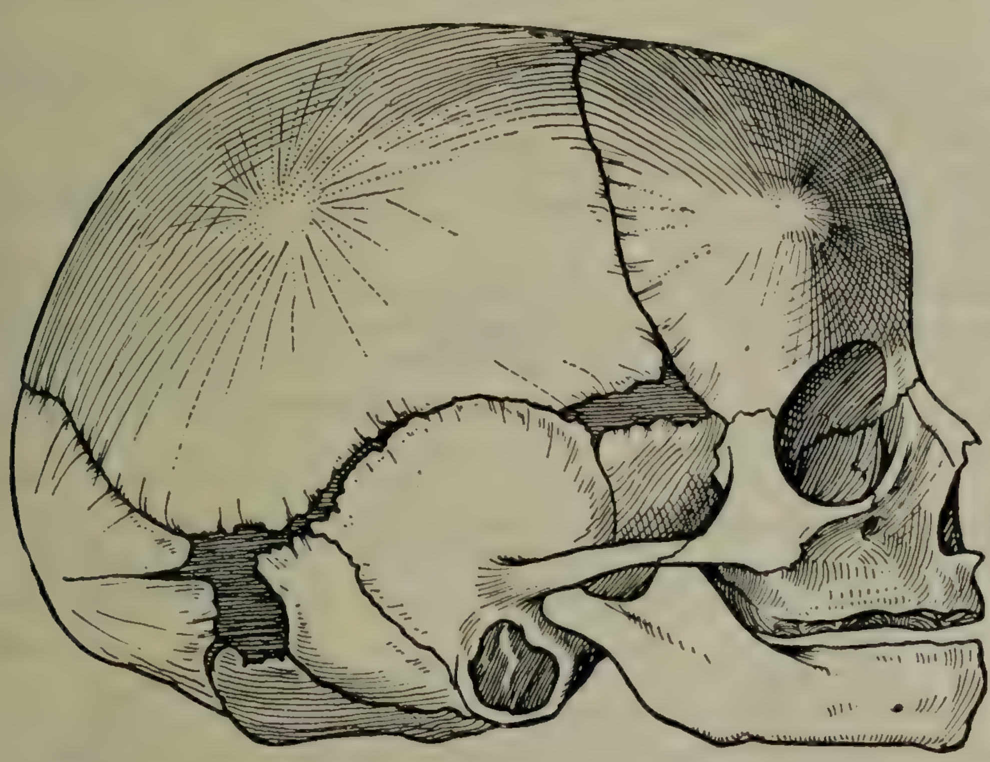


FIG. 167.—THE SKULL AT BIRTH, SHOWING THE ANTERO-LATERAL AND POSTERO-LATERAL FONTANELLES.

'he latter increase affects chiefly the frontal and facial regions. In ld age the cranial bones become thinner, the cranial air sinuses undergo nlargement, and the sutures show indications of obliteration.

Characters of the Female Skull.—The skull is smaller, smoother, nd lighter than in the male, the bones are not so thick, the external ccipital protuberance, mastoid processes, and supra-orbital processes re feebly developed. The frontal eminences, on the other hand, re often better developed than in the male, and the orbital openings ess compressed from above downward. The teeth, jaws, and chin re slighter, and in individuals of the same race the female skull is vider in comparison with its length—*i.e.*, more brachycephalic—than ne male. In spite of these differences there is reason to believe that ne most experienced craniologists can only determine the sex of bout seven out of ten skulls with certainty, because before puberty

differentiation has hardly occurred; while, after the menopause, female skulls tend to assume the male characteristics. For this reason it is very important to take the age into account in determining sex.

Racial Peculiarities of the Skull.

In comparing the skulls of different races, attention has to be directed to the following points: the capacity of the cranium, its circumference, its relative length, breadth, and height; the degree of forward elongation of the jaws; and the shape of the anterior nasal and orbital apertures. The **cranial capacity** may be ascertained by filling the skull with shot, or various kinds of seeds, and then measuring the contents in a graduated vessel. The capacity ranges from about 1,200 to 1,600 c.c., and, according to their capacity, skulls are divided into three groups: **macrocephalic,** with a capacity exceeding 1,450 c.c., as in Europeans; **microcephalic,** with a capacity under 1,350 c.c., as in Australians; and **mesocephalic,** between 1,350 and 1,450 c.c., as in Chinese.

In regard to craniometry, the following craniometrical terms may here be summarized:

Alveolar point=the point of meeting of the anterior margins of the alveolar borders of the maxillæ.

Antinion=the most prominent point of the glabella.

Asterion=the point where the parieto-mastoid, occipito-mastoid, and lambdoid sutures meet.

Auricular point=the centre of the opening of the external auditory meatus.

Basion=the centre of the anterior margin of the foramen magnum.

Bregma=the point of junction of the sagittal and coronal sutures.

Dachryon=the point where the horizontal fronto-maxillary suture meets the vertical lacrimo-maxillary suture.

Entomion=the point near the anterior part of the parieto-mastoid suture, where a process of the parietal is received into the parietal notch of the mastoid

Glabella=a point midway between the superciliary arch of the frontal.

Gnathion, or **mental point**=the middle point of the anterior lip of the lower border of the mandible.

Gonion=the outer side of the angle of the mandible.

Inion=the external occipital protuberance.

Jugal point=a point situated at the angle which the posterior border of the frontal process of the zygomatic forms with the superior border of its temporal process.

Lambda=the meeting of the sagittal and lambdoid sutures.

Nasion, or **nasal point**=the meeting of the two fronto-nasal sutures.

Obelion=the point where the horizontal line connecting the parietal foramina intersects the sagittal suture.

Occipital point=the part of the occipital in the median plane at the greatest distance from the glabella.

Ophryon=the centre of a line drawn from one temporal line to the other across the narrowest part of the frontal region.

Opisthion=the centre of the posterior margin of the foramen magnum.

Pterion=the region of the spheno-parietal suture.

Rhinion=the lower part of the internasal suture.

Stephanion=the point where the superior temporal line crosses the coronal suture.

Subnasal point=the centre of the base of the anterior nasal spine.

The **horizontal circumference** of the cranium represents the measurement at the level of a plane passing through the most prominent part of the glabella in front, the pterion laterally, and the occipital point behind.

The greatest **length** represents the measurement from the most prominent

part of the glabella to the occipital point. The greatest **breadth** represents the transverse measurement, but it should be indicated whether this happens to be biparietal or bisquamous. The proportion of greatest breadth to greatest length is the index of breadth, or **cranial index.** In civilized races about 190 mm. represents an average length, and about 148 mm. an average breadth. According to their cranial index, skulls are arranged in three classes—namely, **brachycephalic** (broad and short), with a cephalic index over 80, as in mid-Europeans (Alpine race); **mesaticephalic** (intermediate), with an index of 75 to 80, as in Northern and Southern Europeans and Chinese; and **dolicocephalic** (long and narrow), with a cephalic index below 75, as in Anglo-Saxons and most Africans.

The **height** of the skull represents the measurement from the basion to the bregma, and its proportion to the length is the index of height, or **vertical index.** Its average in civilized races corresponds with the breadth. Since it is obviously impossible to take this measurement in the living, modern craniologists replace it by, or supplement it with, the biauricular height, which, unfortunately, needs a special craniometer.

The **longitudinal arc** of the skull represents the measurement from the nasion to the opisthion carried over the roof, and the basi-nasal length represents the measurement from the basion to the nasion. These two measurements, plus the distance between the basion and the opisthion, represent the vertical circumference of the cranium in the median plane. The degree of projection of the jaws is ascertained from the **gnathic** or **alveolar index.** This index represents the proportion of the basi-alveolar length to the basi-nasal. According to the gnathic index, skulls are arranged in three classes—namely, **orthognathous** (straight and upright jaw), with a gnathic index below 98, as in Europeans; **mesognathous** (intermediate in character), with an index of from 98 to 103, as in Chinese and Japanese; and **prognathous** (projecting jaw), with an index over 103, as in Australians.

Here, again, any comparison between the living head and the dry skull is impossible, and in order to meet this, the auricular point is often substituted for the basion.

The form of the **anterior nasal aperture** is ascertained from the **nasal index.** This represents the proportion of the greatest transverse measurement of the aperture to the height, which latter is the measurement from the nasion to the subnasal point. According to their nasal index, skulls are arranged in three classes—namely, **leptorhine** (narrow nose), with a nasal index below 48, as in Europeans; **mesorhine** (intermediate nose), with an index of from 48 to 53, as in Chinese and Japanese; and **platyrhine** (broad nose), with an index above 53, as in Australians and Kaffirs.

The form of the **orbital aperture** is ascertained from the **orbital index,** which represents the proportion of the height to the width of the orbital aperture. There are three varieties of orbital index—namely, **megaseme** (high index), when it exceeds 89, as in the Chinese; **mesoseme** (intermediate index), when it is between 89 and 84, as in Europeans; and **microseme** (low index), when it is below 84, as in Australians.

Many modern craniologists are not at all satisfied with the value of orbital and nasal indices, and consider that much more information can be obtained from the average of the actual heights and widths. The whole subject of scientific craniology is at present in its infancy, and many factors, such as the range of variation, which cannot be discussed here, have to be taken into account. It should be realized that the most expert craniologist can only occasionally determine the race to which a special skull belongs.

Deformities of the Skull.

The most common cause of cranial deformities is premature synostosis or osseous union of bones which are normally separate, the result being closure or obliteration of certain sutures. When the sagittal suture becomes prematurely obliterated transverse growth is arrested, and, to compensate for this,

increased growth takes place at the coronal and lambdoid sutures. The antero-posterior diameter of the cranium is greatly increased, and the vault assumes a boat-like shape. This variety is known as **scaphocephaly.** When the coronal suture becomes prematurely obliterated, increased growth takes place upwards, and the vertical diameter is greatly increased. This variety is known as **acrocephaly** (pointed head). When *one-half* of the coronal or lambdoid suture becomes prematurely obliterated, oblique deformity takes place, this form being known as **plagiocephaly** (oblique or awry head). When the metopic or frontal suture becomes prematurely obliterated, growth is arrested in the frontal region, and the skull assumes a triangular shape. This variety is known as **trigonocephaly.** When premature obliteration of the sutures at the base of the skull takes place, the deformity known as **cretin skull** results. This is characterized by enlargement of the cranium (except in the occipital region), which becomes very heavy, and assumes an irregular, somewhat conical shape, with the apex at the sagittal suture. It is associated with mental dulness, idiocy, and stunted growth, and the general condition is known as **cretinism.**

When the occipital region bulges markedly the condition is known as **bathrocephaly.** The above description is based on observations of the developing skulls.

Development of Skull.

For purposes of description the skull is divided into *cranial* and *facial* parts. This division also corresponds in a general way with differences in developmental origin, the cranial skeleton being formed in the *paraxial* mesoderm, while the facial skeleton develops in mesoderm derived from the *visceral* arch structures. The developmental and descriptive divisions do not quite correspond, however, as will become apparent.

A. Cranial Development.

This can be divided into *membranous*, *cartilaginous*, and *bony* stages.

1. **Membranous.**—The hind-brain is surrounded by paraxial mesoderm, and this layer, carried forward round the mid-brain and the projecting fore-brain, forms their immediate covering. The membranes of the brain are developed from the *deeper* parts of this layer.

2. **Cartilaginous.**—The paraxial covering begins to show points of chondrification during the fifth week; these points are only in its lower part on the ventral surface of the brain. Formation of actual embryonic cartilage is, of course, a later occurrence, and the condition in the fifth week is really one of development of ' prechondral ' centres. From these points the central basal cartilage is formed.

The relation of the notochord to the base of the skull varies in different animals. In man it lies below the basis cranii, in relation with the pharynx, turning up to enter the postsphenoid region just behind the hypophysial fossa, where it ends. The cartilaginous base, however, although it lies above the notochord, can be quite properly termed ' parachordal.'

The **cartilaginous basis cranii,** developed from these beginnings in the paraxial mesoderm, has certain definite original regions, the arrangement of which can be understood best by gaining a preliminary acquaintance with those seen in a primitive skull. A general scheme of such

primitive chondro-cranial structure is given in Fig. 168, showing two stages. In the first the notochord, placed centrally, extends forward as far as the *pituitary* or *hypophysial space*, occupied by the infundibular growth from the fore-brain. On each side of the notochord are cartilaginous plates—hence termed *parachordal* plates. Two cartilaginous bars extend forward, on each side of the pituitary space, from the notochord area: these bars are therefore *prechordal*. Thus the middle part of the cartilaginous base is made up of a parachordal part (behind the hypophysial space) and a prechordal part (in front of the space). But the chondrification of these areas does not extend very far laterally, and here we find on each side the organs of special sense, embedded

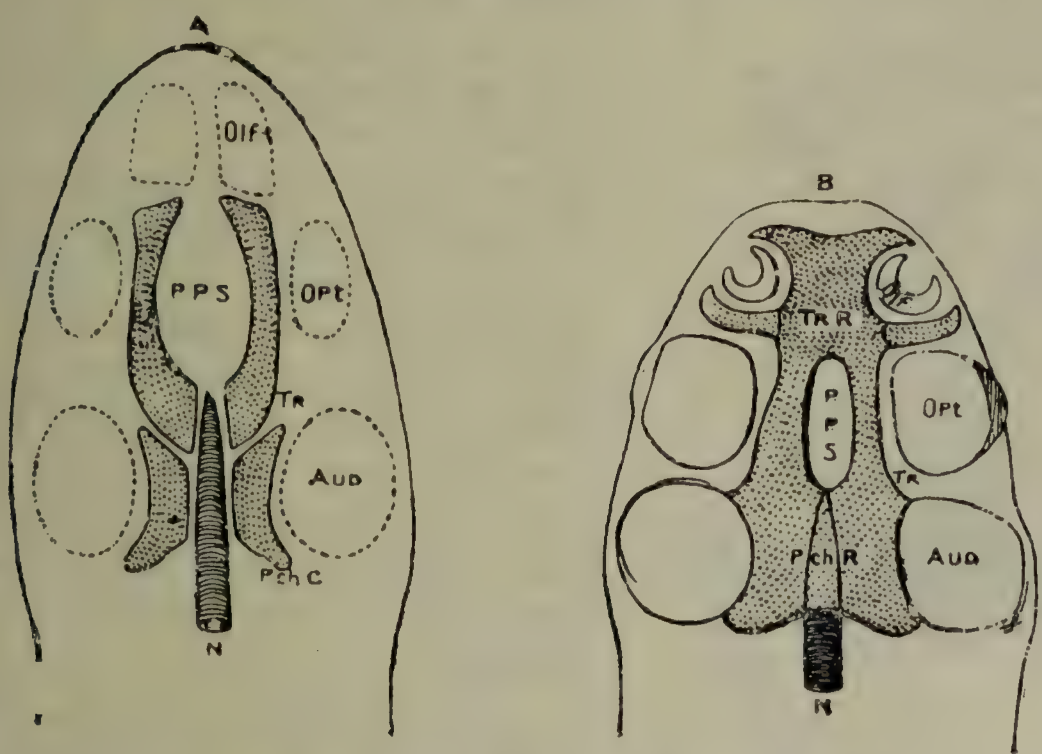


FIG. 168.—DIAGRAMS OF THE PRIMITIVE CARTILAGINOUS CRANIUM (WIEDERSHEIM).

A. First Stage.—N, notochord; PchC, parachordal cartilage; Tr, prechordal cartilage; PPS, primitive hypophysial space; Olf, Opt, Aud, positions of organs of smell, sight, and hearing.

B. Second Stage.—N, notochord; PchR, parachordal region (basilar plate); TrR, fusion of prechordal cartilages; PPS, primitive hypophysial space; TrR, prechordal region; Olf, Opt, Aud, as in A.

in paraxial mesoderm: the *auditory organ* on each side lies beside the parachordal cartilage, the *eye* beside the prechordal bar, and the *olfactory organ* in antero-lateral relation to the same bar.

In the second stage shown in the figure the parachordal and prechordal cartilages have united into a continuous plate, pierced by the hypophysial foramen anterior to the end of the notochord. In addition there are indications of cartilaginous formations associated with the special sense capsules: in the olfactory region, for example, the prechordal plate is prolonged forward between the two organs, and a cartilaginous process ‘ walls in ’ the organ on each side, separating it from the eye—thus showing that each region is enclosed in a cartilaginous ‘ olfactory capsule.’ A capsule is also formed for the eye, but

the immediate surrounding of the globe could not be fixed to the cartilaginous base, and is therefore a variable constituent of the wall of the globe: yet there is a process of cartilage (not shown in figure) which projects (*ala orbitalis*) from the hinder part of each prechordal cartilage, passing out behind the eye. The auditory organ is surrounded rapidly by cartilage, forming the *otic capsule,* which lies thus lateral to the parachordal plate: the two otic capsules quickly fuse with this plate, thus fixing the basal 'floor' with the 'lateral wall,' to which they belong primitively.

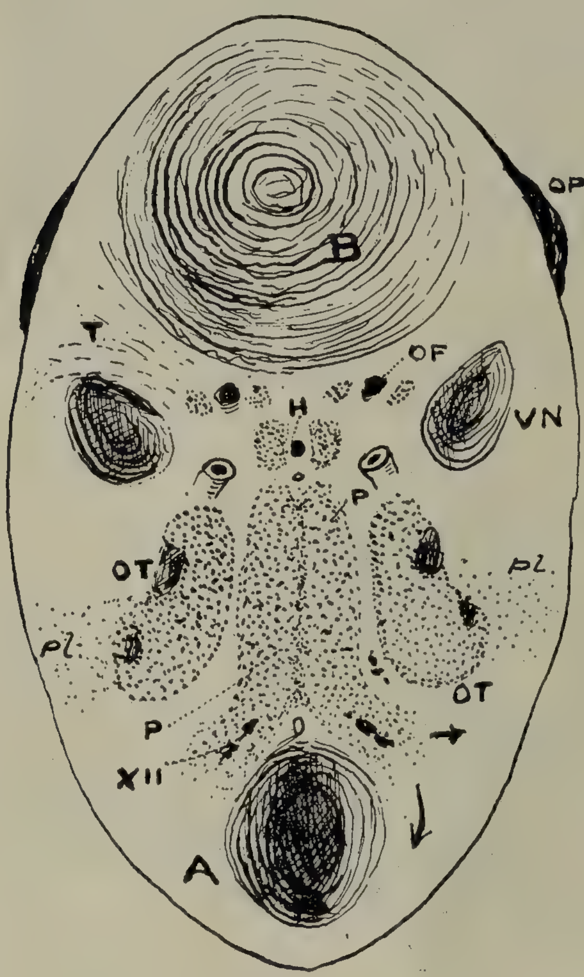


FIG. 169.—PLAN TO SHOW THE CONSTITUENT PARTS OF THE CRANIAL BASE, AS SEEN WHEN CHONDRIFICATION IS BEGINNING AT 13 TO 14 MM.

A, spinal foramen; B, occupied by fore-brain; VN, trigeminal ganglion embedded in parax. mesod.; H, hypophysial foramen; OF, optic foramen; OT, otocyst; P, parachordal cartilage; XII, hypoglossal; *pl.pl.*, parietal plate of cartilage extending from otic capsule.

In the highest form of the skull the orbits come to look more forward than laterally, while the nasal cavities are more apically placed. Thus an interval occurs between the orbit (ala orbitalis) in front, and the otic capsule behind, and in this interval a new (visceral) bone, the ala temporalis of the mammalian skull, is inserted: it has no cartilaginous precursor in its greater part, so that the chondro-cranium in such skulls shows an angled interval between the ala orbitalis and the otic capsule.

If the conditions in the human embryo, at the time that the chondrific changes are beginning to appear, are compared with this general primitive state, the corresponding arrangement of the parts becomes evident. Fig. 169 gives a plan of these as they would be in an embryo between 13 and 14 mm. in length, when the prechondral changes in the paraxial mesoderm are beginning to appear: it shows the position of the formations in the base of the cranial cavity, the spinal cord leaving that cavity through A, while the down-turned fore-brain occupies the hollow B. The hypophysial canal is shown as a small black spot (H) a little distance behind the recess for the fore-brain. Between this and the spinal orifice the parachordal bars (P) are seen: they are evidently paired in formation, but will fuse quickly into a simple *parachordal plate.* The otic capsules (OT) are seen on each side of this, distinct from it, and the internal carotids are seen turning upwards in front of the capsules to enter the cranial cavity.

This is the spot where the artery always enters the vertebrate skull: it pierces the dura mater a little in front of this.

Observe that the parachordal bars are beginning to extend backwards and laterally, as shown by the arrows: this extension is laying the foundation of the *exoccipital* and *post-occipital*. The extension in the figure is pierced by the hypoglossal nerve (XII), and it is likely that there is a separate chondral centre for that part lying between the nerve and the margin of the aperture.

Two short 'sphenoidal bars' have the hypophysial foramen between them, and are evidently representatives of the prechordal bars or of parts of these. They will join quickly and in their subsequent growth will occlude the passage between them.

In front of these and lateral to them are, on each side, two small chondral centres, medial and lateral to the optic foramina (OF). These small chondrifications join round the foramen, extend medially to become confluent with the enlarging 'prechordal' cartilages, and extend gradually laterally into the ridge of tissue (T) which bounds the recess B postero-laterally. This is the *ala orbitalis*, which has thus become an extension outwards from the prechordal cartilage. Observe that the eye is much farther forward: it is partly seen (OPT) projecting on the surface. The angle previously mentioned is therefore already well marked, between the ala orbitalis and the otocyst, and shows a deep depression or sac (VN) which contains the trigeminal ganglion.

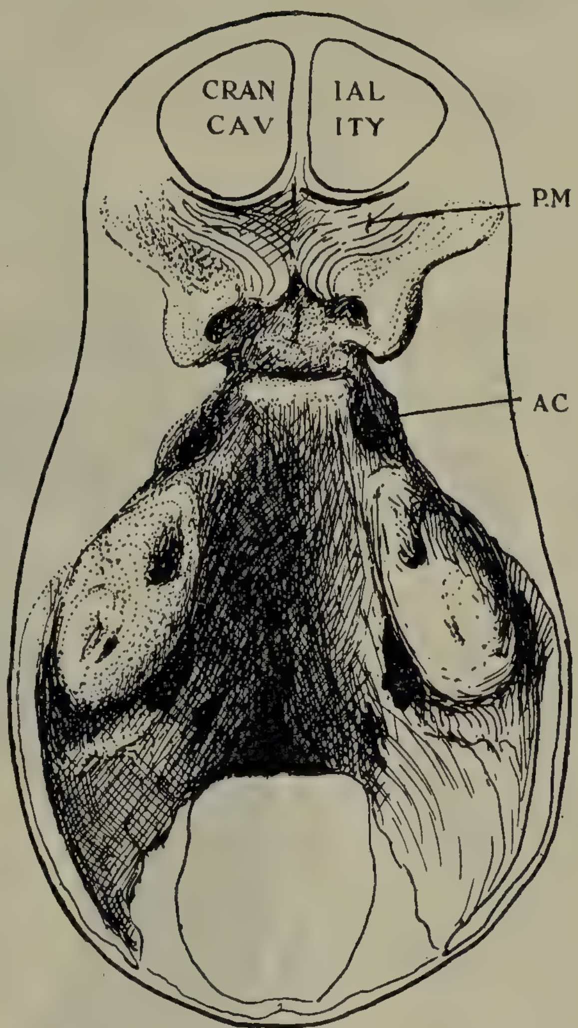


Fig. 170.—Cartilaginous Base of Cranium of an Embryo of 18 Mm.

PM, paraxial mesoderm underlying front parts of cerebral vesicles; AC, alicochlear commissure.

The comparison with the primitive type of Fig. 168 has not presented any difficulty so far, but the formation of the floor of the recess B, and its relation to the type, are not so straightforward. At this stage there is no chondral formation in front of the ala orbitalis, so it is not necessary to consider it, and it will be more conveniently dealt with at a later period.

The prominent curved ridge (T) into which the ala orbitalis extends is placed between the fore-brain and mid-brain, so that its free border points toward the mid-brain flexure. The ala orbitalis lies in the anterior part of its base: the greater part of the remainder becomes the tentorium cerebelli. As the cerebral vesicles grow back, and the hind-brain is closely flexed, the fold (free except where the ala orbitalis holds it) is carried back below its vesicle, covering the

trigeminal ganglion and the dorsal aspect of the otic capsule, and thus coming into position.

The distinct parts of the early chondrification quickly join to form a continuous base, as seen in Fig. 170. The backward growths from the parachordal plate have not met behind, but have practically completed their exoccipital part.

The paraxial mesoderm in which the olfactory region and the eye are embedded has no chondral formation in the early stages. It lies in front of the alæ orbitales, is at first a very thin layer, but deepens

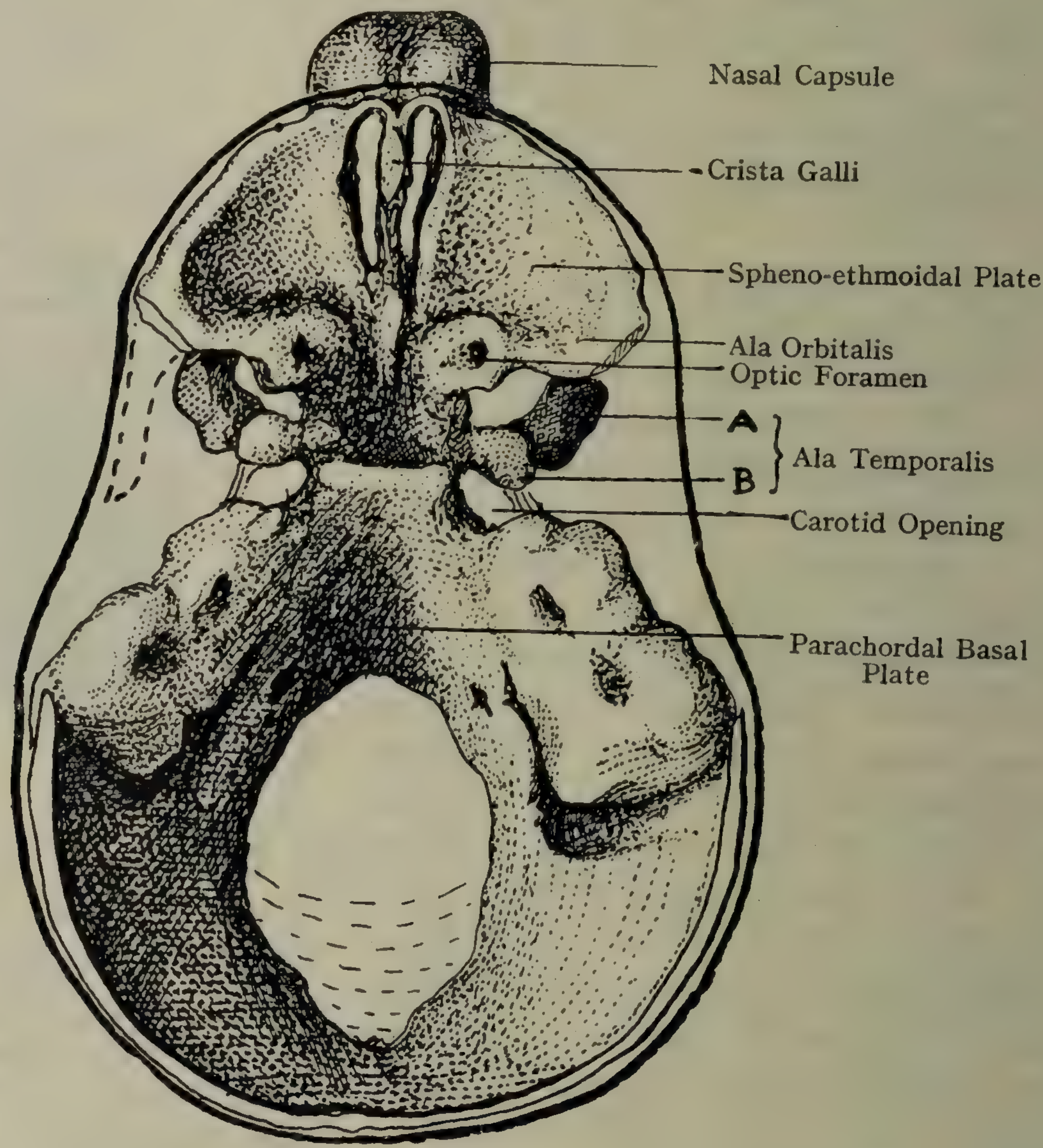


FIG. 171.—CARTILAGINOUS BASIS CRANII OF EMBRYO OF 35 MM.
A, the visceral, and B, the paraxial, portions of the cartilaginous alisphenoidal projection.

relatively quickly, as may be seen in studying the development of the nasal fossæ (p. 85).

The mesoderm (below the fore-brain) which makes the fronto-nasal process is directly continuous with that round the hypophysial region, so that, when this fronto-nasal mesoderm thickens, its condensation and subsequent chondrification is continuous with the presphenoidal cartilage. The median continuation forward of the basal cartilage made in this way is the cartilaginous skeleton of the *nasal septum*, and the nasal fossæ grow upwards and backwards beside this. When they

reach the limit of their extension, their upper parts are immediately in front of, and flush with, the roots of the orbito-sphenoidal processes. The front portion of the chondro-cranium is now formed by the completion of the upper part of the nasal capsule, its fusion with the presphenoidal region behind, and with the orbital process postero-laterally through the medium of a broad *spheno-ethmoidal plate* of cartilage.

About the same time the visceral *ala temporalis* comes into position in front of the otic capsule. Its inner part is cartilaginous, and is attached to the post-sphenoid; its greater part is membranous.

The chondro-cranium, made up in this way, is well formed in the third month, presenting the appearance shown in Fig. 171.

Parts of the Chondro-cranium and their Ultimate Fate.

The parachordal basal cartilage lies between the two otic capsules, by subsequent ossification giving rise to the *basi-occipital.* It extends dorso-laterally, giving origin to the *exoccipital* and *supra-occipital;* the last is in two parts or halves, which pass round the neural axis and meet on its dorsal side, making that part of the occipital which is below the protuberance and upper nuchal lines. The hypoglossal nerve passes through the cartilage where the exoccipital extension arises.

The otic capsule is on each side, beside the basal plate. Nerves and vessels pass between it and the plate, but it establishes continuity with it round these structures. Its antero-medial extremity becomes fused with the basisphenoidal cartilage directly, and, farther out, more indirectly through the medium of a temporary commissure (alicochlear commissure), which connects it with a short alisphenoidal extension from the basisphenoidal region; this encloses a foramen through which the carotid artery passes. The greater part of this cartilaginous otic capsule forms the *petro-mastoid.*

In the central or sphenoidal region of the basal cartilage, although the plate is continuous throughout, it is nevertheless convenient to distinguish a basisphenoidal and a presphenoidal part. The former shows a ridge, the *dorsum sellæ.* The *hypophysial fossa* is in front of this, with *middle clinoid* prominences on each side of it, and the ali-sphenoidal projection already mentioned is continuous with the side of this part of the sphenoidal region (B, Fig. 171). The presphenoid shows the *orbito-sphenoidal processes* projecting from its upper lateral aspects, pierced at their bases by the optic foramina. These are curved plates of cartilage, supporting the cerebral vesicles, and continuous in front with the outer walls of the nasal capsule by means of the spheno-ethmoidal plate; this plate is a further chondrification of the paraxial mesoderm underlying the cerebral vesicles (Fig. 170) with which the mesodermal walls of the nasal capsule are continuous. When ossification occurs, the *frontal bone* is formed in membrane below the spheno-ethmoidal plate, the *inner part of the orbito-sphenoid* is ossified, and the remaining part, with the plate, disappears.

There is a cartilaginous backward prolongation from the outer end of the orbito-sphenoid, variable in extent. It is not shown in the figure, but its position is indicated on the left side by interrupted lines. It seems to be the remnant of a ‘ parietal plate ’ of cartilage connecting the orbito-sphenoid with a broad parietal plate which is attached (Fig. 169) to the outer part of the otic capsule, but which, being at a higher level than the plane of section in the drawing, is not shown in Fig. 171. This incomplete backward extension makes the outer boundary of a triangular interval behind the orbito-sphenoid, in which the *cartilaginous* rudiments of the *greater wing* of the sphenoid are seen. These rudiments consist, on each side, of two cartilaginous structures, distinct in their origins: (*a*) An inner paraxial portion extending out from the basisphenoidal cartilage, and affording the commissure with the otic capsule; this part becomes the *lingula*; (*b*) a larger outer portion, at a lower level, derived from visceral (maxillary) mesoderm, and secondarily attached to the first part; this makes the *inner part of the greater wing* and the *root of the lateral pterygoid plate.*

The *pterygoid hamulus* of the inner plate is preformed in *cartilage.*

Meckel's cartilage and Reichert's bar, of visceral origin, form part of the chondro-cranium. The first has its ventral end involved in the ossification of the *mandible,* its dorsal end forms the *malleus* and *incus,* while the remaining or intermediate part disappears. Reichert's cartilage, having separated off the *stapedial* rudiment from its dorsal end, becomes attached to the otic capsule, where it forms the *tympano-hyal*; it makes the *styloid* process below this, and the stylo-hyoid ligament and small cornu of the hyoid bone at a lower level.

The cartilaginous olfactory capsule is open below and above, but the upper opening is partly bridged across, at a later date, round the fibres of the olfactory nerves. It consists of a median septum and two lateral walls. The cartilaginous septum is continuous above and behind with the presphenoidal cartilage. Its upper and back part ossifies as the *perpendicular plate of the ethmoid,* the remainder forming the main septal cartilage. Each lateral sheet forms the *orbital plate* in its upper part, remaining cartilaginous below this until it disappears; the lower and front portion of this sheet constitutes the basal part of the *inferior nasal concha* in its anterior part. The other nasal conchæ and sinus walls are formed as secondary structures on the inner aspect of the lateral plate. The upper and back extremity of the capsule is in the form of a cup-like recess, and the *sphenoidal concha* is developed from this.

The upper surface of the brain is covered by mesoderm in which bones are developed *in membrane.* Certain broken bands of cartilage, however, are found running across this region in its posterior part, just above the supra-occipital region. These are known as ‘ tecta,’ and may be remnants of a more extensive cartilaginous cranium. They are covered by the membrane bones, and disappear early in fœtal life.

3. **Osseous Stage.**—The general formation of bones corresponding with the cartilage has just been described, and the details of ossification are given under the individual bones.

B. **Facial Skeleton.**

With the exception of Meckel's cartilage, which has already been described, the skeleton of the face is not preformed in cartilage, although it is in many places applied to the cartilaginous substratum of the chondro-cranium.

The *frontal bone* has been seen already to be formed in membrane on the orbital surface of the spheno-ethmoidal plate, its facial portion extending upward in front of the margin of this plate.

The *lacrimal* and *nasal* bones, and probably also the frontal process of the maxilla, are formed in the mesoderm covering the anterior and upper, unossified, parts of the nasal capsule. The *frontal process* of the *maxilla* appears to incorporate with it in its growth a small projection of cartilage, the 'paranasal process,' jutting out from the wall of the nasal capsule.

The bones below the level of the eyes are formed in the mesoderm of the maxillary process. This process, growing forward below the eye on each side, reaches the lower edge of the outer wall of the nasal cavity, and passes inwards below this to reach, fuse with, and invade the fronto-nasal process. The part below the eye gives origin to the *body of the maxilla,* while that part which covers in, by its invasion, the fronto-nasal process is the seat of development of the *premaxillary* portion of the jaw. The mesodermal mass, however, is thickest behind the region of the maxilla, extending, in this broad part of the face, from skin to wall of pharynx, or common mouth cavity of the younger embryonic stages; the outer and greater portion of this mass is used in forming certain soft parts, but a membrane bone, the *medial pterygoid plate,* is developed in its inner part, and the *lateral plate* is completed more superficially.

In front of the pterygoid region the maxillary mass makes the side wall of the common mouth cavity, and also covers a great part of the roof of this cavity, reaching, in both situations, the margins of the posterior bony apertures of the nose. It extends along the inner aspect of the outer nasal wall, and on the surface of the septum, and, on the side wall of the mouth, forms the palatine fold, which closes in the greater part of the posterior opening. The *palatine bone* is formed in this mesoderm lining the *inner* aspect of the outer wall of the nasal capsule, and extends into the palatine fold, the *palatine shelf of the maxilla* growing into the fold in front of it. The *vomer* is developed in the corresponding layer covering the lower and posterior portion of the nasal septum, that part which is not used in the formation of the perpendicular plate of the ethmoid.

The *zygomatic* forms in an upgrowth of maxillary mesoderm behind the eye. This upgrowth of visceral mesoderm is associated with the

growth of the temporal muscle and other structures, and it is probable that the *squamous portion of the temporal* and *zygomatic process* are really visceral bones formed in this mesoderm and applied to the cartilaginous remnants already described as forming the parietal plate. The tympanic bone is developed in membrane of visceral origin.

Summary of Classification of Skull Bones.

		Paraxial.	Visceral.
Cranium	*Cartilage bones*	Occipital, petromastoid, body and orbital process of sphenoid with lingula, ethmoid.	Inner small part of alisphenoid, ossicles of ear, hamular end of medial pterygoid plate.
	Membrane bones	Interparietal, parietal, frontal.	Outer part of alisphenoid, pterygoid processes, tympanic ring and squama.
Face	*Cartilage bones*	—	Small part of frontal process of maxilla (Meckel's rod in lower jaw).
	Membrane bones	Nasal, lacrimal.	Maxilla, zygomatic, palatine, vomer, mandible, posterior part of inferior nasal concha (?).

The Hyoid Bone.

The hyoid bone forms a part of the visceral-arch skeleton of the skull, and the structures concerned in its development are the second and third visceral arches of each side.

Second Visceral or Hyoid Arch.—The cartilage of this arch is known as the **hyoid bar,** or *cartilage of Reichert,* and its *distal* or *ventral segment* gives rise to the **lesser horn** or **cerato-hyal.**

Third Visceral or Thyro-hyoid Arch.—The distal or ventral end of the cartilage of this arch is connected with that of its fellow of the opposite side by a median piece of cartilage, which acts as a bond of union between them, and is from that circumstance called the **copula.** The copula also connects the right and left hyoid bars. The **body** of the hyoid bone, or the **basi-hyal,** is developed from the **copula;** and each **greater horn,** or **thyro-hyal,** is developed from the *cartilaginous bar* of the corresponding *third* visceral arch.

THE TEETH.

The **teeth** are divided into two sets—namely, the temporary, milk, or deciduous, which belong to early infancy, and the permanent, which replace the temporary. The temporary teeth are twenty in number—ten upper, five in each maxilla, and ten lower, five in each half of the mandible. The number of permanent teeth is thirty-two—sixteen upper, and sixteen lower.

The Permanent Teeth.—Proceeding from the median line in a direction outwards and backwards, the permanent teeth are as follows: medial incisor, lateral incisor, canine, first premolar, second premolar,

and first, second, and third molars. The third molar is known as the *dens serotinus* or wisdom tooth. Each tooth is composed of the following parts: the **crown,** which is the part above the gum; the **root,** which is the part embedded in the socket; and the **neck,** which lies between the crown and root. The surface of a tooth which looks towards the lip is called **labial,** and that looking towards the tongue **lingual,** whilst the opposed surface of one is called **medial** or **proximal,** and the other **lateral** or **distal.**

The Incisors.—There are *eight* incisor teeth—two in each upper jaw, and two in each half of the lower jaw. In each case the two incisors are known as *medial* and *lateral* respectively. Their crowns are chisel-shaped, the anterior surface being convex and the posterior concave.

The **upper medial incisor** is larger than the lateral, and it gradually tapers from the cutting edge of the crown to the root. The length of the **crown** exceeds its breadth. The *labial* surface is slightly convex, whilst the *lingual* surface is concave. The *lingual* surface presents near the gum a ridge, called the **cingulum.** The *medial angle* of the cutting edge of the crown is longer or more projecting than the lateral angle.

The **root** is long, tapering, and conical.

The **upper lateral incisor** is smaller than the medial, which it for the most part resembles. The *lateral angle* of the cutting edge of the crown is rounded off, and the *cingulum* is more prominent than in the upper medial incisor.

The **lower medial incisor** is smaller than the lateral, and narrower than the upper medial incisor. The *cingulum,* if present, is not well marked. The **root** is much compressed laterally.

The **lower lateral incisor** is larger than the medial, which it for the most part resembles. The presence of a *cingulum* is rare. The **root** is longer than that of the medial incisor, and on each

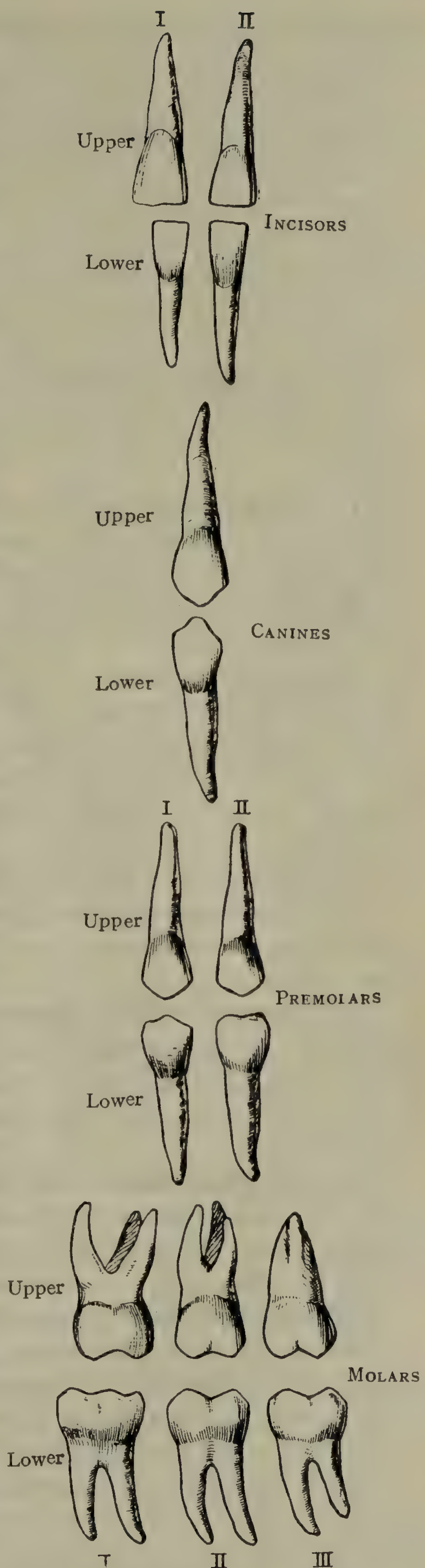


Fig. 172.—The Permanent Teeth of the Left Side.

flattened lateral surface there may be an indication of a longitudinal groove.

The Canines.—There are *four* canine teeth—one in each upper jaw, and one in each half of the lower jaw.

The **crown** of a canine tooth is larger than that of an incisor. It is somewhat conical, and terminates in a cusp, from which circumstance the canine teeth are known as the *cuspidate teeth.* The *labial* surface of the crown is convex, and the tip of the cusp is nearer the anterior or medial than the posterior or lateral margin of the crown.

In the **upper canines** the *lingual* surface of the crown usually presents a slight median ridge, which extends from the cusp to a ridge which represents the *cingulum.* The **root** is long, thick, and almost round.

The **lower canines** have no median ridge on the *lingual* surface, which may be slightly concave. The *cingulum* is absent. The **root** is shorter than in the upper canines.

The Premolars.—There are *eight* bicuspid teeth—two in each upper jaw, and two in each half of the lower jaw.

Upper Premolars.—The **crown** is cuboidal, and its *labial* border is longer than the *lingual.* It has *two* cusps—labial and lingual—both of which are prominent. The *labial* cusp is the larger and broader of the two, and the cusps are separated by a deep fissure. The *labial* and *lingual* surfaces of the crown are convex, and there is no *cingulum.* The **root** is single, much compressed laterally, and usually marked on either side by a longitudinal groove.

The **first upper premolar** has frequently *two* slender roots. This occurs so often that it may be regarded as the normal condition in that tooth.

The **second upper premolar** differs from the first in the following respects: (1) Its **crown** is larger, and approaches more nearly the molar type; and (2) its *lingual* cusp is larger and broader than that of the first upper premolar, so that its labial and lingual cusps are of nearly equal size.

Lower Premolars.—These teeth are smaller than the upper premolars. The *labial* cusp has an inclination inwards towards the mouth, and the *lingual* cusp is depressed. The cusps are connected by a *low-lying ridge.* The **root** is single, round, and tapering.

The **second lower premolar** differs from the first in the following respects: (1) Its **crown** is larger, and approaches more nearly the molar type; and (2) its *lingual* cusp is stout, and not so much depressed as that of the first lower bicuspid.

The second lower premolar has occasionally two roots.

The Molars (*Multicuspidate Teeth*).—There are *twelve* molar, or grinding teeth—three in each upper jaw, and three in each half of the lower jaw.

First and Second Upper Molars.—The upper surface of the **crown** is somewhat square, the angles being rounded off. The grinding

urface is furnished with *four* cusps, situated at each angle of the quare, two of them being labial and two lingual. The *anterior lingual* usp is the largest, and it is connected with the *posterior labial* cusp y a stout oblique ridge. The *labial* cusps are longer or more project- ıg than the *lingual* cusps, which applies to all the upper molars. 'he fissure between the two labial cusps and that between the two ngual cusps appears for a short distance on the labial and lingual urfaces of the crown respectively. The *posterior lingual* cusp is ccasionally suppressed.

It is usually fairly easy to place an upper molar in position by oticing the roots; these are recurved at their ends, so that the front f the tooth is easily told. Of the three roots, two are labial and one ngual.

In the lower molars the roots are also recurved, but to decide hich is the labial and which the lingual side the crown must be arefully noticed, remembering that the upper teeth overlap the lower terally. On account of this the outer or labial edge of the crown of he lower tooth is worn, while in the upper tooth it is the inner edge hich is slightly bevelled by wear.

Third Upper Molar.—This tooth is subject to much variety. Its **rown** is usually of smaller size than that of the first and second. 'he two *lingual cusps* of the **crown** are frequently confluent. The **hree roots** are blended together to form a tapering cone.

Lower Molars.—The **first lower molar** is the largest. The upper urface of the **crown** is somewhat square, and its grinding surface is rovided with *five* cusps. Four of these are placed at the angles of he square, and are separated from each other by a crucial fissure. 'he *posterior limb* of this fissure bifurcates, and the *fifth cusp* lies in he angle of bifurcation. This cusp may be in the middle line, but usually lies towards the *labial aspect*, from which aspect it can eadily be seen. The *lingual* cusps are longer or more projecting han the *labial* cusps, which applies to all the lower molars. The ssure which separates the two *labial* cusps usually passes for a short istance on to the labial surface of the crown, but the fissure between ie two *lingual* cusps only occasionally passes on to the lingual surface f the crown. The **root** has *two* fangs—*anterior* and *posterior*. Each ing is much compressed from before backwards, and in most cases ach presents a slight backward curve.

The **second lower molar** bears a general resemblance to the first. 'he *fifth cusp* is often absent, and, when present, it is of small size. 'he two fangs of the **root** are frequently blended together.

The **third lower molar** is of larger size than the third upper molar. ts **crown** is large, and is usually provided with *five* cusps. Its root ay have two separate fangs, or these may be confluent. In the tter case a groove indicates the double condition of the root.

Dental Arches.—The alveolar arches of the maxillæ and mandible, nd the upper and lower teeth, are so disposed as to form two almost imilar curves. When the mouth is closed, the summits of the crowns

of the upper and lower teeth are brought together, the line of contact being known as the *dental articulation.*

Since the upper median incisor has a much wider crown than the lower its outer edge overlaps the lateral lower incisor crown, and this overlap is maintained throughout the dental arcade, the interval between two upper teeth corresponding to the crown of a lower. The two arcades end posteriorly in the same vertical line owing to the third upper molar being smaller than the lower.

The Temporary Teeth.—Proceeding from the median line, these are as follows on either side: two incisors, central and lateral, one canine, and two molars, first and second. Their necks are more constricted than in the permanent set. The incisors and canines resemble, for the most part, those of the permanent set, but they are smaller. The molars, which are replaced by the permanent premolars, exceed them in size, the second molars being particularly

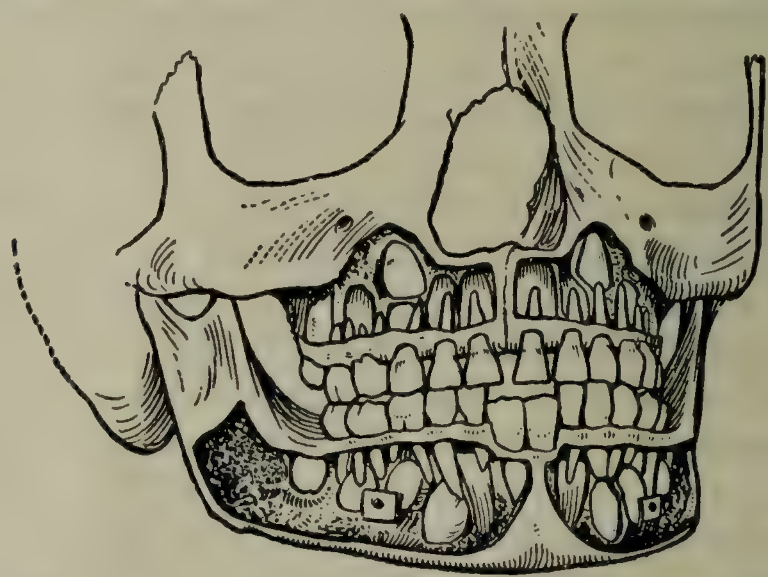


FIG. 173.—THE MAXILLÆ AND MANDIBLE AT THE SEVENTH YEAR, SHOWING MOST OF THE TEMPORARY TEETH, AND THE PERMANENT TEETH ABOUT TO REPLACE THEM.

The first permanent molars and the permanent lower central incisors are in position.

large. The first upper molar has three cusps—two labial and one lingual; the second upper and first lower molars have each four, and the second lower molar has five.

In addition to these distinctions, the milk teeth are whiter than the permanent ones, and the roots of the molars more widely splayed. Moreover, their crowns are more bulbous.

Eruption of the Teeth.—The eruption of particular teeth of the lower jaw precedes that of the corresponding teeth of the upper jaw, and the somewhat variable times of eruption may be taken, for practical purposes, to be as follows:

Temporary Teeth.

Incisors	6th to 12th month.
First molars	12th to 14th ,,
Canines	14th to 20th ,,
Second molars	20th to 24th ,,

Permanent Teeth.

First molars	6th year.
Central incisors	7th ,,
Lateral incisors	8th ,,
First premolars	9th ,,
Second premolars	10th ,,
Canines	11th ,,
Second molars	12th ,,
Third molars	17th to 25th year.

About the sixth year is the period at which most teeth are present the jaws, there being the twenty temporary teeth, and all the per-anent, except the four wisdom teeth (namely, twenty-eight), making all forty-eight.

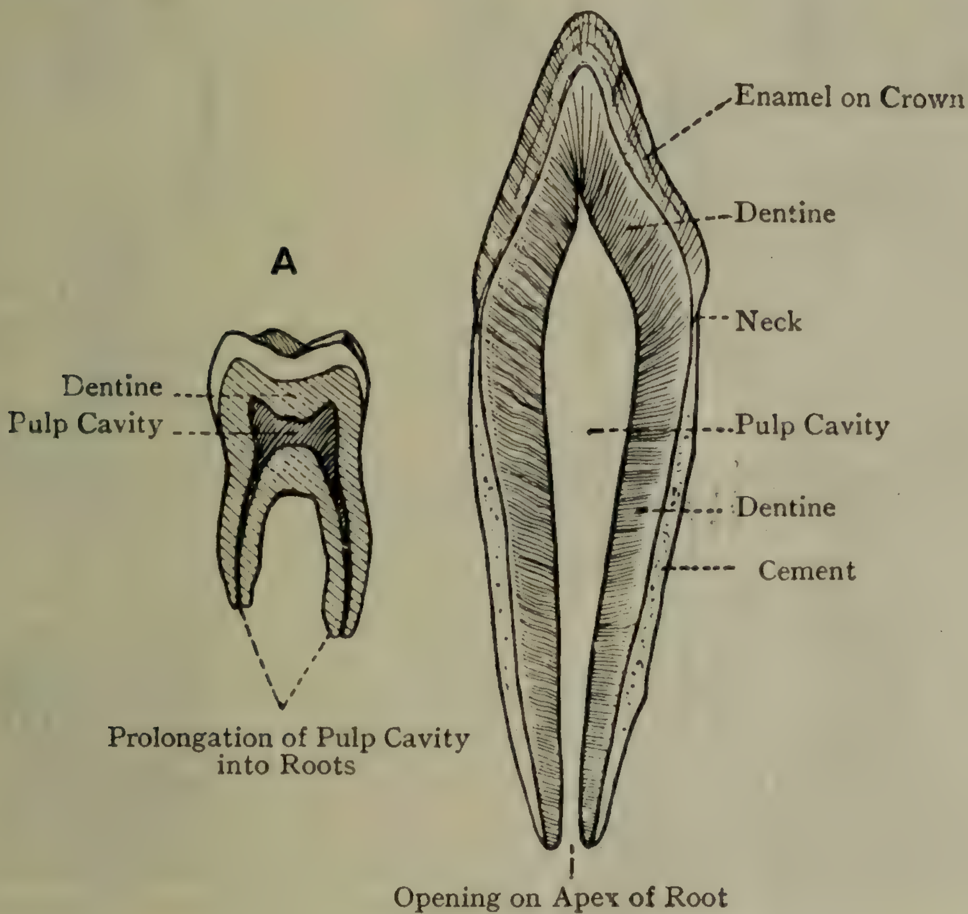


FIG. 174.—SECTIONS OF TEETH.
A, lower molar; B, lower incisor.

Structure of a Tooth.—The crown of a tooth contains a central ivity, called the **pulp cavity,** which is occupied by the **dental pulp.** he shape of the pulp cavity corresponds with that of the crown, and extends into the root, and as many fangs as compose it, terminating a small opening on the apex of the fang. The cavity also extends r a little into the cusps of the premolars and molars, and in the in-sors it is continued into each angle of the crown. The wall of the ivity presents a number of openings, which lead into the dental inaliculi. The **dental pulp** is composed of a matrix of connective ssue, containing bloodvessels, nerves, cells, and fibres, which latter em to be processes of the cells. It is destitute of lymphatics. The ells are scattered throughout the matrix, and at the surface of the

pulp they form a continuous layer, being there known as the **odontoblasts**. This layer is sometimes spoken of as the *membrana eboris*. The pulp is very vascular and sensitive, its vessels and nerves reaching it through the minute openings at the apices of the roots.

The substance of the tooth is formed of three tissues—namely, ivory or dentine, enamel, and cement or crusta petrosa. The dentine forms the principal part of the tooth, surrounding the pulp cavity and its prolongations; the enamel covers the exposed part or crown; and the cement covers the root.

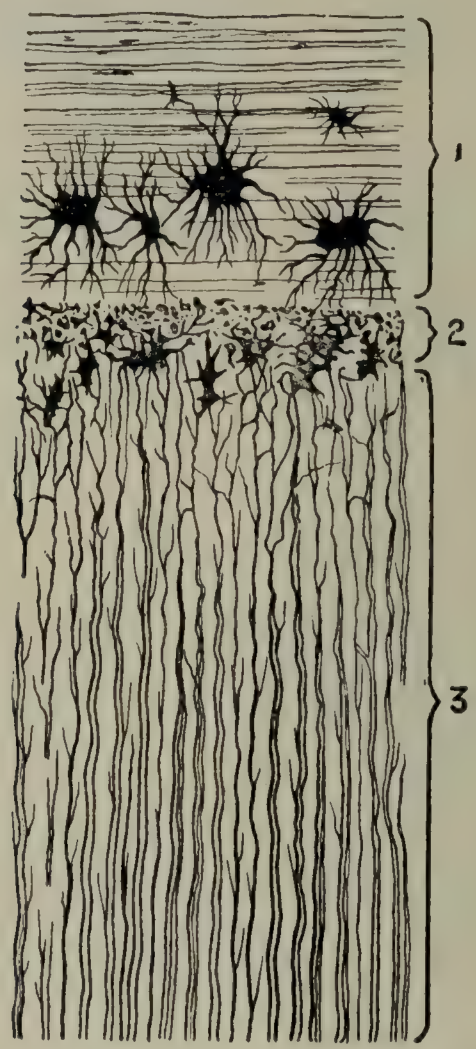


Fig. 174a.—Section of the Root of a Tooth.

1, cement; 2, granular layer of Purkinje; 3, dental canaliculi.

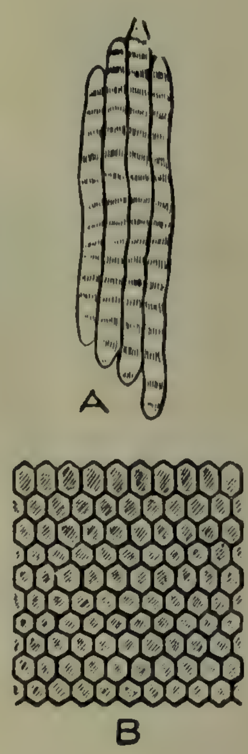


Fig. 174b.—Enamel Prisms.

A, four prisms (longitudinal view); B, surface of the enamel.

Dentine.—This bears a resemblance to bone, but contains rather less animal and more earthy matter, the proportion in 100 parts being about 28 of animal matter to 72 of earthy. The dentine has a striated appearance, due to the fact that it is traversed by a number of minute branched channels, called the **dental canaliculi,** which radiate in a curved manner outwards from the pulp cavity to the deep aspect of the enamel and cement. These tubules contain processes of the odontoblasts which form the membrana eboris, and are known as **Tomes' fibres.** The part of the dentine adjacent to the enamel and cement is known as the **granular layer** of Purkinje. It presents a

ımber of irregular spaces, known as the *interglobular spaces*, which e surrounded by minute globules of calcareous matter.

Enamel.—This caps and protects the dentine of the crown. It exceedingly hard, which is due to the fact that it contains no animal atter—at least, to any appreciable extent. It consists of solid xagonal prisms, which are marked by transverse striations. These e received by their deep extremities into depressions on the dentine, ıd are placed vertically on the summit of the crown, but horizontally ı its sides. At the period of eruption of a tooth, and for some little me thereafter, the enamel of the crown is covered by a thin membrane, lled the **enamel cuticle,** or **Nasmyth's membrane.**

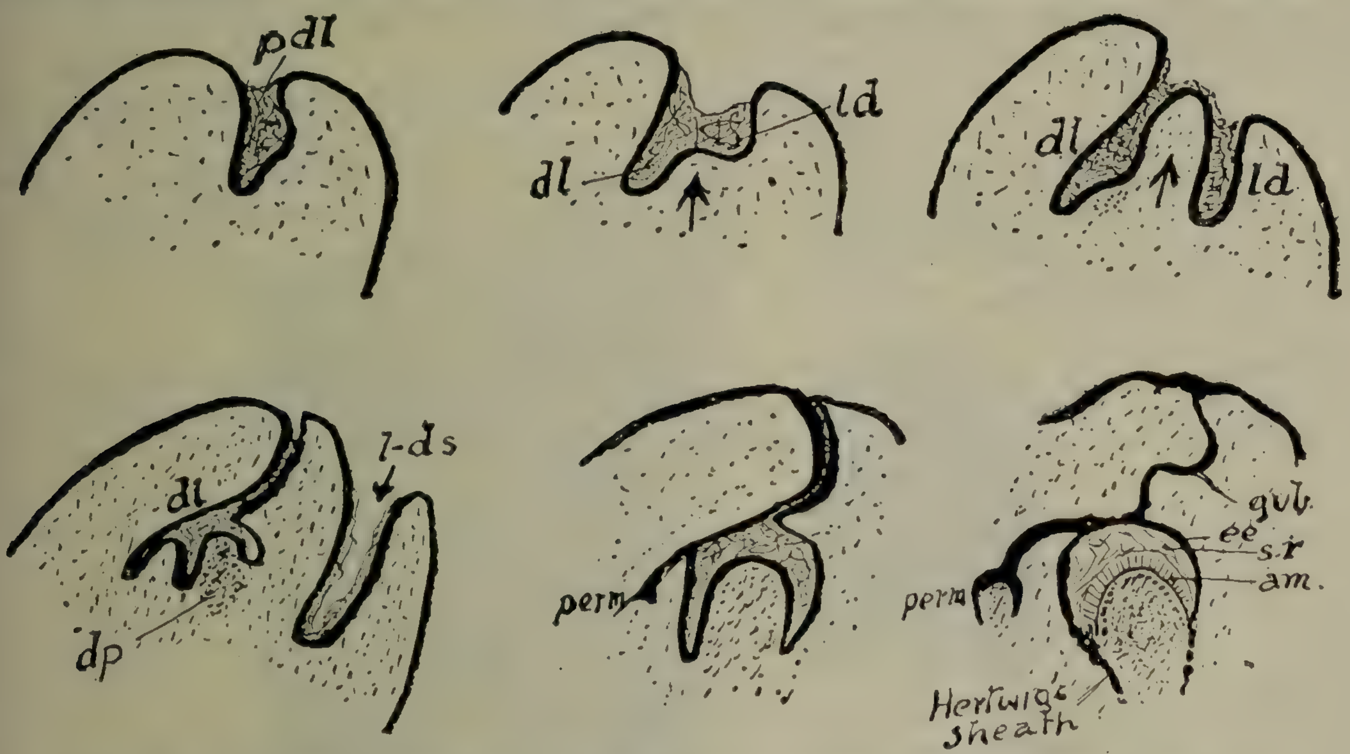


FIG. 175.—DIAGRAMS TO SHOW FORMATION OF ENAMEL ORGANS.

ıe primary dental lamina (*p.dl*) is divided by a mesodermal upgrowth into dental (*dl*) and labio-dental (*ld*) laminæ. Enamel organ forms the labial side of shelf, that of the permanent tooth (*perm*) from its free border. *gub.*, gubernaculum, a remnant of the lamina; *l-ds*, labio-dental sulcus; *ee*, external epithelium; *st*, stellate reticulum; *am*, ameloblast layer.

Cement, or Crusta Petrosa.—This covers the dentine which forms ıe root of the tooth. It is true bone, and contains lacunæ and canalic- i, but it is destitute of Haversian canals.

The root of a tooth is maintained in its socket by the dental peri- steum (periodontal membrane), which covers the cement, and lines the all of the socket, being continuous with the gum at the neck of the ooth. The articulation is called **gomphosis.**

Development of the Teeth.

The teeth are calcified papillæ of the gingival mesoderm, their crowns being overed by calcified ectodermic cells. Three structures are involved in the evelopment of a tooth—namely, (1) the **enamel organ,** which furnishes the *ıamel*; (2) the **dental papilla,** which gives rise to the *dentine* and *dental pulp*; ıd (3) the **dental sac,** from the inner layer of which the *cement* is formed. The ıamel organ is developed from the *ectoderm*, whilst the dental papilla and the ental sac are of *mesodermic origin*.

The development of the temporary teeth begins by a thickening of th covering epithelium, which is gradually depressed below the general surface This is usually described as 'ingrowth of the epithelium,' but what actuall occurs is that the mesoderm, first on its lingual side and then in front of it, grow up beside the line of thickening, which retains its original level. In this wa a sunken ridge of epithelium forms in each jaw, like a reversed projection fron the surface, with its 'free' edge directed into the mesodermal bed. This i known as the **primary dental lamina.** The later growth of mesoderm, on it outer or labial face, leads to the buried ridge in its further deepening bein subdivided from below, as it were, and thus (Fig. 175) showing now an anterio **labio-dental lamina** and a posterior **dental lamina.** The **labio-dental** or **labio-gingival lamina** is concerned with the lip and gum, and it presents superficiall a furrow, called the *labio-dental* or *labio-gingival groove*, which divides it into tw parallel ridges—*labial* for the lip, and *gingival* for the gum. The labio-gingiva groove itself deepens, and separates the lip from the gum.

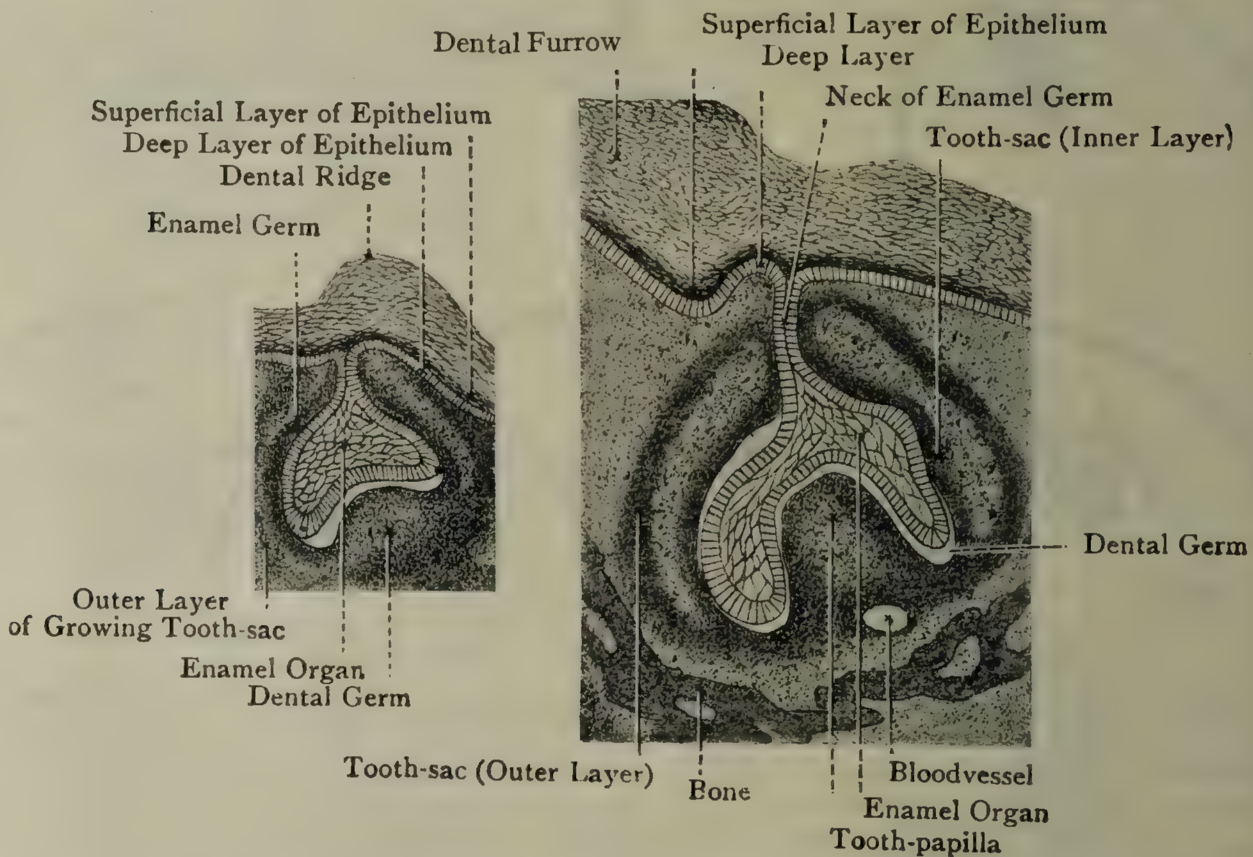


FIG. 176.—DEVELOPMENT OF TOOTH (FREY, AFTER THIERSCH): VERTICAL TRANSVERSE SECTION OF UPPER JAW.

The **true dental lamina** is concerned with the enamel. Along its attachment to the oral epithelium a furrow is formed, called the *dental furrow*, and its deep margin lies in the mesoderm of the embryonic jaw.

The true dental laminæ, which are of ectodermic origin, are at first unbroken, but they soon become broken up into separate masses, called **enamel organs,** there being twenty of these for the temporary teeth, ten upper and ten lower. Each **enamel organ** appears as a thickening or protuberance of ectodermic cells on the *deep margin* of the true dental lamina, which protuberance soon becomes flask-shaped, the neck being directed superficially. This neck elongates and thins, and the connection between the enamel organ and the ectodermic cells of the free surface of the gum is thereby maintained by a strand of cell, the gubernaculum. Moreover, the enamel organs become isolated from one another by the breaking down of the interposed cell-layers of the lamina.

The **dental papilla** appears as an elevation of the mesoderm subjacent to each enamel organ. The number of papillæ, therefore, corresponds to the number of enamel organs. As the dental papilla grows, it becomes capped by the enamel

·gan, which also invests it laterally. The enamel organ thus becomes moulded ver the dental papilla in the form of a cap.

Enamel Organ.—As stated, the enamel organ is of ectodermic origin, being erived from the true dental lamina, which, in turn, is derived from the ecto- ermic cells covering the surface of the gum. The chief cells of the enamel ·gan are situated deeply, and lie close to the surface of the dental papilla. hey are **long columnar cells,** which are called **enamel cells, adamantoblasts,** : **ameloblasts,** and they give rise to the enamel prisms.

Formation of Enamel Prisms.—Each **enamel cell** gives rise to one *enamel rism.* The *deep part* of each cell undergoes calcification. The superficial ıds of the enamel cells do not become calcified, but form a delicate membrane, ılled the **enamel cuticle,** or **Nasmyth's membrane,** which covers the crown of ıe tooth for a short time after its eruption.

Dental Papilla.—As stated, the dental papilla is of mesodermic origin, and gives rise to the dentine and dental pulp. Essentially, the papilla is a collec- on of mesodermic cells, which become transformed into connective tissue, ıis being permeated by bloodvessels and nerves.

The cells at the surface of the papilla become enlarged, and are called **odonto- lasts.** These cells are identical with the osteoblasts of developing bone, and ıey form a continuous layer, known as the **membrana eboris.** From these ells the dentine is laid down. The central portion of the dental papilla, con- sting of connective tissue, bloodvessels, and nerves, constitutes the **dental ılp.**

Hertwig's sheath is a prolongation of ectodermal cells from the periphery : the enamel organ, surrounding the growing dental papilla. It appears to be ecessary for the formation of dentine in the papilla, for this substance does not rm in the absence of ectoderm.

Formation of Dentine.—The dentine is laid down in successive layers. Each yer consists at first of a fibrous dentinal matrix, called *prodentine,* the fibres : which are continuous with those of the dental pulp. Subsequently the atrix undergoes calcification by the deposits of calcareous matter. During ıe formation of these layers the odontoblasts become shifted inwards towards ıe centre, and they leave behind them fine processes, which become invested y the calcified fibrous matrix of the dentine. In this manner the **dental canalic- li** are formed, with processes of the odontoblasts within them, which represent ıe *fibres of Tomes.* The dentine so formed constructs a case for each dental apilla. The central part of the papilla, consisting of connective tissue, blood- essels, and nerves, forms, as stated, the **dental pulp.** The peripheral part of ıe dentine has several small uncalcified areas, which lie between globular ıasses of calcareous matter. These areas represent the *interglobular spaces* of ıe adult tooth.

Dental Sac.—This sac, like the dental papilla, is of mesodermic origin. As ıe dental papilla is undergoing differentiation into dentine and dental pulp, ıe mesodermic connective tissue around the papilla becomes condensed into follicle, called the **dental sac,** which encloses both the dental papilla and the orresponding enamel organ. The developing tooth (enamel organ and dental apilla) thus becomes isolated, the enamel organ being only in connection with ıe ectoderm of the gum by its neck. The part of the dental sac which is related) the crown of the tooth is connected with the surface of the gum by a band : connective tissue. This part of the sac disappears. The part of it which is lated to the root of the tooth undergoes important developments. It consists : *two* layers—inner and outer. The *inner layer* gives rise to the **cement,** or **rusta petrosa,** which breaks up the sheath of Hertwig as it forms, whilst the *outer yer,* remaining fibrous, forms the **dental periosteum,** or **periodontal membrane.**

Permanent Teeth.—The process of development of the permanent teeth is milar to that of the temporary teeth. The enamel organs of those permanent eeth (*teeth of succession*) which are to replace the temporary teeth—namely, ıe permanent incisors, canines, and premolars—are developed as thickenings : protuberances of the true dental laminæ, as in the case of the temporary teeth,

and they grow inwards on the lingual aspects of the temporary enamel organs (see Fig. 175).

The enamel organs of the three permanent molar teeth spring from a backward prolongation of the true dental lamina.

Teeth Present at Birth.—At the period of birth the gums contain *forty-four teeth.* These consist of—(1) the twenty temporary teeth; (2) the twenty permanent teeth, which are to replace the temporary teeth; and (3) the four first permanent molar teeth. At birth the second and third permanent molar teeth, eight in all, are not yet developed.

Eruption of the Temporary Teeth.—As the permanent teeth grow, they exercise pressure upon the roots of those temporary teeth which they are about to replace. This continued pressure leads to partial absorption of the roots of the temporary teeth. These teeth, therefore, become loosened in their sockets, and as the permanent teeth continue to advance, the loosened temporary teeth are pushed out by the advancing permanent teeth. Osteoclasts also take part in the absorption of the roots. The actual forces at work to bring about eruption are quite unknown.

CHAPTER VI

THE BONES OF THE UPPER LIMB

THE **upper limb** is arranged in four divisions—namely, the pectoral or shoulder-girdle, brachium or arm proper, antibrachium or forearm, and manus or hand. The **shoulder-girdle** consists of the clavicle and scapula, the **arm** proper comprises the humerus, the **forearm** is composed of the radius and ulna, and the **hand** is subdivided into a *carpus*, comprising eight bones, a *metacarpus*, consisting of five bones, and *phalanges*, which number fourteen.

The Clavicle.

The **clavicle** or collar-bone is situated at the lower part of the neck anteriorly, where it lies above the first rib, and it extends outwards and backwards from the upper border of the manubrium sterni to the acromion process of the scapula. The bone presents two curves: an inner or sternal, occupying two-thirds, with its convexity directed forwards; and an outer or acromial, extending over the outer third, with its convexity directed backwards. These curves impart elasticity to the bone. The clavicle is divided into a shaft and two articular extremities.

The shaft is usually quadrilateral in section in its inner two-thirds, but in many cases is triangular; it is compressed from above downwards over its outer third. The *superior surface* is for the most part narrow, but laterally it becomes broad. At its inner third, near the postero-superior border, it presents a rough ridge, about $1\frac{1}{2}$ inches long, for the origin of the clavicular head of the sterno-mastoid. At its outer expanded part it is encroached upon by the tendinous fibres of the trapezius and deltoid. Elsewhere it is covered by the skin, fascia, and platysma. The *anterior surface* is convex over its inner two-thirds, and concave over its outer third, where it is reduced to a mere rough border. Over the inner half it is flat and rough for the origin of the clavicular portion of the pectoralis major, and over its outer marginal third it gives origin to the clavicular portion of the deltoid. At the inner end of the deltoid impression there is sometimes a pointed projection, known as the *deltoid tubercle*. The *posterior surface* is concave over its inner two-thirds, and convex over its outer third, where it is narrowed into a rough border. The inner two-thirds overhang the subclavian vessels and trunks of the brachial plexus, whilst the outer marginal third gives insertion to the upper fibres of the trapezius. At the inner end of the impression for these fibres, opposite the deltoid spine, there is a conical projection which extends on to the inferior surface for a little, called the *conoid tubercle*, for the conoid part of the

coraco-clavicular ligament. About the centre of the posterior surfac there is the **nutrient foramen** (often double) for the nutrient arter which is a branch of the suprascapular. The canal to which the forame leads is directed *outwards*. The foramen may be situated on the inferio surface in, or close to, the subclavian groove, or there may be tw foramina, one on the posterior and one on the inferior surface, abou an inch apart. Close to the sternal end the posterior surface give partial origin to the sterno-hyoid. The *inferior surface* present near its sternal end the impression for the costo-clavicular ligamen about an inch long. Just lateral to and behind this is often a smoot oblique depression marking the point where the clavicle rests agains and presses upon the first rib. In the middle third of the lowe surface there is the *subclavian groove*, which extends from the rhomboi impression to near the conoid tubercle, and gives insertion to th subclavius. The groove is bounded by two lips, anterior and posterio to which the clavipectoral fascia is attached in two laminæ. A

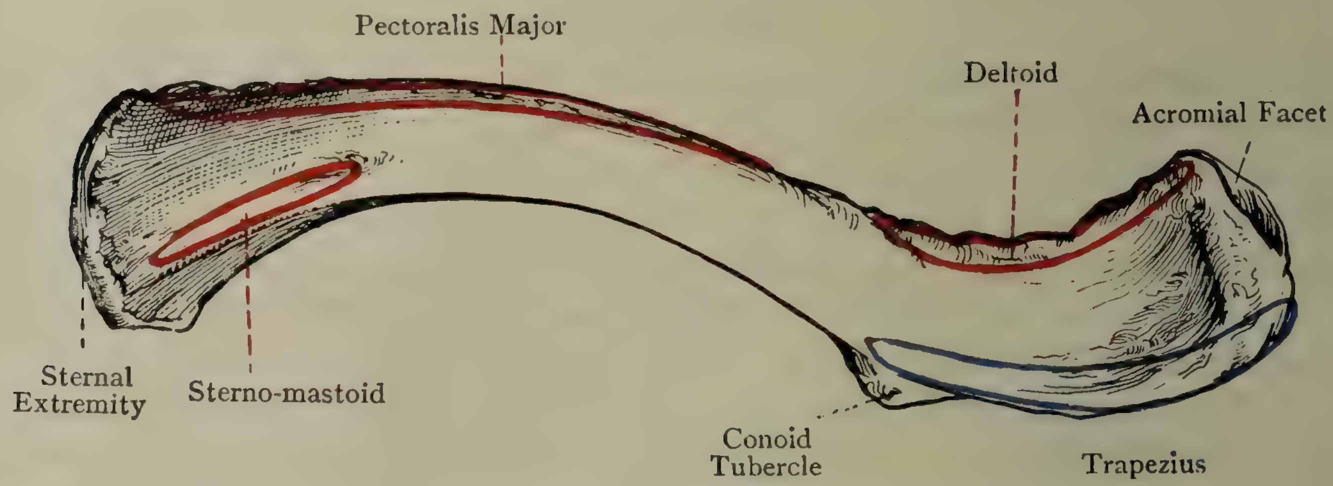


FIG. 177.—THE RIGHT CLAVICLE SUPERIOR VIEW).

the outer extremity of the inferior surface there is a rough obliqu line, called the *trapezoid line*, which extends forwards and outward from the conoid tubercle, and gives attachment to the trapezoid par of the coraco-clavicular ligament. The conoid tubercle is more full seen here than on the posterior border, and is situated at the postero medial extremity of the trapezoid line.

The **borders** of the clavicle over its outer third are anterior an posterior. The *anterior border* bifurcates, over the inner two-thirds into an *antero-superior* and *antero-inferior border*, which enclose be tween them the anterior surface. The *posterior border* bifurcates, ove the inner two-thirds, into a *postero-superior* and *postero-inferior* border the latter forming the posterior lip of the subclavian groove. Th antero-superior and postero-superior borders limit the superior surface the postero-superior and postero-inferior limit the posterior surface the postero-inferior and antero-inferior limit the inferior surface, and as stated, the antero-inferior and antero-superior limit the anterio surface.

The **sternal extremity** is enlarged and covered by cartilage. A

viewed on end, it is somewhat triangular, and presents a prominent posterior angle which is directed downwards, inwards, and backwards. The surface is concave from before backwards, and convex from above downwards, and it articulates with the clavicular impression on the upper border of the manubrium sterni, an inarticular fibro-cartilage intervening. The circumference of the sternal end is rough for the sterno-clavicular and interclavicular ligaments, except inferiorly, where there is a narrow articular strip for the first costal cartilage.

The **acromial extremity** presents an oval facet for the acromion process of the scapula.

The clavicle receives its blood-supply from the suprascapular and thoraco-acromial arteries.

Articulations.—*Medially* with the manubrium sterni and first costal cartilage, and *laterally* with the acromion process of the scapula.

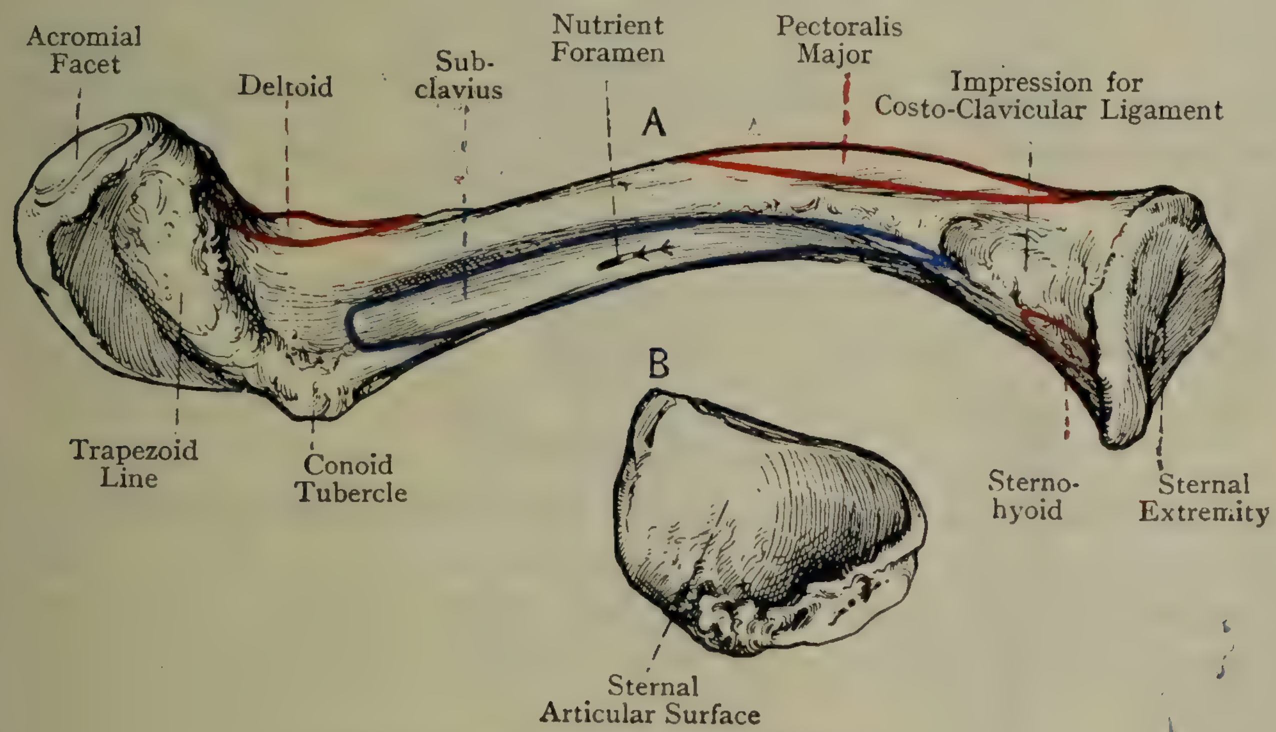


FIG. 178.—THE RIGHT CLAVICLE.

A, inferior view; B, sternal extremity.

Structure.—The exterior is composed of compact bone which is thickest towards the centre, and the interior of coarse cancellated tissue, the principal lamellæ being disposed longitudinally. The clavicle has no medullary canal, but, towards the centre of the shaft, the medullary spaces of the cancellated tissue are of large size.

Varieties.—(1) There may be a deltoid spine. (2) The superior surface may present a small slit-like aperture almost invariably corresponding with the position of the nutrient foramen, for one of the descending branches of the cervical plexus of nerves.

The Clavicle of the Female.—The bone is smoother, more slender, straighter, and more cylindrical over its inner two-thirds, than that of the male. An average male English clavicle measures 6 inches; a female, $5\frac{1}{2}$ inches.

Ossification.—The clavicle, which is the earliest bone to ossify, has **two primary centres** and **one secondary centre.** It is preceded by a rod of connective tissue. Within the two halves of this rod collections of 'precartilaginous tissue' are formed, and within these at their contiguous ends the primary centres appear about the *sixth week.* Subsequently the precartilaginous collections fuse, and thereafter the primary centres coalesce. Ossification from these two centres proceeds at first in the precartilaginous tissue, but subsequently in the cartilage to which this tissue gives place. The primary centres may fail to join, with the result that the clavicle may persist in two halves.

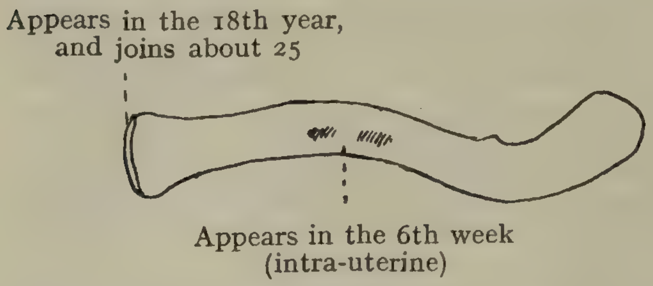


FIG. 179.—OSSIFICATION OF THE CLAVICLE.

The **secondary centre** appears in the cartilage of the *sternal end* about the *twentieth year,* and forms a mere scale which seldom covers the whole articular surface. This epiphysis joins the shaft about the *twenty-fifth year* (Mall and Fawcett).

It will be noticed that in bones with a shaft and one epiphysis *the nutrient foramen and the canal to which it leads are directed towards that extremity which has no epiphysis.* This is illustrated in the clavicle and the metacarpal, metatarsal, and phalangeal bones, and the rule may be stated in another way by saying that the nutrient artery runs away from the growing end of the bone.

The Scapula.

The **scapula** or shoulder-blade is situated on the posterior aspect of the thorax, where it extends from the second to the seventh rib, being separated by muscles from the thoracic wall. It consists of a body and three processes—namely, a spine, an acromion, and a coracoid process.

The **body** is a thin triangular plate, and it presents two surfaces, three borders, and three angles. The *costal surface, venter,* or *subscapular fossa* is concave, and the bone forming it is for the most part thin, except near the lateral or axillary border, where there is a thick, round, elongated ridge. It gives origin to the subscapularis, except (1) along the anterior aspect of the base from the superior to the inferior angle, where the serratus anterior is inserted, and (2) over the front of the neck. The costal surface is crossed by three or four oblique ridges, which extend upwards and outwards from the base, and give attachment to intramuscular tendons of origin of the subscapularis muscle.

The **dorsal** or **posterior surface** is irregularly convex, and is divided into two unequal parts by the spine. The upper division, along with the superior surface of the spine, forms the *supraspinous fossa.* It represents about one-fourth of the dorsal surface, and gives origin over its inner two-thirds to the supraspinatus. In the region of the neck it presents a nutrient foramen for a branch of the suprascapular artery. The lower division, along with the inferior surface of the spine, forms the *infraspinous fossa,* and it represents about three-fourths of the

dorsal surface. Towards the lateral border it presents an elongated concavity, external to which is an oblique line extending from its upper end downwards and inwards to the base near the inferior angle. The infraspinous fossa, as far out as this oblique line, gives origin to the infraspinatus, except at the upper and outer part, and it presents a nutrient foramen superiorly, close to the spine near the centre, for a branch of the circumflex scapular artery. The oblique line marks off impressions for the teres muscles and circumflex scapular artery, as

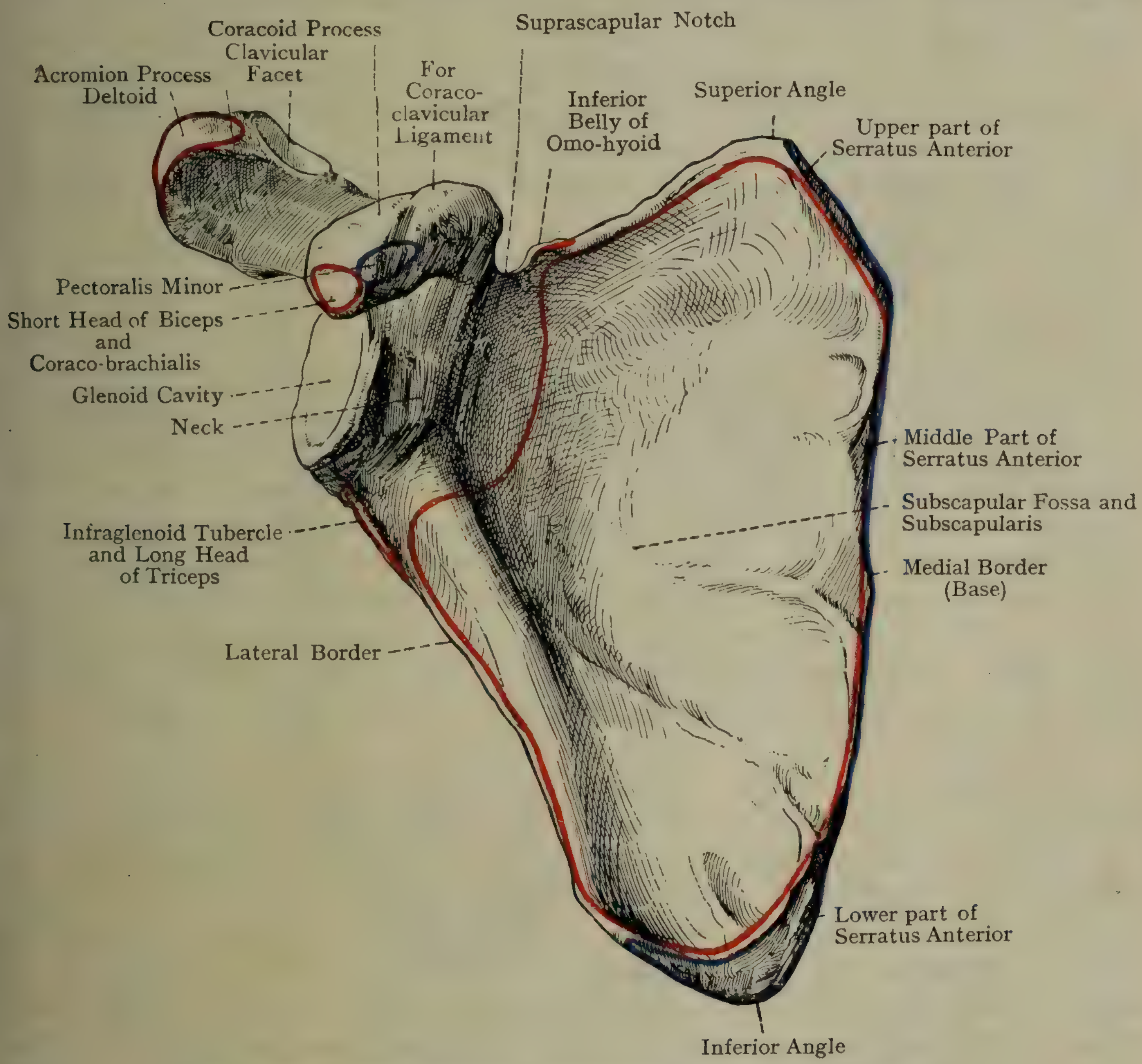


FIG. 180.—THE RIGHT SCAPULA (ANTERIOR VIEW).

follows: the teres minor arises from about the upper two-thirds, near the centre of which there is a groove for the circumflex scapular artery, and the teres major arises from about the lower third. The impression for the latter muscle is oval; it extends on to the back of the inferior angle, and it is separated from the impression for the teres minor by a short rough line. This line gives attachment to an intermuscular septum which separates the teres muscles, and the oblique line to a septum which separates these muscles from the infraspinatus. The supra- and infraspinous fossæ communicate with each other by means

of the *spino-glenoid notch,* which lies outside the short lateral border of the spine, and transmits the suprascapular artery and nerve.

The **borders** are upper, medial, and lateral. The *upper border,* which is the shortest and thinnest, extends from the superior angle to the coracoid process. Close to that process it presents the *suprascapular notch.* This is converted into a foramen by the suprascapular ligament, which sometimes undergoes ossification. The suprascapular nerve passes backwards beneath the ligament, and the suprascapular artery over it, whilst the inferior belly of the omo-hyoid arises from its inner part and from the adjacent portion of the upper border. The *medial border* is known as the *base.* It is the longest, intermediate in thickness, and extends from the superior to the inferior angle. It is convex, and is divisible into three parts. One part represents the base of the small triangular surface by which the spine arises from the medial border, and it gives insertion to the rhomboid minor; another extends from this to the superior angle, and gives insertion to the levator scapulæ; and the third extends downwards to the inferior angle, and gives insertion to the rhomboid major. On the costal surface close to this border there is a long narrow linear impression, which widens towards the superior and inferior angles, and gives insertion to the serratus anterior. The *lateral border,* which is the thickest and intermediate in length, extends from the inferior angle to the lower margin of the glenoid cavity. Below that cavity it presents a rough impression, an inch long, called the *infraglenoid tubercle,* which gives origin to the long head of the triceps, and a little below this a groove for the circumflex scapular artery, which also marks the dorsal surface. The costal surface of the bone close to this border presents a groove over the upper two-thirds, which gives origin to many fibres of the subscapularis.

The **angles** are superior, inferior, and lateral. The *superior angle,* which is thin, is situated at the meeting of the upper and medial borders, and it forms the highest part of the body, being on a level with the second rib. Its costal surface gives insertion to a part of the serratus anterior, and its edge to a portion of the levator scapulæ. The *inferior angle,* somewhat thick and round, is situated at the meeting of the medial and lateral borders, and it forms the lowest part of the bone, being on a level with the seventh rib. Its costal surface gives insertion to a part of the serratus anterior, and its dorsal surface gives origin to a portion of the teres major. Below the impression for the latter muscle there is sometimes a rough semilunar marking for a slip of origin of the latissimus dorsi. The *lateral angle,* which is massive, is situated at the upper end of the lateral border. It forms the *head* of the bone, and supports the glenoid cavity, which articulates with the head of the humerus.

The **glenoid cavity,** so named from its shallowness, is pyriform, with the narrow end upwards, and its direction is outwards and forwards. Its margin is slightly elevated and rough for the labrum glenoidale, and immediately outside the margin the capsular ligament

of the shoulder-joint is attached. About a third of the way down the anterior part of this margin is a slight notch marking the attachment of the inferior gleno-humeral ligament, and comparable with the acetabular notch in the acetabulum. Superiorly it presents a small rough elevation, called the supraglenoid tubercle, which gives origin to the long head of the biceps. The *neck* is the constricted portion which extends from the suprascapular notch to a point immediately above the infraglenoid tubercle, and it is most evident posteriorly, where it forms, with the lateral border of the spine, the spino-glenoid

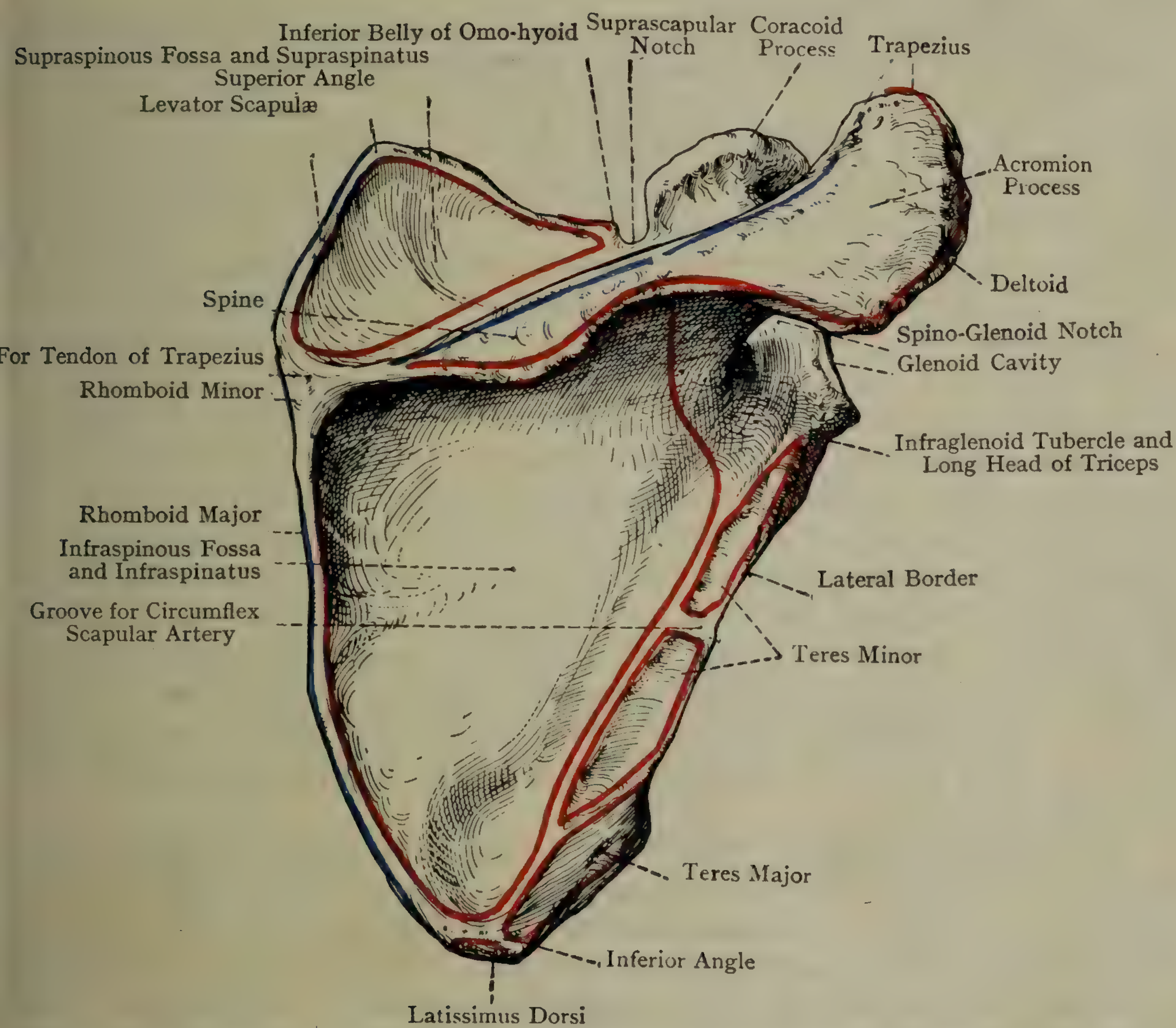


FIG. 181.—THE RIGHT SCAPULA (POSTERIOR VIEW).

notch. In this latter situation there are numerous foramina for branches of the suprascapular artery.

The **spine** is situated on the dorsum of the bone, which it crosses in a direction outwards and slightly upwards. It commences at the medial border in a flat triangular surface, over which the tendon receiving the lower fibres of the trapezius glides, with the intervention of a bursa. It soon becomes very prominent, and at its outer extremity it undergoes a slight twist and forms the acromion process. It is triangular, and compressed from above downwards. The *superior surface* forms part of the supraspinous fossa, and gives origin to fibres

of the supraspinatus, whilst the *inferior surface* forms part of the infraspinous fossa, and gives origin to fibres of the infraspinatus. The *lateral border*, which is short, bounds medially the spino-glenoid notch. The *anterior border* is continuous with the body of the bone. The *posterior border* or *crest* presents an upper lip, which gives insertion to part of the trapezius; a lower lip, giving partial origin to the deltoid; and an intervening rough surface which is encroached upon by the tendinous fibres of these two muscles. The upper lip is often very projecting at its inner end, where the tendon receiving the lower fibres of the trapezius is inserted.

The **acromion** is situated at the outer extremity of the spine, and its direction is outwards, upwards, and forwards, so as to overhang the glenoid cavity. It is somewhat triangular, and is compressed from above and behind downwards and forwards. The *postero-superior surface,* which is rough, gives origin at its lower part to some fibres of the deltoid, and elsewhere is subcutaneous. The *antero-inferior surface,* which is smooth and concave, overhangs the glenoid cavity, and is related to the subacromial bursa. The *outer border* is continuous with the lower lip of the posterior border of the spine, where there is a projection called the *acromial angle,* and this outer border gives origin to a portion of the deltoid by a series of tubercles. The acromial angle represents the metacromial process of comparative anatomy, and is a useful landmark for taking measurements of the arm. The *inner border* is continuous with the upper lip of the posterior border of the spine, near which it gives insertion to a part of the trapezius, whilst near the tip of the acromion it presents an oval facet for the outer extremity of the clavicle. The upper and lower margins of this facet are rough for the acromio-clavicular ligaments. The *tip* or *apex* of the process is situated at the meeting of the outer and inner borders. The acromion is pierced by many arterial twigs derived from the acrominal rete.

The **coracoid process,** which is strong and curved, springs from the upper aspect of the head immediately lateral to the suprascapular notch. It is directed at first upwards and forwards for about ½ inch, and then, bending sharply, it is directed forwards and outwards to terminate in a blunt tip. The *ascending portion* is compressed from before backwards. Its *anterior surface* is related to the subscapularis, and the *posterior* to the supraspinatus. Its *outer border* gives attachment to a portion of the coraco-humeral ligament, and the *inner border,* which bounds the suprascapular notch laterally, gives attachment at its upper part to the suprascapular ligament. The *horizontal portion* of the process is compressed from above downwards. Its *antero-medial border,* which is long and convex, and the adjacent portion of the superior surface, give insertion anteriorly to the pectoralis minor, whilst posteriorly they give attachment to the costo-coracoid ligament and the clavipectoral fascia. The *postero-lateral border,* which is short, receives the fibres of the coraco-acromial ligament, and gives attachment to a portion of the coraco-humeral ligament. At the back part

›f the antero-medial border there is the *conoid impression* for the conoid ›art of the coraco-clavicular ligament. On the back part of the superior ›urface there is the *trapezoid line*, for the trapezoid part of the coraco-›lavicular ligament, which extends forwards and outwards from the ›onoid impression, and the pectoralis minor is sometimes inserted into ›his surface and may make a groove upon it. The *inferior surface* of ›he horizontal portion is smooth and concave. The *tip* or *apex*, which ›s blunt, gives origin to the conjoined short head of the biceps and

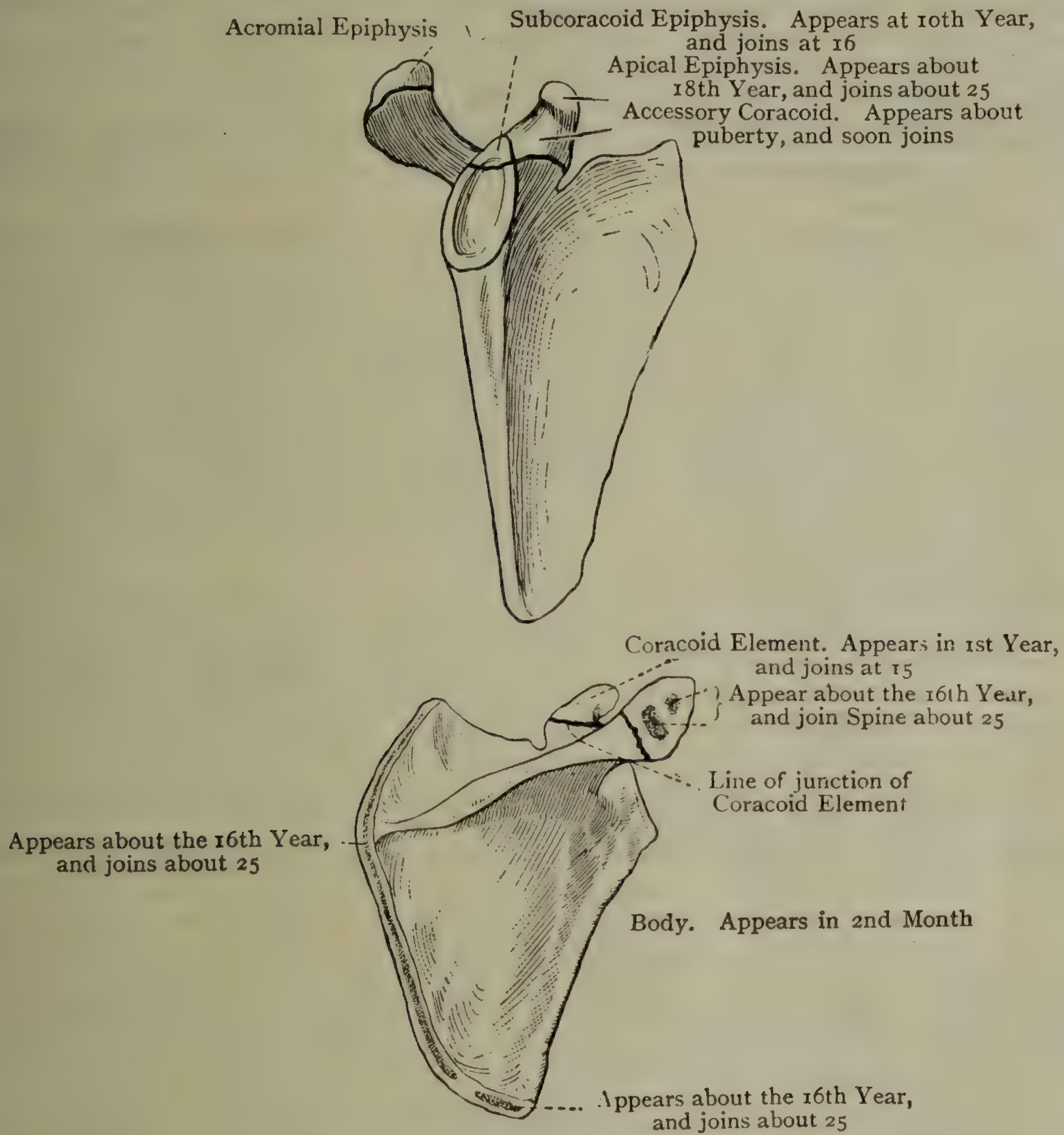


FIG. 182.—OSSIFICATION OF THE SCAPULA.

coraco-brachialis. It is useful to notice that the tip of the coracoid process forms a landmark for reaching the shoulder-joint from in front, just as the metacromial tubercle does behind.

The coracoid process of man represents the *coracoid bone* of monotremata and lower vertebrates.*

Articulations.—By its acromion process with the outer extremity of the clavicle, and by the glenoid cavity with the head of the humerus.

* Some morphologists, however, regard it as an ossified myocomma between the neck and shoulder muscles, in which case the mammalian clavicle may not be homologous with the reptilian.

Structure.—The scapula is a flat or tabular bone, and is composed of two tables of compact bone. In the head, lateral border, inferior angle, and processes there is cancellous tissue between the two tables, but in the central portions of the supra- and infraspinous fossæ there is none, and the two tables coalesce, so that the bone is very thin and transparent.

Varieties.—(1) Suprascapular foramen due to ossification of suprascapular ligament. (2) Fenestrated scapula, presenting one or more perforations in the subscapular fossa. (3) Separation of the acromion process, which may be connected with the spine by a plate of cartilage, or by fibrous tissue. (4) Imperfect synostosis of the coracoid process, which, however, is extremely rare. (5) An articular facet on the coracoid process for the clavicle.

Ossification.—The scapula has **one primary centre** and **eleven secondary centres.** The **primary centre** appears in the body a little distance from the neck about the *eighth week*.

The **coracoid process,** cartilaginous at birth, has **four secondary centres**—coracoid, subcoracoid, supracoracoid, and apical. The *coracoid centre* appears before the end of the *first year*, and gives rise to the chief part of the process, which joins about the *fifteenth year*. The *subcoracoid centre* appears about the *eighth to tenth year*, and soon joins the main coracoid. It forms the triangular part of the process which enters slightly into the *extreme upper and inner part* of the glenoid cavity. The *supracoracoid centre* appears about the *eighteenth year*, and forms a thin laminar epiphysis on the upper surface of the process. It joins about the *twenty-fifth year*. The *apical centre* appears about the *eighteenth year*, and forms an epiphysis which caps the tip of the process, and joins about the *twenty-fifth year*.

Acromial Process.—The inner or basal portion is ossified from the spine, which in turn is ossified from the primary centre for the body. The greater portion constitutes an epiphysis, which has **two secondary centres.** These appear about the *sixteenth year* and soon join. The acromial epiphysis usually joins the rest of the process about the *twenty-fifth year* or earlier. Union, however, may not take place, and then the acromial epiphysis forms a separate *acromial bone*, connected with the rest of the process by cartilage or by fibrous tissue, and this condition may simulate a fracture.

Glenoid Cavity.—The fundus or bed of this cavity is ossified from the primary centre for the body, and its extreme upper and inner part is formed from the subcoracoid centre. Besides these the cavity has two special secondary centres—superior and inferior. The superior glenoid centre appears about the *tenth year*, and it joins the fundus or bed of the fossa about the *sixteenth year*. The inferior glenoid centre appears about the *sixteenth year*, and forms the glenoid epiphysial plate. It joins about the *twentieth year*, and gives rise to the slight concavity of the fossa.

The other secondary centres are allocated as follows: (1) Posterior border of spine; (2) inferior angle; (3) base. These centres appear about the *sixteenth year*, and join about the *twenty-fifth year*. It must be realized that all these centres are not invariably present in any one specimen.

Generalized Shoulder-Girdle.

Fig. 183 shows a diagram of a generalized shoulder-girdle—that is to say, an ideal from which any existing arrangement may be obtained by a suppression or fusion of parts.

The glenoid cavity, where the humerus articulates, is the point of primary importance; it is fixed to the front of the double sternum by the coracoid, and another stay, the precoracoid, moors it to the

mid-ventral line of the root of the neck. This bar is usually perforated at its distal end by a foramen.

The ventral ends of the coracoid and precoracoid are connected by the epicoracoid.

The dorsal part of the glenoid cavity is formed by the scapula, a triangular plate with dorsal and ventral surfaces, which is still further fixed to the mid-ventral line of the neck by two membrane bones, the clavicle and interclavicle.

Where the clavicle is attached to the preaxial border of the scapula is a process representing the spine and acromion, and the medial border of the scapula articulates with another plate, the suprascapula, represented by the epiphyses of the medial border in the human shoulder-girdle.

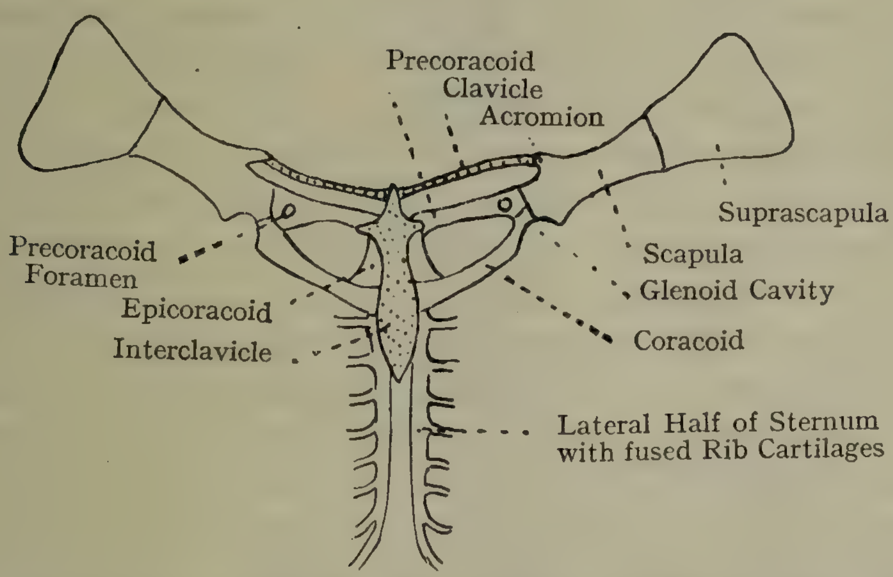


FIG. 183.—SCHEME OF GENERALIZED SHOULDER-GIRDLE.

The sternum is shown as two parallel bars, each formed by the union of the ventral ends of ribs which have fused.

The Humerus.

The **humerus** extends from the shoulder to the elbow, its direction being downwards and slightly inwards. It is a long bone, and is divisible into a shaft and two extremities, upper and lower.

The **upper extremity** includes the head, anatomical neck, greater and lesser tuberosities, commencement of the bicipital groove, and surgical neck. The **head,** which is almost hemispherical, is smooth, convex, and covered by cartilage. Its direction is upwards, inwards, and backwards, and it articulates with the glenoid cavity of the scapula. The *anatomical neck* is the constriction immediately beyond the cartilage of the head. It is best marked above, especially between the head and greater tuberosity, and it gives attachment to the capsular ligament of the shoulder-joint. It is pierced by numerous nutrient foramina. The **greater tuberosity** is situated obliquely on the outer surface, immediately beyond the anatomical neck. It presents three flat muscular impressions—an *upper* for the insertion of the supraspinatus, a *middle*

for the infraspinatus, and a *lower* for the teres minor, which latter muscle continues to take insertion into a rough marking on the shaft for at least ½ inch below the lower impression. The **lesser tuberosity** is an oval prominence situated on the anterior aspect immediately beyond the anatomical neck. It gives insertion to the subscapularis, which continues to take insertion into the adjacent part of the shaft for about ½ inch. The commencement of the bicipital groove, which lodges the long tendon of the biceps, lies between the two tuberosities, where it is bridged over by the transverse ligament. It presents a large nutrient foramen close to the greater tuberosity for an offset of the ascending branch of the anterior circumflex humeral artery. The *surgical neck* is the constriction below the tuberosities.

The upper extremity of the humerus receives its principal blood-supply from the anterior and posterior circumflex humeral arteries.

The **shaft** is almost cylindrical in its upper half, but it is laterally expanded and triangular in its lower half. The *anterior aspect* presents superiorly the *bicipital groove,* which commences between the tuberosities, where it is deep, and passes downwards and slightly inwards, terminating about the junction of the upper and middle thirds. It is bounded by two rough lips, lateral and medial. The lateral lip, which is the more prominent, gives insertion over about its lower three-fourths to the pectoralis major, this portion being called the *pectoral ridge.* It is in line with the anterior border of the lower half of the shaft. The medial lip gives insertion over about its lower two-thirds to the teres major, this portion being known as the *teres ridge.* It is in line with the medial border of the lower half of the shaft. The floor of the groove over about its middle third gives insertion to the latissimus dorsi. The groove is occupied by the long tendon of the biceps, invested by a tubular prolongation of the synovial membrane of the shoulder-joint, and the ascending branch of the anterior circumflex humeral artery. The *outer aspect* of the shaft presents a rough V-shaped mark, called the *deltoid tuberosity,* for the insertion of the deltoid. The point of the V, which is embraced by two slips of brachialis, is at the centre of the shaft, whence it extends upwards for about 2 inches. Its anterior margin is in line with the pectoral ridge, and its posterior margin bounds superiorly the lower part of the spiral groove. On the *inner aspect* of the shaft, about the centre, there is a rough line about 1½ inches long, placed in the course of the medial border, for the insertion of the coraco-brachialis. Immediately below this line is the principal **nutrient foramen** for the nutrient branch of the brachial artery, the canal to which it leads being directed *downwards.* The *posterior* and *lateral aspects* of the upper part of the shaft present a winding groove, called the **spiral groove,** for the radial nerve and profunda brachii vessels. It commences in the upper third posteriorly, and is directed downwards and forwards on to the lateral surface, where it terminates a little below and behind the apex of the deltoid tuberosity. The lower part of this groove is occupied by a pointed slip of brachialis. In the upper part of the groove there is usually a

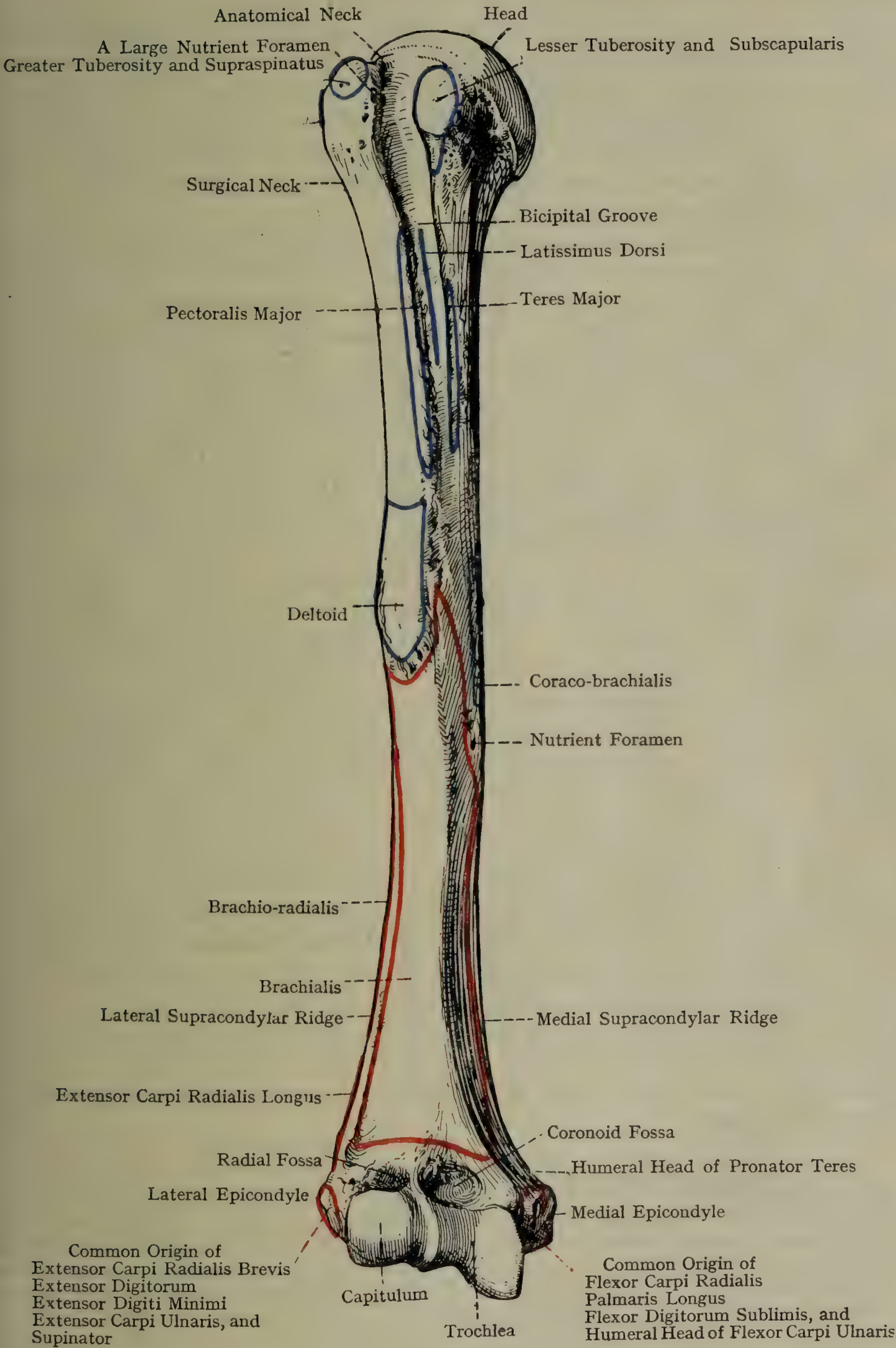


FIG. 184.—THE RIGHT HUMERUS (ANTERIOR VIEW).

nutrient foramen for a branch of the profunda brachii artery. On the posterior aspect of the shaft, over about its upper third, lateral to the spiral groove, there is a rough marking which gives origin to the lateral head of the triceps, extending as high as the lower part of the insertion of the teres minor. The medial head of the triceps commences to arise in a pointed manner from the back of the shaft medial to the spiral groove, where it reaches a little above the lower border of the tendon of the teres major.

The lower half of the shaft, being triangular, presents three surfaces and three borders. The *posterior surface*, which is flat, terminates at the olecranon fossa, and it gives origin to most of the fibres of the medial head of the triceps. The *lateral* and *medial surfaces*, as well as the anterior border which separates them, give origin to brachialis. The *anterior border*, which is round, separates the lateral surfaces, and is in line with the anterior margin of the deltoid tuberosity, and, above this, with the lateral lip of the bicipital groove. The *lateral border* is called the *lateral supracondylar ridge*. It is sharp and prominent, and extends from the lateral epicondyle to the spiral groove. It gives attachment to the lateral intermuscular septum. Anteriorly its upper two-thirds give origin to the brachio-radialis, and the lower third to the extensor carpi radialis longus. Posteriorly it gives origin to the medial head of the triceps. The *medial border* forms the *medial supracondylar ridge*, and is not so prominent as the lateral. It commences at the medial epicondyle, and it can be followed up through the line for the insertion of the coraco-brachialis into the medial lip of the bicipital groove. It gives attachment to the medial intermuscular septum. Anteriorly it gives origin to brachialis, posteriorly to the medial head of the triceps, and in its lower part to some fibres of the humeral head of the pronator teres. The medial surface of the shaft, in front of the medial supracondylar ridge, and about 2½ inches above the medial epicondyle, sometimes presents a sharp spur-like projection directed downwards, called the *supracondylar process*. When present it gives attachment to a fibrous band which passes to the medial epicondyle, and gives origin to a third head of the pronator teres. In such cases the band forms an arch through which the median nerve passes, and frequently the brachial artery. The supracondylar process represents a portion of bone which forms a supracondylar foramen in many vertebrates.

There is a very archaic lizard called Sphenodon, in which there is not only this entepicondylar foramen for the median nerve on the inner side of the humerus, but an ectepicondylar foramen for the radial nerve on the outer side. It has been suggested that the shaft of the humerus between the two foramina and the bars bounding the foramina on each side represent the remnants of three fin rays of the pectoral limb of the fish. Be this as it may, the process in man sometimes causes trouble and difficulty in diagnosis.

The **lower extremity** presents at either side the medial and lateral epicondyles, and inferiorly a transversely elongated articular surface covered by cartilage, and divided by a vertical curved ridge into a

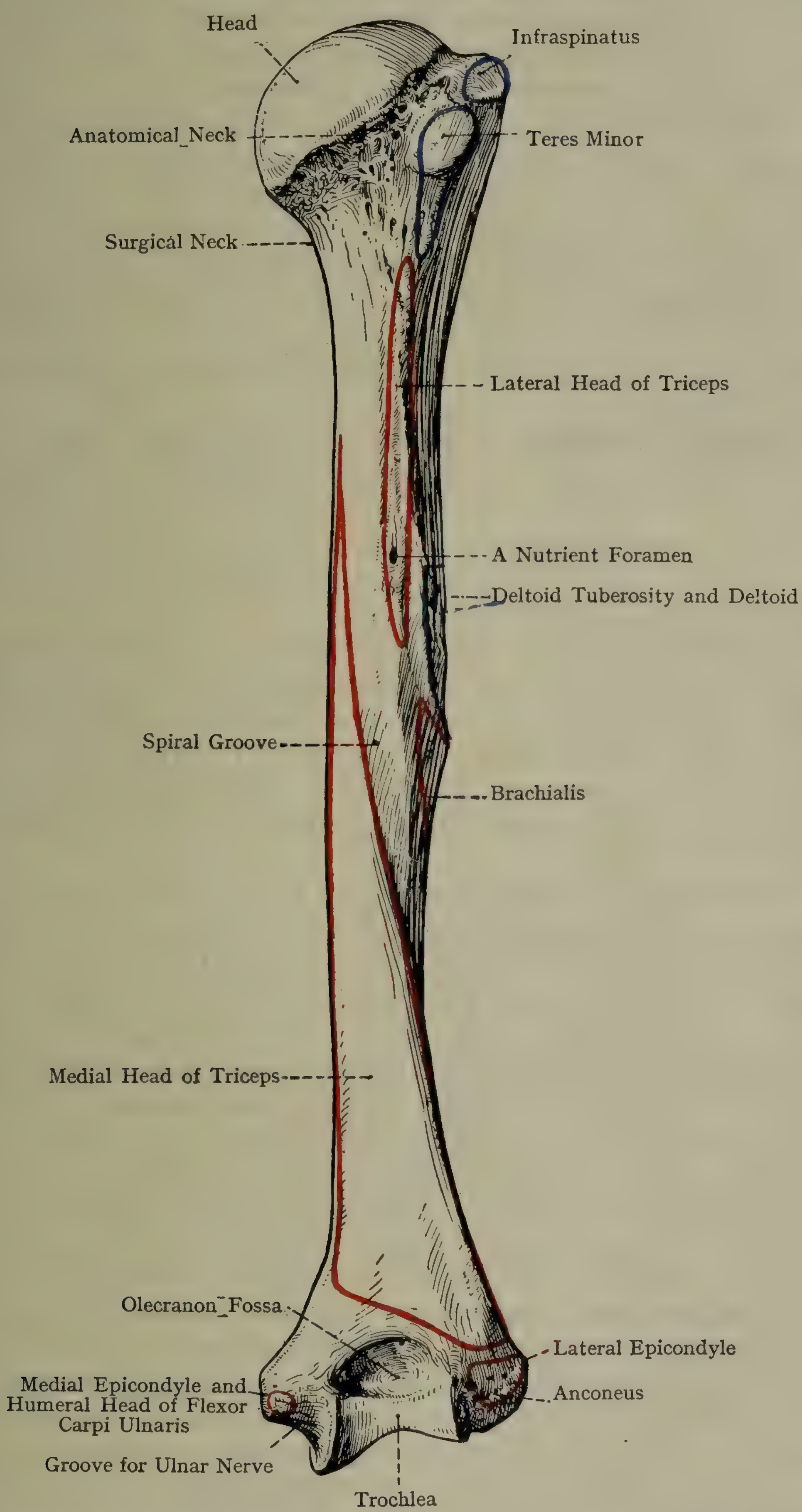


FIG. 185.—THE RIGHT HUMERUS (POSTERIOR VIEW).

lateral part, called the capitulum, and a medial, called the trochlea. Above the capitulum in front there is a rough transverse depression, called the radial fossa. Above the trochlea in front is the coronoid fossa, and above it posteriorly is the olecranon fossa.

The **medial epicondyle** (*epitrochlea*) is very prominent, and is directed inwards and slightly backwards. Its lower part and the adjacent portions of its anterior and posterior aspects give attachment to the medial ligament of the elbow-joint. Its anterior aspect gives origin to the common tendon of the humeral head of the pronator teres, flexor carpi radialis, palmaris longus, part of the flexor digitorum sublimis, and the humeral head of the flexor carpi ulnaris. Behind the medial epicondyle, close to the trochlea, is the *ulnar groove*, through which the ulnar nerve passes.

The **lateral epicondyle** is much less prominent than the medial. Anteriorly it gives origin to the common tendon of the extensor carpi radialis brevis, extensor digitorum, extensor digiti minimi, extensor carpi ulnaris, and supinator. Posteriorly it presents an impression for the anconeus, and inferiorly a depression near the capitulum for the lateral ligament of the elbow-joint.

The **capitulum** mainly takes the form of a rounded eminence. It is limited to the anterior and inferior aspects of the bone, and articulates with the cup-shaped depression on the head of the radius. Medial to the rounded portion there is a groove for the play of the inner convex part on the head of the radius. The *radial fossa* receives the anterior margin of the head of the radius in complete flexion of the elbow-joint.

The **trochlea** is pulley-shaped, and turns completely round from the front to the back of the bone, becoming rather broader posteriorly. It is concave from side to side, and convex from before backwards. The medial border is more prominent and thicker than the lateral, and extends lower down. As viewed from in front, the borders are inclined downwards and slightly inwards, but posteriorly they incline upwards and slightly outwards, and so the trochlea is here brought into the centre of the bone. The trochlea articulates with the trochlear of the ulna. The *coronoid fossa* receives the coronoid process of the ulna in flexion of the elbow-joint, and the anterior ligament is attached just above it. The *olecranon fossa*, much larger than the coronoid, receives the olecranon process of the ulna in extension of the joint, and its margins give attachment to the posterior ligament. The portion of bone which separates the two fossæ is thin, and is sometimes perforated by a foramen, called the *supratrochlear foramen*.

In the vicinity of the lower extremity there are numerous nutrient foramina for branches of the profunda, ulnar collateral, and supratrochlear of the brachial, radial and ulnar recurrent, and interosseous recurrent, arteries.

Articulations.—*Superiorly* with the scapula, and *inferiorly* with the radius laterally, and ulna medially.

Structure.—The shaft is composed of compact bone, which is

ıicker at the centre than at the extremities. It contains a medullary ınal, lined with a thin coating of cancellated tissue, which does not each higher than the surgical neck of the bone. The articular ex-remities are filled with cancellated tissue, except at the surface, where ıere is a thin layer of compact bone.

Varieties.—These are (1) a supracondylar process, and (2) a supratrochlear ramen.

Ossification.—The centre for the shaft appears in the sixth to seventh week, nd at birth both ends are usually cartilaginous: there is often a centre present t birth, however, in the head of the bone, probably more commonly in girls. he upper end (the growing end) has three centres—for the articular head and ıch of the tuberosities. That r the head appears usually ı the first few months after irth (M.), that for the greater ıberosity within the year (F.) just after this (M.), while the ntre for the lesser tuberosity ɔmes between four and five; l these centres are rather ariable. They fuse together, rming a compound *proximal piphysis*, at four to five in ɔys, about a year earlier in rls. The whole epiphysis joins e shaft at about twenty (M.), ut in women about eighteen.

The lower end has four econdary centres, the most edial of which is separated om the others by a downward rolongation of the shaft. The ıpitular centre appears first the second to third year. hat for the medial epicondyle, e separated centre, shows in e fifth (F.) to eighth (M.) year. The trochlear centre is found at nine (F.) or n (M.), and that for the lateral epicondyle about two years later. The shaft ssification extends down about the time of puberty between the trochlear and edial epicondylar centres. The others join together to form a *lower epiphysis*, hich fuses with the shaft at about fourteen in girls and seventeen in boys; e medial epicondyle joins the shaft about a year or less afterwards.

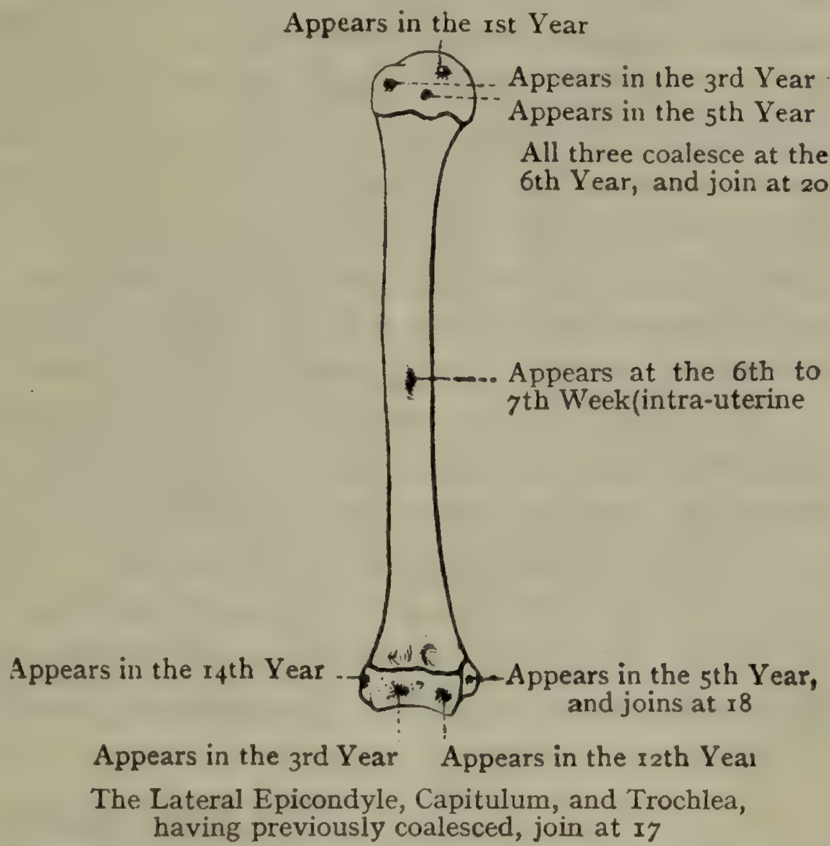


FIG. 186.—OSSIFICATION OF THE HUMERUS (M.).

Epiphyses and the Law of Ossification.

The **law of ossification** applicable to long bones with an epiphysis r epiphyses at either end is as follows: *the epiphysis or epiphyses, at e end towards which the nutrient foramen and the canal to which it leads re directed, are the last to show signs of ossification, but they are the first join the shaft.* The only exception to (a part of) this rule occurs in e *fibula.*

It is obvious that a bone will make most growth at that end where e epiphysial line remains longest, and we have seen, in the case of e clavicle, that the nutrient artery runs away from the growing end f the bone.

It has now only to be realized that the artery nearly always ru towards the elbow and away from the knee, and it follows that t bones of the upper extremity grow from the ends away from t elbow, while in the lower extremity they grow from the ends neare the knee. Whether the epiphyses appear early or late seems to ha no influence on the growth of a bone; indeed, it does not make a difference whether there is a bony epiphysis or not until that epiphy fuses with the shaft and the epiphysial line is thus obliterated.

We have seen that the epiphysis of the clavicle does not appe until eighteen, but by that time the bone is almost fully grown. It interesting to note that in the tailed amphibia (newts, etc.) the epiphys remain cartilaginous throughout life, while in birds no bony epiphys occur, but the bony shaft grows to the very end of the cartilage, a growth stops when the epiphysial line has reached the articular surfac

It will be obvious that the epiphyses of the humerus are divid into two perfectly distinct groups. One of these, comprising t head, the capitulum, and the trochlea, consists of articular or *pressu* epiphyses, and these are the ones which, by their fusion with the sha eventually stop the growth of the bone.

Another group, consisting of the greater and lesser tuberosities a the two epicondyles, are non-articular and associated with the pull muscles, and so are often spoken of as *traction* epiphyses.

A third variety of epiphyses, not present in the humerus, but inc cated in the coracoid process and medial border of the scapula, represe parts of the skeleton which were once of greater importance than the are now; and for these the name of *atavistic* epiphyses is suggested.

The Radius.

The **radius** is the lateral bone of the forearm (which is assume to be in a position of supination). It is parallel with, and shorter tha the ulna, and extends from the elbow to the wrist. It is a long bon and is divisible into a shaft and two extremities.

The **upper extremity** presents a head and neck. The **head** is dis shaped, and covered by cartilage, both on its upper surface and ci cumference. The *upper surface*, at its centre, presents a depressio which articulates with the rounded portion of the capitulum of th humerus in flexion of the elbow-joint. Around this depression th surface is convex, especially on the inner side, and this portion glide on the inner grooved part of the capitulum. The circumferentia cartilage is deeper on the inner aspect than elsewhere, and this portio articulates with the radial notch of the ulna, whilst the remainde plays within the orbicular ligament. The constricted portion below th head is called the **neck.** It is cylindrical, and its upper part is embrace by the annular ligament, whilst beyond this on the outer and fron aspect it gives insertion to a few fibres of the supinator. The uppe extremity presents several nutrient foramina for branches of the radia recurrent and interosseous recurrent arteries.

The **shaft** increases in size from above downwards, and is curved, he convexity being directed outwards and slightly backwards. This urve imparts elasticity to the bone, and guards it against the shocks o which it is so much exposed from the fact that it supports the hand. The shaft is triangular, and presents superiorly, on its antero-medial ispect just below the neck, an oval eminence, called the *tuberosity of adius.* This is divided vertically into two parts, a rough posterior portion which gives insertion to the tendon of the biceps, and a smooth interior part which is separated from that tendon by a bursa. Below he radial tuberosity the shaft presents three borders and three suraces. The *anterior border* extends from the lower and anterior part of the tuberosity to the anterior border of the styloid process. In its ipper third it crosses the shaft obliquely downwards and outwards, his portion of it being called the *anterior oblique line.* This line imits laterally the insertion of supinator, and medially the origin of the lexor pollicis longus, whilst its prominent edge gives origin to the hin radial portion of the flexor digitorum sublimis. The *interosseous order* commences at the lower and back part of the radial tuberosity, ind near the lower extremity of the shaft it divides into two ridges, which pass to the anterior and posterior margins of the ulnar notch. At its commencement it is round and indistinct, and immediately below the tuberosity it gives attachment to the oblique cord. Over he rest of its extent it is sharp and wiry for the attachment of the nterosseous membrane, which is also connected with the posterior of he two lower divisions. The *posterior border* extends from the back of he tuberosity to the prominent dorsal tubercle about the centre of the posterior border of the lower extremity. In its upper third it crosses he shaft obliquely downwards and outwards, this portion of it, which is prominent, being called the *posterior oblique line.* This line imits the insertion of supinator above, and the origin of the abductor pollicis longus below.

The *anterior surface* is situated between the anterior and interosseous borders. In the upper two-thirds it is concave, and gives origin to the flexor pollicis longus. In the lower third it is flat and xpanded, and this portion gives insertion to the pronator quadratus, xcept close to the anterior border of the lower extremity, where it ives attachment to the anterior radio-carpal ligament of the wristoint. The anterior surface presents the **nutrient foramen** about the unction of the upper and middle thirds. The direction of the canal o which it leads is *upwards,* and it gives passage to the nutrient branch f the anterior interosseous artery. The portion of bone between the nterior oblique line, the lower part of the front of the neck, and the uberosity gives insertion to a portion of supinator. The *lateral surface* s situated between the anterior and posterior borders. It is convex rom above downwards, and from side to side. In its upper third it ives insertion to supinator; at its centre there is a rough impression, ully an inch long, for the insertion of pronator teres; and below this supports the tendons of the extensores carpi radialis longus et brevis

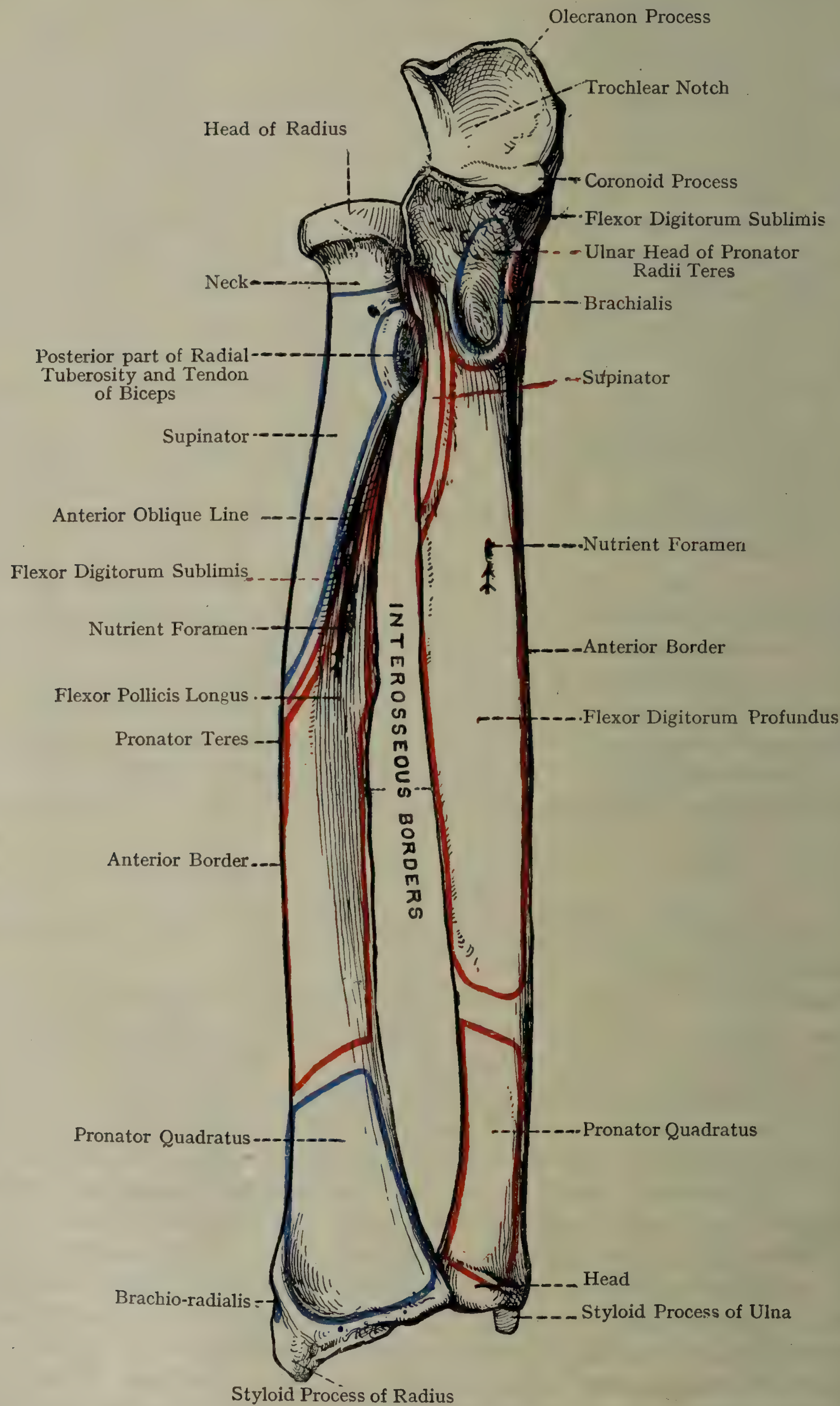


FIG. 187.—THE RIGHT RADIUS AND ULNA (ANTERIOR VIEW).

nd is crossed obliquely by the tendons of the abductor pollicis longus nd extensor pollicis brevis. The lateral surface also supports the rachio-radialis, which is inserted into its lower extremity close to the ase of the styloid process. The *posterior surface* is situated between he posterior and interosseous borders. Above the posterior oblique ne it is covered by supinator, which takes insertion into its outer alf. Below the posterior oblique line it is concave over about the niddle third, where it gives origin from above downwards to the bductor pollicis longus and extensor pollicis brevis. The lower third s broad and convex, and it supports the tendons of the extensor ollicis longus, extensor digitorum, and extensor indicis.

The **lower extremity** is large and cuboidal. Laterally it presents he styloid process, medially the ulnar notch, and inferiorly the carpal rticular surface, the latter two being covered by cartilage. The **tyloid process** projects downwards as a stout conical process, terminatng in a round tip which gives attachment to the lateral ligament of the vrist-joint. The inner surface is covered by the cartilage of the carpal rticular surface. The outer surface presents a groove directed downvards and slightly forwards, and subdivided into two compartments, he anterior of which transmits the tendon of the abductor pollicis ongus, and the posterior that of the extensor pollicis brevis. This roove is separated from the pronator surface in front by a prominent ubcutaneous ridge which gives attachment to the extensor retinacuum. The anterior surface supports a portion of the radial artery.

The **ulnar notch** is concave from before backwards, and articulates vith the outer convex surface of the head of the ulna.

The **carpal articular surface** is of large size, and its plane is oblique, eing sloped outwards and a little downwards. It is concave from efore backwards, and from side to side, and is divided into two parts y an antero-posterior elevation. The outer division is triangular, its artilage being prolonged on to the inner surface of the styloid process, nd it articulates with the scaphoid bone. The inner division is quadilateral, and articulates with the lunate bone. It is separated from the lnar notch by a sharp concave margin, which gives attachment to he base of the triangular interarticular disc. Immediately above the nterior border there is a rough surface for the attachment of the nterior radio-carpal ligament. The posterior border is on a slightly ower level than the anterior, and is irregularly convex. It presents bout its centre a prominent elevation, called the *dorsal tubercle*, nd is divided into three grooves—outer, middle, and inner. The *uter groove*, which is broad, is bounded laterally by a ridge which sepaates it from the groove on the outer surface of the styloid process, and nedially by the dorsal tubercle. It is usually subdivided by a faint ine into two compartments, the outer of which transmits the tendon f the extensor carpi radialis longus, and the inner that of the extensor arpi radialis brevis. The *middle groove*, narrow and deep, is directed rom above downwards and outwards, and is bounded laterally by the lorsal tubercle, which slightly overhangs it, and medially by an oblique

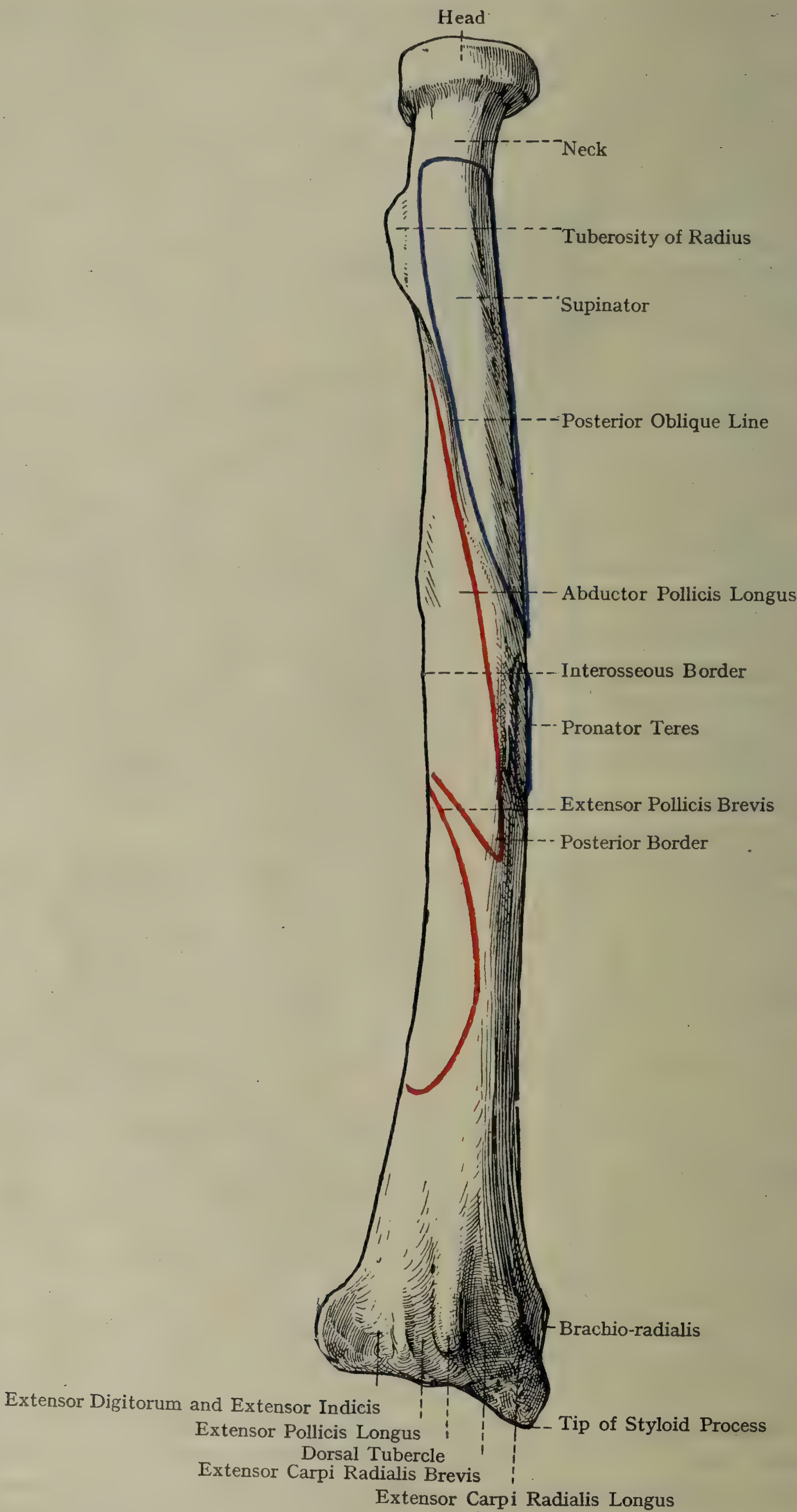


FIG. 188.—THE RIGHT RADIUS (POSTERIOR SURFACE).

idge separating it from the inner groove. It transmits the tendon of he extensor pollicis longus. The inner groove is single, and transmits he tendons of the extensor digitorum, the extensor indicis, the posterior nterosseous nerve, and the anterior interosseous artery. It is separated rom the ulnar notch by a sharp ridge which, with the ulna in position, ounds a groove for the tendon of the extensor digiti minimi. The

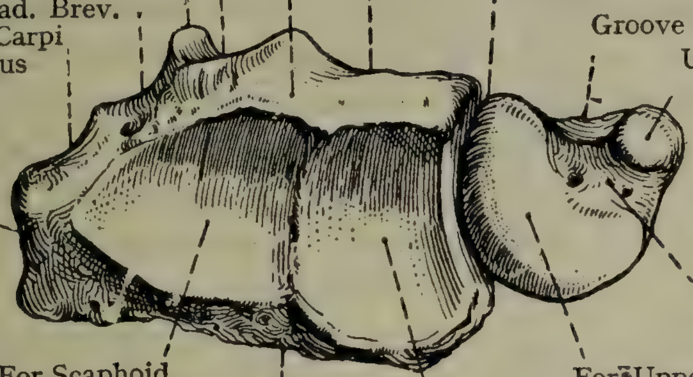


FIG. 189.—THE LOWER ENDS OF THE LEFT RADIUS AND ULNA AS SEEN FROM BELOW IN PRONATION.

The dorsal aspect is upwards.

idges separating the grooves give attachment to deep expansions of he extensor retinaculum ligament, which, with the ligament, convert he grooves into fibro-osseous canals.

The lower extremity presents several nutrient foramina for branches of the anterior and posterior interosseous arteries, and anterior and oosterior carpal networks.

Articulations.—*Superiorly* with the capiulum of the humerus and radial notch cavity of the ulna, and *inferiorly* with the head of he ulna, scaphoid, and lunate.

Structure.—This is similar to that of long oones. At the lower extremity the cancellous issue extends upwards for about $1\frac{1}{2}$ inches above the styloid process, this level being the ite of Colles' fracture.

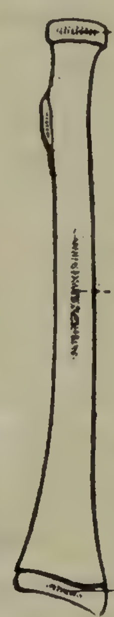


FIG. 190.—OSSIFICATION OF THE RADIUS (M.).

Ossification.—A shaft centre appears in the seventh veek; the ends and tuberosity are cartilaginous at oirth. The distal (growing end) centre comes in the econd year in boys, in the first year in girls. Union vith the shaft about nineteen or later in boys, and at seventeen or earlier in girls.

The centre for the head appears from four to six, he earlier dates for girls.

The tuberosity is formed by the main shaft centre, but occasionally an epiphysial cap develops on it about puberty, with junction in a short time.

The Ulna.

The **ulna** is the medial bone of the forearm (which is assumed to be in a position of supination). It is parallel with, and longer than, the radius, and extends from the elbow to the wrist, being separated from the latter joint by the triangular interarticular disc. It is a long bone, and is divisible into a shaft and two extremities, the upper of which is of large size.

The **upper extremity** presents the olecranon and coronoid processes, and the trochlear and radial notches. The **olecranon** forms the highest part of the bone, and is curved forwards at its upper part. It is largely subcutaneous. Superiorly it presents a broad, flat, quadrilateral surface, at the back part of which is a rough elevation for the insertion of the triceps. In front of this there is a smooth area where a bursa intervenes between that muscle and the bone when the elbow is flexed. At its anterior part, near the anterior margin, there is a narrow transverse impression for part of the posterior ligament of the elbow-joint. The superior surface is limited anteriorly by a sharp convex border, projected at its centre into a process, called the *beak,* which overhangs the upper part of the trochlear notch, and is received into the olecranon fossa of the humerus in extension of the joint. The anterior surface is directed downwards and forwards, and forms the upper part of the trochlear notch. The posterior surface, smooth, flat, and triangular, is subcutaneous, and covered by a bursa. The inner surface presents a tubercle for the ulnar head of the flexor carpi ulnaris, and the inner border gives attachment to the posterior part of the medial ligament of the elbow-joint. The outer surface gives insertion to a portion of the anconeus, and the outer border gives attachment to fibres of the posterior ligament of the joint.

The **coronoid process** is pyramidal, with the base attached to the rest of the ulna, and the linear apex directed forward. The superior surface forms the lower and anterior part of the trochlear notch. The inferior surface is rough and concave, and the roughness is prolonged upon the anterior surface of the shaft for about an inch, giving rise to a triangular impression, the inner half of which gives insertion to brachialis. The upper part of this surface, close to the anterior border of the process, affords attachment to the anterior ligament of the elbow-joint. The lower pointed portion presents laterally a rough prominence, called the *tuberosity,* which gives insertion to fibres of brachialis, and attachment to the oblique cord. The anterior margin is sharp, convex, and curved slightly upwards, and it is projected at its outer part into a process, called the *beak,* which is received into the coronoid fossa of the humerus in flexion of the elbow-joint. The inner surface gives attachment to the anterior portion of the medial ligament of the elbow-joint, and at its upper part it presents a tubercle for the ulnar head of the flexor digitorum sublimis. Leading downwards from this there is a short ridge for the origin of the deep head of the pronator teres, below which a slip of the flexor pollicis longus sometimes arises. Behind

the flexor sublimis tubercle there is a depressed surface which gives origin to the highest fibres of the flexor digitorum profundus. The outer surface presents the radial notch.

The **trochlear notch,** which articulates with the trochlea of the humerus, when viewed from the side, forms half a circle. The upper half of the cavity is formed by the anterior surface of the olecranon process, and the lower half by the upper surface of the coronoid process. It is constricted at the centre by a notch at either side, which marks the meeting of the olecranon and coronoid processes, the inner notch being bridged over by a fibrous band with which the middle part of the medial ligament of the elbow-joint blends. The cartilage of the cavity is sometimes broken up at this part by a narrow, rough, transverse interval. Extending from the beak of the olecranon to the beak of the coronoid there is a longitudinal elevation, which divides the cavity into two.

The **radial notch,** which is situated on the outer surface of the coronoid process, is concave from before backwards, and articulates with the inner aspect of the head of the radius. Its anterior and posterior margins give attachment to the cornua of the annular ligament.

The upper extremity presents several nutrient foramina for branches of the anterior and posterior ulnar recurrent and interosseous recurrent arteries.

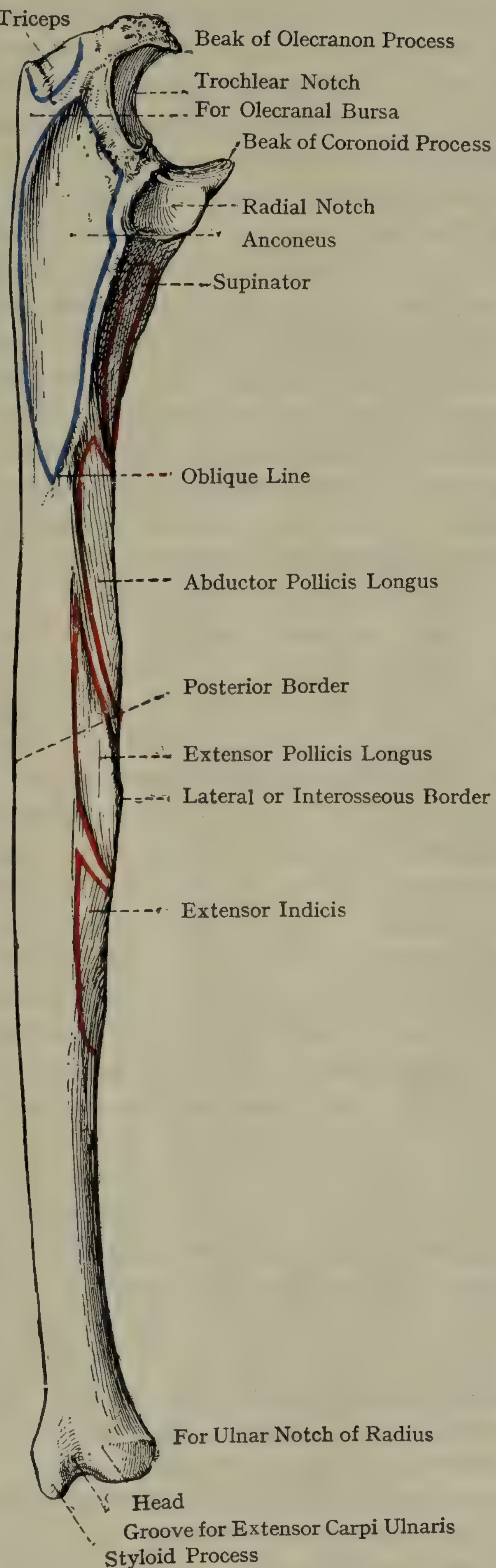


FIG. 191.—THE RIGHT ULNA (POSTERIOR SURFACE).

The **shaft** diminishes in size from above downwards, and is triangular in its upper three-fourths, where it is slightly curved, with the convexity directed backwards. In the lower fourth it is slender and subcylindrical, being flattened in front. It presents three borders and three

surfaces. The *anterior border* extends from the flexor sublimis tubercle on the inner margin of the coronoid process to the front of the styloid process. Over its upper three-fourths it is round, and gives origin to fibres of the flexor digitorum profundus. Over its lower fourth it is sharp, and gives origin to the pronator quadratus. The *posterior border* extends from the apex of the triangular subcutaneous surface on the back of the olecranon to the back of the styloid process. Over its upper two-thirds it gives attachment to a strong aponeurosis, and common origin to the flexor and extensor carpi ulnaris, and flexor digitorum profundus, but the practical point about it is that it is subcutaneous from the olecranon to the styloid processes, and by running a finger down it a fracture may be detected easily. The *lateral* or *interosseous border* extends from the apex of the bicipital hollow, about 2 inches below the radial notch, to the outer aspect of the head. Over the middle three-fifths of the shaft it is sharp and prominent, but over the lower fifth it is very faint. It gives attachment to the interosseous membrane.

The *anterior surface* is situated between the anterior and interosseous borders. It is concave over its upper three-fourths, and gives origin to part of the flexor digitorum profundus. The lower fourth is flat, and gives origin to the pronator quadratus. This surface presents the **nutrient foramen** a little above the centre, the direction of the canal to which it leads being *upwards*. It gives passage to the nutrient branch of the anterior interosseous artery. The *medial surface* is situated between the anterior and posterior borders. Over its upper two-thirds it gives origin to part of the flexor digitorum profundus, the lower portion being subcutaneous. The *posterior surface* is situated between the posterior and interosseous borders, and is directed backwards and outwards. It presents superiorly the *oblique line*, which extends from the supinator ridge on the posterior margin of the bicipital hollow to the posterior border at the junction of the upper and middle thirds. The triangular portion above this line is called the *anconeal surface*, which extends over the outer surface of the olecranon. It gives insertion to the anconeus. The posterior surface, below the oblique line, is divided into two lateral parts by a vertical ridge. The inner portion has the extensor carpi ulnaris playing over it, and the outer gives origin, from above downwards, to the abductor pollicis longus, extensor pollicis longus, and extensor indicis. On the outer aspect of the shaft superiorly there is a triangular depression, which commences immediately below the small radial notch, and extends downwards for about 2 inches. It is bounded in front and behind by prominent lips, the anterior of which passes above into the outer margin of the coronoid process, and the posterior into the posterior margin of the radial notch. The upper part of the posterior lip, which is prominent, is called the *supinator ridge*, and it gives origin to a part of supinator. The two lips form by their meeting the commencement of the lateral or interosseous border. The anterior part of this surface superiorly receives the tuberosity of the radius, with the tendon of inser-

tion of the biceps, in pronation, whilst the posterior part gives origin to fibres of supinator.

The **lower extremity** is small, and presents a head and styloid process. These are separated behind by a groove for the tendon of the extensor carpi ulnaris, and below by a rough pit which gives attachment to the apex of the triangular interarticular disc. The outer aspect of the **head** is convex, and covered by cartilage for articulation with the ulnar notch of the radius, a portion of the synovial membrane, called *membrana sacciformis*, intervening. The inferior surface, also covered by cartilage, is flat, and is related to the upper surface of the triangular interarticular disc.

The **styloid process,** of small size and subcutaneous, projects downwards from the posterior and inner part of the head (mainly from the back part), and it terminates in a round tip which gives attachment to the medial ligament of the wrist-joint.

When the hand is pronated it must be realized that the knob on the ulnar side of the wrist, which forms such a prominent landmark, is not the back, but the front of the head of the ulna.

The lower extremity presents several nutrient foramina for branches of the anterior and posterior interosseous arteries.

Articulations.—*Superiorly* with the trochlea of the humerus, and the inner aspect of the head of the radius; *inferiorly* with the ulnar notch of the radius, and the triangular interarticular disc, the latter structure separating it from the os triquetrum.

Structure.—This is similar to that of long bones.

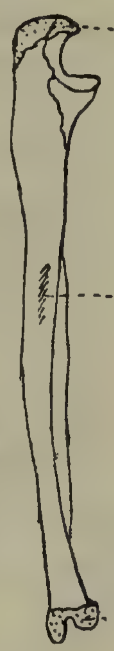


FIG. 192.—OSSIFICATION OF THE ULNA (M.).

Ossification.—The ulna ossifies in cartilage from **one primary,** and **two secondary, centres.** The centre for the shaft appears during the seventh week: this forms the coronoid process by extension. The ends of the bone are cartilaginous at birth. The epiphysial centre for the lower end appears at about five to six years in boys, about six months earlier in girls. They unite with the shaft at nineteen (M.) or seventeen (F.) approximately.

The centre for the olecranon appears about ten (M.) or eight (F.), and joins the shaft about seventeen (M.) or fourteen to fifteen (F.). It only forms the recurved piece of the olecranon, and there is often an additional centre for the tip.

An occasional accessory centre for the styloid process is described.

The Carpus.

The **carpus** or wrist is composed of eight short bones, which are arranged in two rows, four in each row. The rows are called *first* or *proximal,* and *second* or *distal.* The bones of the first row, from without

inwards, are called scaphoid, lunate, triquetral, and pisiform; whils those of the second row, in a similar order, are named trapezium trapezoid, capitate, and hamate.

The Scaphoid Bone.

The **scaphoid bone,** which is characterized by its boat-like shape lies with its long axis oblique, the broad end being directed upward and inwards, and the narrow end or prow downwards, outwards, anc forwards. *Superiorly* it presents a convex articular surface for th radius, which encroaches on the dorsal aspect. *Inferiorly* it als presents a convex articular surface directed downwards, outwards and backwards, which likewise encroaches on the dorsal aspect, anc is divisible into two parts—an outer for the trapezium, and an inne for the trapezoid. The *medial surface* presents two articular facets—a superior, crescentic, narrow from above downwards, and looking inwards for the lunate; and an inferior, large, concave, and directed downward

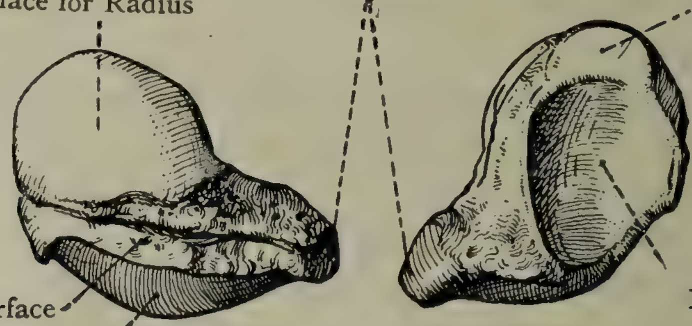


FIG. 193.—THE RIGHT SCAPHOID BONE.

A, posterior view; B, medial view.

as well as inwards, for the outer side of the head of the capitate. The *lateral aspect* takes the form of a rough border, extending from the radial surface to the tubercle, and giving attachment to the lateral ligament of the wrist-joint. At its lower end there is a prominent *tubercle,* directed forwards, which gives attachment to fibres of the flexor retinaculum and abductor pollicis brevis. The *palmar surface* is rough and triangular. The *dorsal surface,* being encroached upon by the superior and inferior convex articular surfaces, is reduced to a rough oblique groove for the posterior ligament of the wrist.

The tubercle of the scaphoid is a useful surgical landmark, and can be felt on the outer side of the wrist just below the styloid process of the radius.

Articulations.—*Superiorly* with the radius, *inferiorly* with the trapezium and trapezoid, and *medially* with the lunate and capitate.

The Lunate Bone.

The **lunate bone** is characterized by the crescentic concavity on its nferior surface. *Superiorly* it presents a quadrilateral, convex, artic-ılar surface for the radius, which encroaches on the dorsal aspect. The *inferior surface* is deeply concave from before backwards. The ;reater part of it articulates with the upper surface of the head of the :apitate, and the narrow inner strip with the upper border of the ıamate. The *lateral surface,* narrow from above downwards, presents ı crescentic facet for the scaphoid. The *medial surface,* which is nclined downwards and outwards, is deep from above downwards, ınd presents a quadrilateral facet for the triquetral. The *palmar* and *lorsal surfaces* are rough, the former being large, convex, and quadri-ateral, and the latter small and flat.

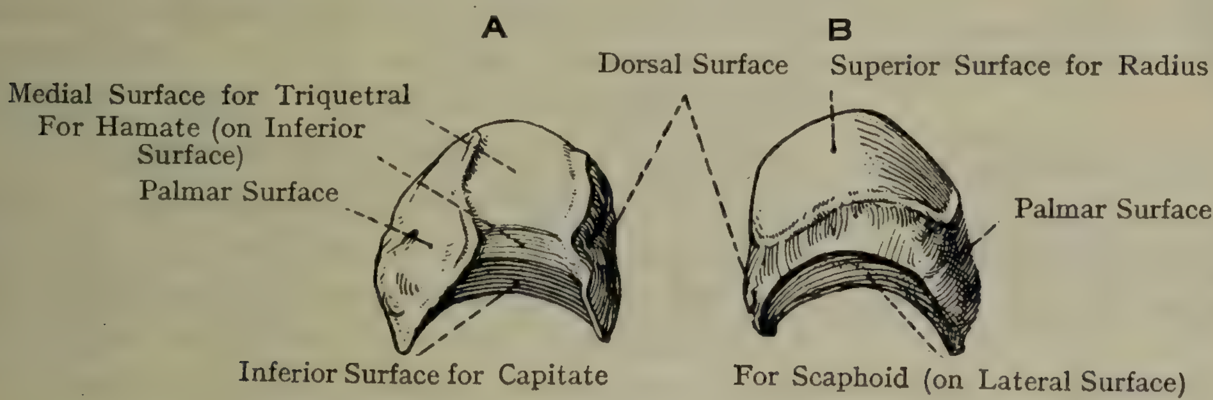


FIG. 194.—THE RIGHT LUNATE BONE.
A, medial view; B, supero-lateral view.

Articulations.—*Superiorly* with the radius, *inferiorly* with the :apitate and hamate, *laterally* with the scaphoid, and *medially* with the riquetral.

The Triquetral Bone.

The **triquetral bone** is characterized by its resemblance to a wedge, r pyramid, and it lies obliquely with the base directed outwards and ıpwards. The *lateral surface,* which corresponds with the base, resents a quadrilateral facet for the unate. The *medial surface,* which epresents the rounded apex, is of imited extent, and rough for the nedial ligament of the wrist-joint. The *palmar surface* has a circular, lean-cut, flat facet, which occupies ather more than the inner and lower ıalf, and articulates with the pisi-orm, the rest of the surface being ough. The *supero-posterior surface* is divisible into two parts, outer nd inner. The outer portion, which is close to the base, presents convex facet for the inferior surface of the triangular interarticular isc. The inner portion is marked by two rough oblique grooves,

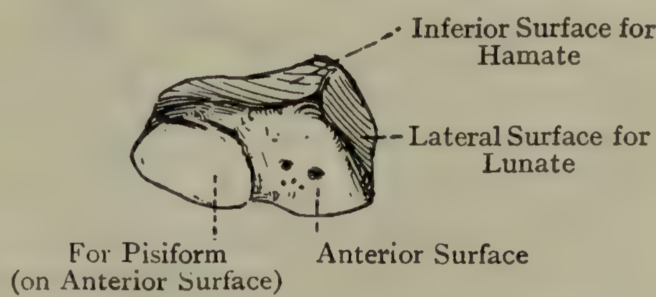


FIG. 195.—THE RIGHT TRIQUETRAL BONE (ANTERIOR, LATERAL, AND INFERIOR SURFACES).

superior and posterior, separated by a ridge which is dorsally placed. The *inferior surface* presents a large triangular facet, concavo-convex from without inwards, for the hamate.

Articulations.—*Superiorly* with the triangular interarticular disc, *inferiorly* with the hamate, *laterally* with the lunate, and *anteriorly* with the pisiform.

The Pisiform Bone.

The **pisiform bone,** as its name implies, is pea-shaped, and is placed in front of the triquetral, which constitutes its only articulation. It is an irregular sphere, except *posteriorly*, where it presents over its upper three-fourths a circular, flat facet for the triquetral, the lower fourth being non-articular. The long axis of the bone is directed downwards and slightly outwards. The *palmar surface* gives attachment superiorly to the flexor carpi ulnaris, inferiorly to the piso-hamate and piso-metacarpal ligaments, and abductor digiti minimi, and laterally to a portion of the flexor retinaculum. The *medial surface* is irregularly convex, and has a narrow, rough groove for a ligament. The *lateral* presents the smooth, shallow *ulnar groove*, lodging the ulnar nerve.

FIG. 196.—THE RIGHT PISIFORM BONE (POSTERO-LATERAL VIEW).

The Trapezium.

The **trapezium** is the lateral bone of the second row, and is characterized by a groove and ridge on its palmar surface, and a saddle-shaped facet on its inferior surface. It is polyhedral, and its long axis is directed

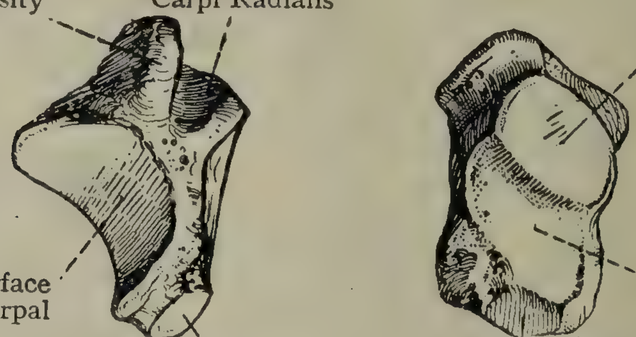


FIG. 197.—THE RIGHT TRAPEZIUM.
A, antero-inferior; B, supero-medial view.

downwards and inwards. The *superior surface* presents a semi-oval, concave facet for the scaphoid. The *inferior surface* presents a saddle-shaped facet, concave from side to side, convex from before backwards, and directed outwards as well as downwards, for the base of the first

metacarpal bone. The *medial surface* has two facets—an upper, which is large and concave, for the trapezoid, and a lower, which is small, for the base of the second metacarpal bone. The *lateral surface* is broad, pentagonal, and rough. The *palmar surface*, rough and elongated from above downwards and inwards, is broad above and narrow below. Superiorly it presents a deep groove, directed downwards and inwards, which transmits the tendon of the flexor carpi radialis, and lateral to this groove a prominent crest which gives attachment to the flexor retinaculum, abductor pollicis brevis, and opponens pollicis. The *dorsal surface* is broader than the palmar, and its inferior and medial angle is much elongated towards the base of the second metacarpal bone, with which it articulates by the small facet on its inner aspect.

Articulations.—*Superiorly* with the scaphoid, *inferiorly* with the first metacarpal, and *medially* chiefly with the trapezoid, but also with the second metacarpal.

The Trapezoid Bone.

The **trapezoid bone** somewhat resembles the trapezium, but it is destitute of a groove and tuberosity. Its antero-posterior diameter is longer than the transverse. The *palmar surface* is small and pentagonal, and it gives origin to fibres of the oblique head of adductor pollicis.

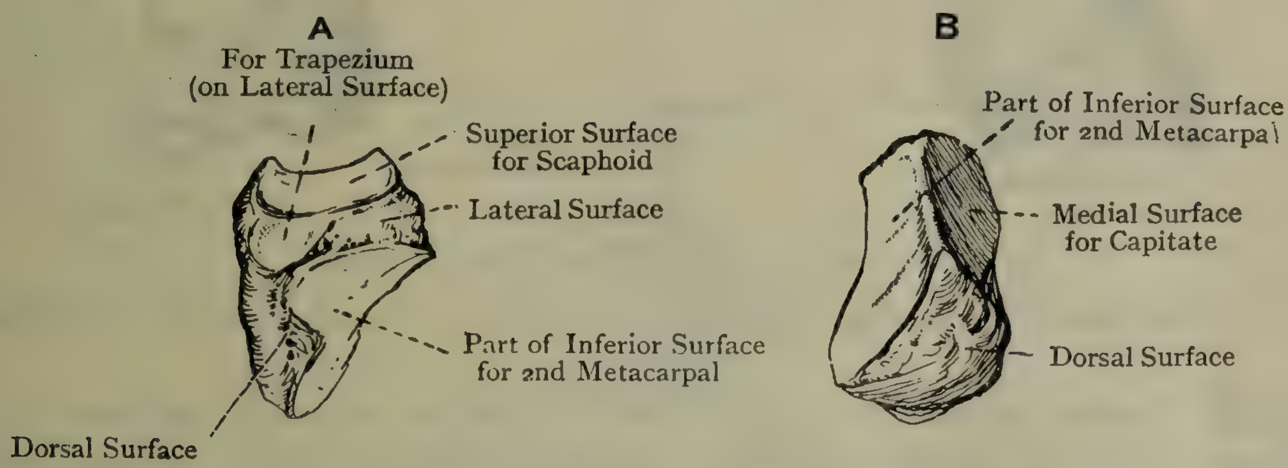


Fig. 198.—The Right Trapezoid Bone.

A, lateral view; B, posterior view.

The *dorsal surface* is large, and has its medial and inferior angle elongated towards the styloid process of the third metacarpal bone. Both of these surfaces are rough for ligaments. The *superior surface* presents a quadrilateral, concave facet, elongated from before backwards, for the scaphoid. The *inferior surface* is characterized by a large saddle-shaped facet, convex from side to side and concave from before backwards, for the base of the second metacarpal bone. The *lateral surface* has a convex facet for the trapezium, below which there is a rough triangular surface with the base directed anteriorly. The *medial surface* is concave from before backwards, and its anterior portion presents a facet for the capitate.

Articulations.—*Superiorly* with the scaphoid, *inferiorly* with the second metacarpal, *laterally* with the trapezium, and *medially* with the capitate.

The Capitate Bone.

The **capitate** is the largest bone of the carpus, its distinctive characters being that it is composed of a head, neck, and body. The superior and lateral aspects of the **head** are convex, and merge gradually into each other. The cartilage of the superior aspect is prolonged more behind than in front, and articulates with the lunate. The lateral aspect of the head articulates with the scaphoid. The medial aspect of the head is flat, and presents the commencement of the facet for the hamate bone. The **neck** is mainly present in front and behind.

The **body** is quadrilateral, and narrower in front than behind. The *palmar* and *dorsal surfaces* are rough, the former giving origin to fibres of the oblique head of adductor pollicis. The *lateral surface,* which is continuous with the outer convex aspect of the head, presents anteriorly a facet for the trapezoid. The *medial surface* presents at its back

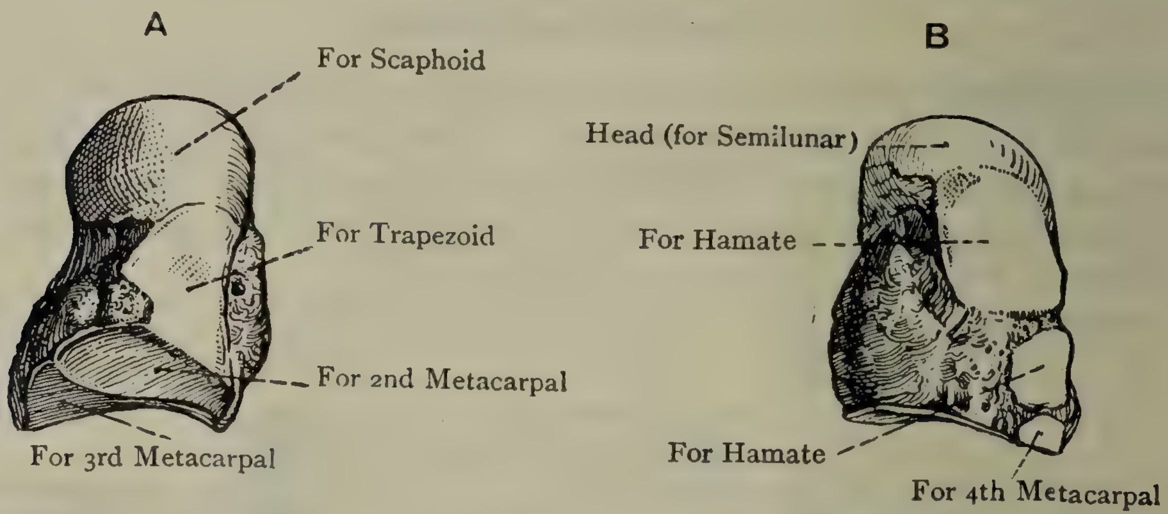


Fig. 199.—The Right Os Magnum.

A, lateral view; B, medial view (the double unciform facet is abnormal).

part the lower portion of the facet for the hamate, which is here narrow. The *inferior surface* is narrow in front, but broad behind, and the medial of the two posterior angles is elongated downwards and inwards. This surface presents three facets. The middle one is the largest, and articulates with the third metacarpal bone. The lateral one is a narrow, concave strip for the second metacarpal bone. The medial one, small and circular, tips inferiorly the projecting postero-medial angle, and articulates with the fourth metacarpal bone.

Articulations.—*Superiorly* with the lunate, *superiorly* and *laterally* with the scaphoid, *inferiorly* with the second, third, and fourth metacarpal bones, *laterally* with the trapezoid, and *medially* with the hamate.

The Hamate Bone.

The **hamate bone** is characterized by a hook-like process on its palmar surface. It is triangular, or wedge-shaped, and lies with its base downwards. The *superior extremity* presents a narrow facet for the lunate. The *inferior surface* is divided by an antero-posterior

ridge into two quadrilateral facets, the outer of which articulates with the fourth, and the inner with the fifth, metacarpal bone. The *palmar surface*, which is rough, presents at its lower and inner part a prominent curved projection, called the *hook*. This process is laterally compressed, the lateral surface being concave and the medial convex, so that the direction of the curve is outwards. Its borders are superior, inferior, and anterior. The medial surface gives origin to the flexor, and opponens, digiti minimi, and close to the root the *ulnar groove* for the deep branch of the ulnar nerve may sometimes be seen. The anterior border gives attachment to the flexor retinaculum and the piso-hamate ligament. The *dorsal surface* is extensive and rough. The *lateral surface* pre-

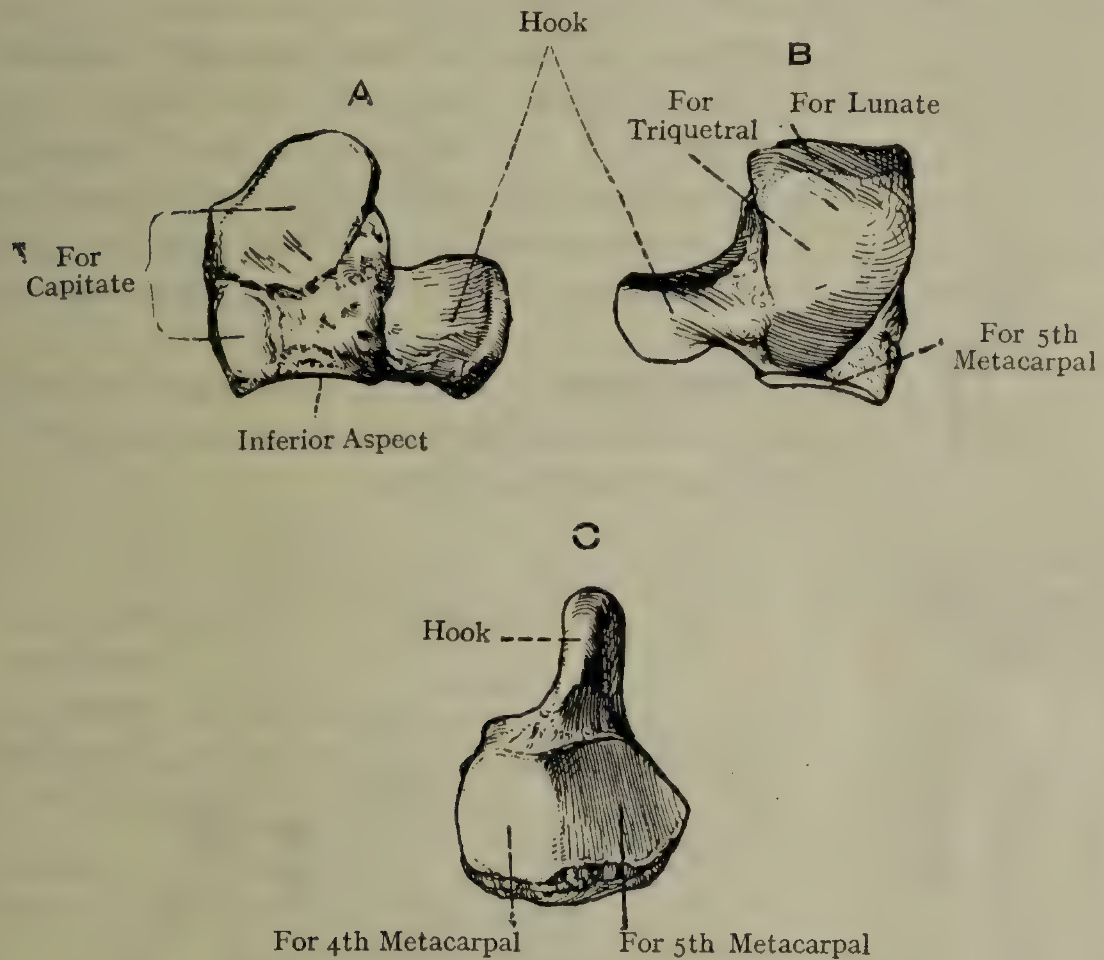


FIG. 200.—THE RIGHT HAMATE BONE.
A, lateral view; B, supero-medial view; C, inferior view.

sents an elongated facet, broad above and narrow below, where it is confined to the back part, for articulation with the capitate. The *supero-medial surface* is concavo-convex from below upwards, and articulates with the triquetral. The medial border, situated at the meeting of the supero-medial and inferior surfaces, is narrow and rough, its direction being from before backwards.

Articulations.—*Superiorly* with the lunate, *supero-medially* with the triquetral, *inferiorly* with the fourth and fifth metacarpal bones, and *laterally* with the capitate.

The **carpus as a whole** is narrower above than below. The *dorsal aspect* is irregularly convex, and the dorsal surfaces of the bones of the first row (exclusive of the pisiform) are narrow, but in the second

row they are broad, this being reversed on the palmar aspect. It is to be noted that the postero-medial angles of the trapezium, trapezoid, and capitate are distinctly elongated. The *palmar aspect* is rendered concave by the tubercles of the scaphoid and trapezium laterally and the pisiform bone and hook of hamate medially. These projections give attachment to the flexor retinaculum, which with the palmar concavity forms a fibro-osseous canal for the passage of the flexor tendons and median nerve. The *superior aspect,* which is directed backwards as well as upwards, is convex, and articulates with the radius and triangular interarticular disc. The *inferior* or *metacarpal aspect* is somewhat undulating. The *inferior surface* of the first row is for the most part deeply concave, but laterally it is convex. The *superior surface* of the second row is concavo-convex from without inwards, the concavity being formed by the trapezium and trapezoid, into which the scaphoid convexity above is received, whilst the convexity is formed by the capitate and hamate, and is received into the concavity above.

Structure.—The carpal bones are each composed of cancellated tissue, covered by a thin shell of compact bone.

FIG. 201.—CARPUS OF SPHENODON LIZARD.

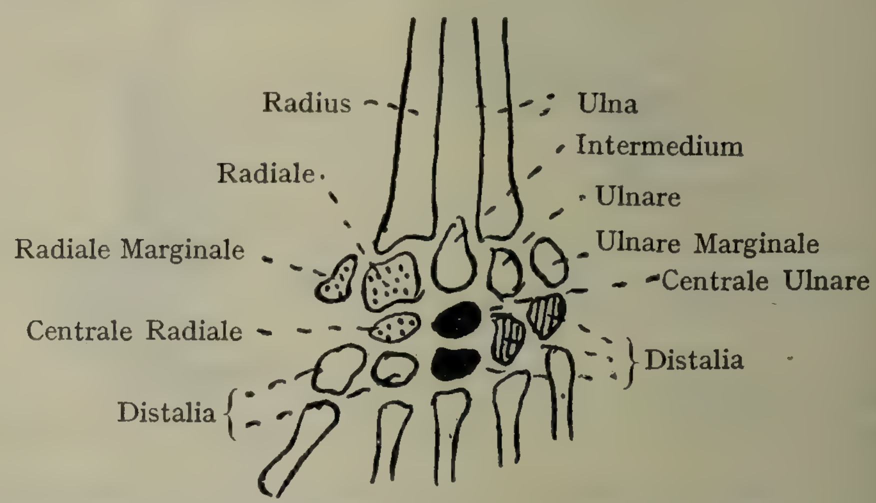


FIG. 202.—SCHEME OF A GENERALIZED CARPUS.

Varieties.—The number of carpal bones is sometimes increased to nine, which is brought about in one or other of the following ways: (*a*) The scaphoid, lunate, trapezium, or capitate may be divided into two parts; (*b*) the styloid process at the base of the third metacarpal, or the hook of the hamate, may remain an independent ossicle; or (*c*) there may be a persistent *os centrale,* situated on the dorsal aspect between the scaphoid, trapezoid, and capitate. It is said that fractured carpal bones seldom unite, but each piece develops an articular surface and resembles a separate bone.

Ossification.—The carpal bones are all cartilaginous at birth. Each ossifies from **one centre** in the following order, and at the following periods approximately:

Capitate, 1st year.	**Trapezium,** 5th year.
Hamate, 2nd year.	**Scaphoid,** 6th year.
Triquetral, 3rd year.	**Trapezoid,** 6th year.
Lunate, 5th year.	**Pisiform,** 10th year.

The most primitive or generalized carpus is a transcendental arrangement which is not found in any living animal. The nearest approach to it is found in the Sphenodon lizard, which only lacks one bone of the complete series, the radiale marginale (see Fig. 201).

The accompanying diagram (Fig. 202) gives the generalized arrangement with the names by which the bones are known in comparative morphology. In man the radiale marginale has fused with the radiale to form the tubercle of the scaphoid, and these two have then coalesced with the centrale radiale, so that the human scaphoid contains three morphological elements. The centrale ulnare joins the third distale to form the capitate, while the fourth and fifth distalia probably fuse to form the hamate.

The Metacarpus.

The **metacarpus** supports the phalanges, and is composed of five long bones, which are named numerically from without inwards, that of the thumb being the first. Each bone is divisible into a shaft and two extremities, proximal and distal. The **shaft** is triangular, except in the first, in which it is compressed from before backwards. It is longitudinally concave on the palmar aspect, and presents three surfaces, two lateral and a dorsal. The *lateral surfaces* give attachment to interosseous muscles, and are separated from each other by an anterior border. The *dorsal surface* over its proximal third presents a median ridge, which in the case of the fifth metacarpal is placed towards the inner side. Over the distal two-thirds the ridge bifurcates, its divisions passing each to the dorsal tubercle on the side of the head, and enclosing between them a flat triangular surface.

The **head** or **distal extremity,** which articulates with a proximal phalanx, is convex, and covered by cartilage, except laterally. The cartilage is prolonged farther on the palmar than on the dorsal surface, and terminates anteriorly in a concave border, the extremities of which form small condyles. Laterally the head is compressed, and presents at either side a dorsal tubercle and palmar depression for the collateral ligament of the metacarpo-phalangeal joint.

The **base** or **proximal extremity** is irregularly quadrilateral, being broader on its dorsal than palmar surface, and it articulates superiorly with the carpus, and at either side with its fellows, except in the case of the first.

The First Metacarpal Bone.—This is shorter than any of the others, and its shaft is compressed from before backwards. The *palmar aspect*, which has an inclination inwards, has the anterior border placed nearer the inner than the outer side. The outer margin and adjacent part of the palmar aspect give insertion to the opponens pollicis, and the inner margin over its proximal half gives origin to the outer head of the first dorsal interosseous. The *dorsal surface* is slightly convex, and is destitute of the ridge which characterizes the others. The **head** is elongated transversely, and articulates on its palmar surface with two sesamoid bones. The **base** is transversely oval, and has a saddle-shaped articular surface for the trape-

zium, which is concave from before backwards, and convex fro side to side. Laterally it presents a tubercle for the insertion the abductor pollicis longus, and medially it gives origin to the firs palmar interosseous. The side to which the bone belongs may be told by the outer part of the saddle-shaped facet being the larger.

Articulations.—*Superiorly* with the trapezium, and *inferiorly* with the first phalanx of the thumb, and the two sesamoid bones.

Fig. 203.—The First Right Meta-carpal Bone (Palmar View).

The Second Metacarpal Bone.—This is the longest. Its **base,** which is the largest, has a V-shaped notch for the trapezoid, being concave from side to side. Medial to this, it rises into a prominent border, which presents a faceted strip for the capitate, and laterally at the back part there is a small facet for the trapezium. The inner side presents an antero-posterior facet, notched at the centre of its lower border, for the third metacarpal The *palmar aspect* gives insertion to the principal part of the tendon o the flexor carpi radialis, and origin to a portion of the oblique hea of adductor pollicis. The dorsal aspect at its outer part gives insertio to the extensor carpi radialis longus, and at its inner part to a smal slip of the extensor carpi radialis brevis, there being a notch betwee the two impressions. The **shaft** gives origin to the first and secon dorsal, and second palmar, interossei.

Articulations.—*Superiorly* with the trapezium, trapezoid, an capitate magnum, *medially* with the third metacarpal, and *inferiorl* with the proximal phalanx of the index finger.

The Third Metacarpal Bone.—This is next in length to the second Its distinctive character is the styloid process at the base. Th superior surface of the **base** articulates with the capitate. The oute side presents an antero-posterior facet, notched at its lower border for the second metacarpal. The inner side presents two circular facets separated by a rough vertical groove, for the fourth metacarpal The palmar aspect gives insertion to a slip of the flexor carpi radialis and origin to a portion of the oblique head of adductor pollicis. Th dorsal aspect laterally gives insertion to the principal part of th extensor carpi radialis brevis, and it is projected upwards at its oute angle into the **styloid process.** The anterior border of the **shaft,** ove its distal two-thirds, gives origin to the transverse head of adducto pollicis, and the shaft also affords origin to the second and thir dorsal interossei.

Articulations.—*Superiorly* with the capitate and the second an

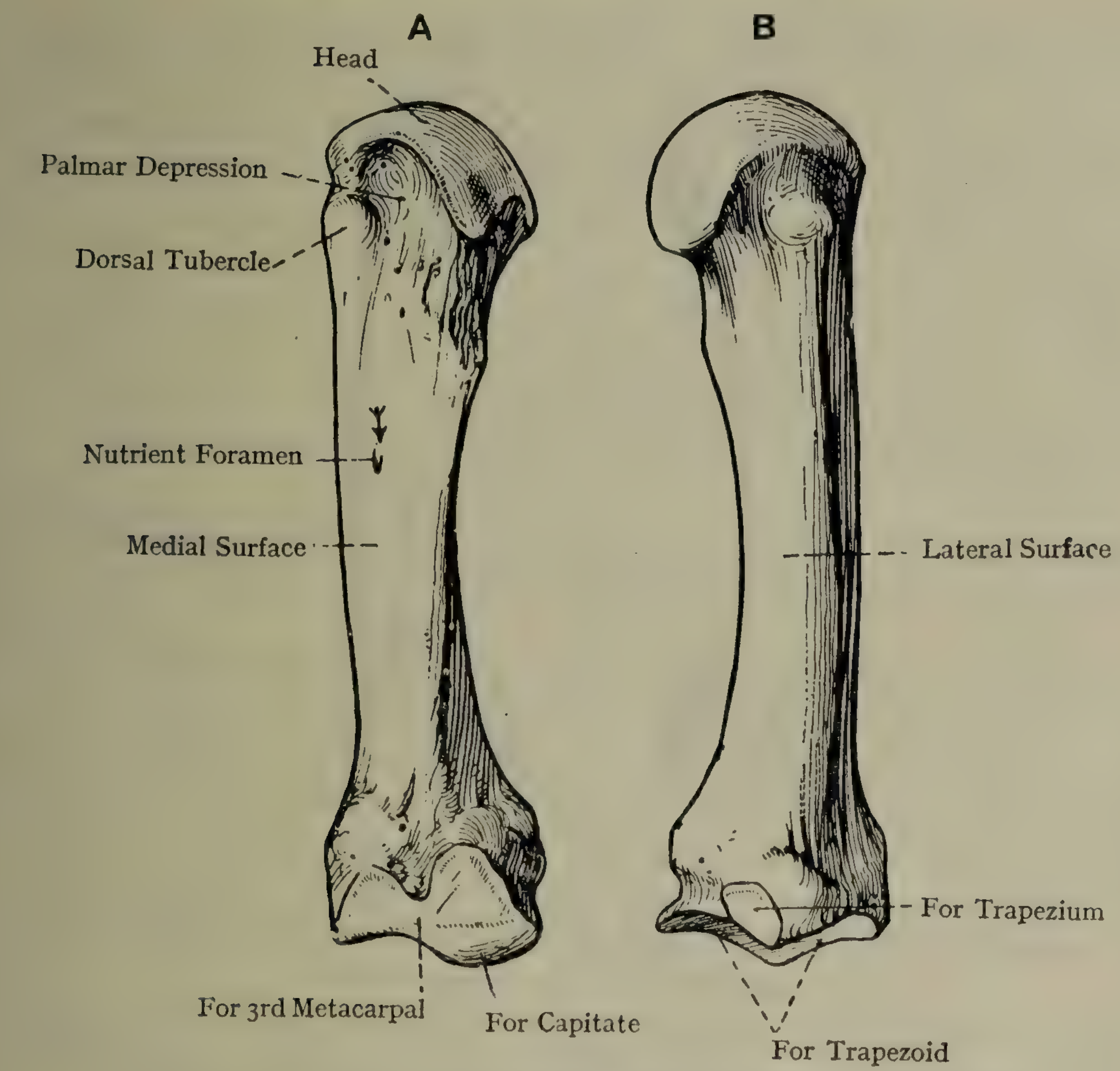


FIG. 204.—THE SECOND RIGHT METACARPAL BONE.
A, medial view; B, lateral view.

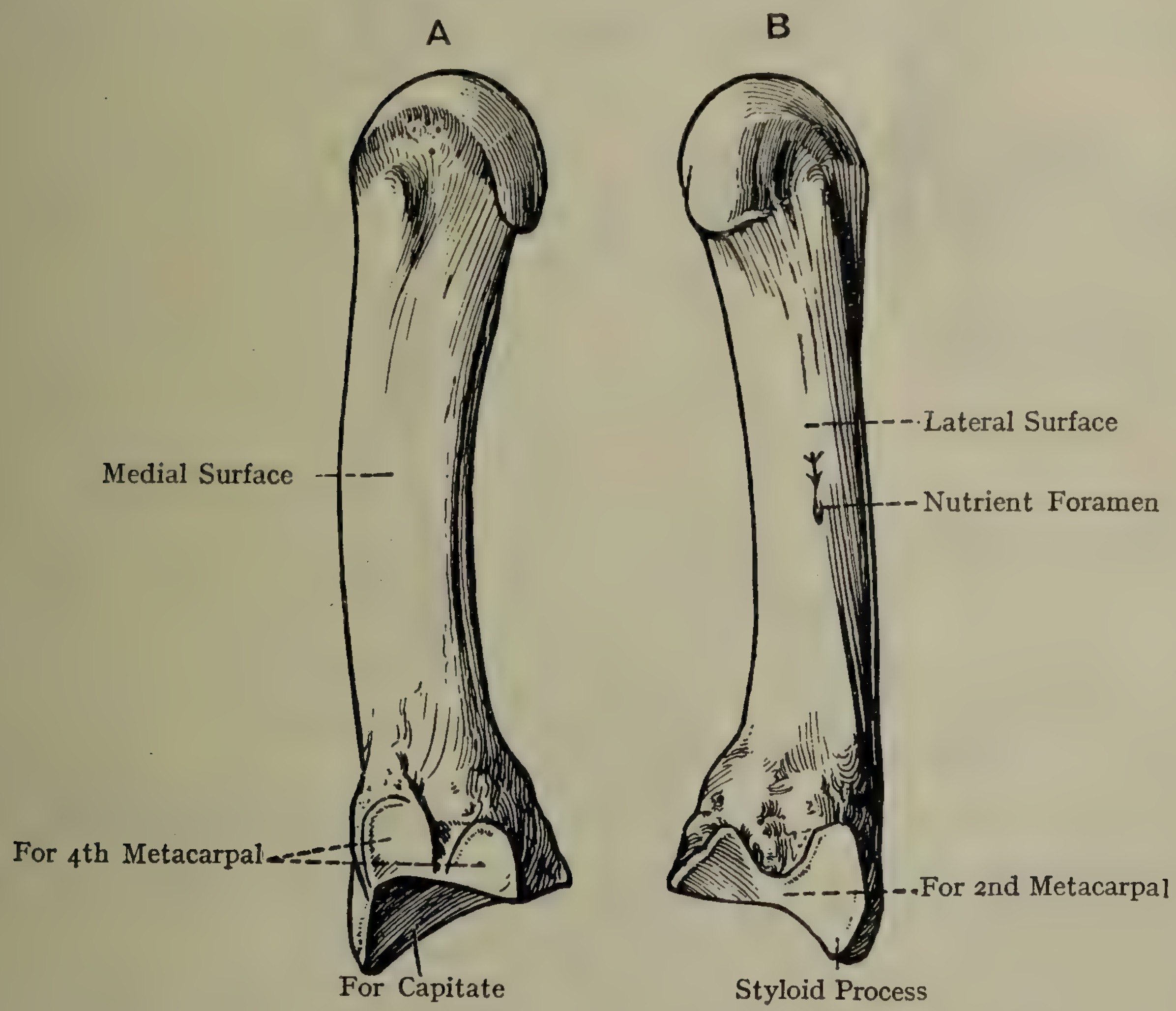


FIG. 205.—THE THIRD RIGHT METACARPAL BONE.
A, medial view; B, lateral view.

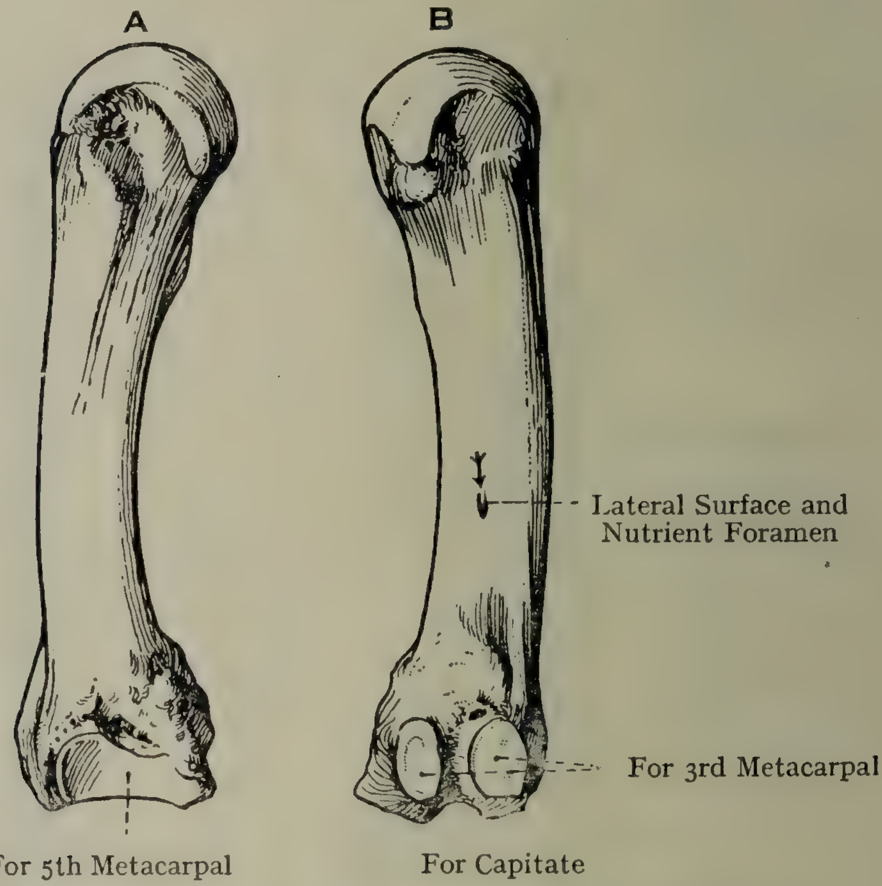


FIG. 206.—THE FOURTH RIGHT METACARPAL BONE.
A, medial view; B, lateral view.

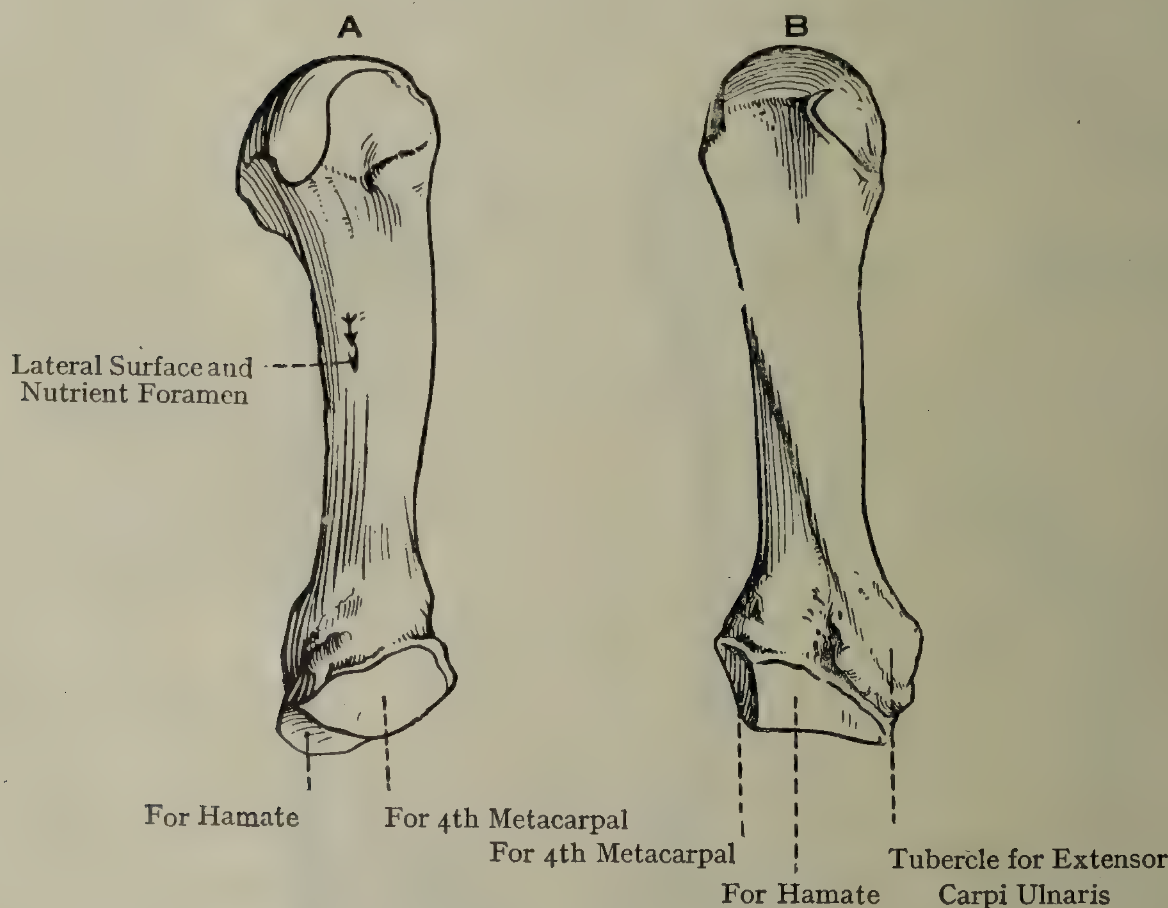


FIG. 207.—THE FIFTH RIGHT METACARPAL BONE.
A, lateral view; B, dorsal view.

fourth metacarpal bones, and *inferiorly* with the proximal phalanx of the middle finger.

The Fourth Metacarpal Bone.—This is shorter than the third, and its base is small. The outer side of the **base** usually presents two circular facets, separated by a rough vertical groove, for the third metacarpal, though quite often one of these facets is wanting. The inner side has a semi-oval facet for the fifth metacarpal. The superior surface presents two facets. One is large for the hamate, whilst the other, situated at the outer and posterior part, is small for the capitate. The **shaft** gives origin to the third and fourth dorsal, and third palmar, interossei.

Articulations.—*Superiorly* with the capitate, hamate, and third and fifth metacarpals, and *inferiorly* with the proximal phalanx of the ring finger.

The Fifth Metacarpal Bone.—This is shorter than the fourth, but longer than the first. The superior surface of the **base** presents a quadrilateral facet for the hamate. The outer side has an auricular facet for the fourth metacarpal, and the inner side presents a rounded tubercle for the insertion of the extensor carpi ulnaris. The inner margin of the **shaft** gives insertion to the opponens digiti minimi, and the shaft also affords origin to the fourth dorsal, and fourth palmar, interossei.

Articulations.—*Superiorly* with the hamate, *laterally* with the fourth metacarpal, and *inferiorly* with the proximal phalanx of the little finger.

Each metacarpal bone presents a **nutrient foramen,** that of the first, and usually that of the second, being situated on the *inner* or *ulnar side* of each shaft, whilst those of the third, fourth, and fifth are situated on the *outer* or *radial side.** The foramen of the first and the canal to which it leads are directed *downwards* towards the head, but those of the other four are directed *upwards* towards the base. The nutrient artery of the *first* metacarpal is furnished by the princeps pollicis artery, those of the *second* and *third* are branches of the first palmar metacarpal, that of the *fourth* is furnished by the second palmar metacarpal, and that of the *fifth* by the third palmar metacarpal arteries.

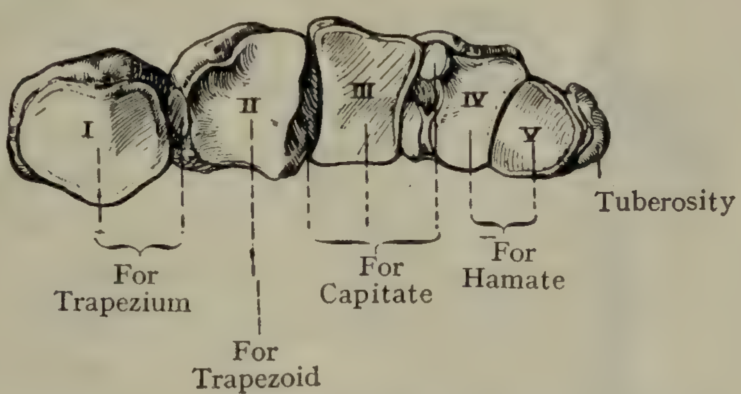


FIG. 208.—THE BASES OF THE RIGHT METACARPAL BONES (SUPERIOR VIEW).

The **metacarpus as a whole** is concave from side to side, and also longitudinally, on its palmar aspect, whilst the dorsal aspect is convex. The first metacarpal stands off at an angle from its fellows, and occupies

* Of 100 second metacarpal bones examined, 59 had the nutrient foramen on the inner side, and 41 on the outer.

a more anterior plane, thus fitting it for the important movemen of *opposition* on the part of the thumb. The other four metacarpal lie very nearly parallel with each other. They articulate with on another by their bases, but diverge slightly towards their heads, wher they are connected on their palmar aspects by the transverse meta carpal ligament. Between the five bones there are four intervals called *interosseous spaces,* the first being that between the first an second bones.

The Phalanges.

The **phalanges** are also known as *ossa internodia,* from their positio between the joints of the fingers. The fingers, of which they forn the framework, are called pollex or thumb, index, middle, ring, an little, respectively. The number of phalanges is fourteen, three fo each of the four inner fingers, and two for the thumb. They ar arranged in rows, both longitudinally and transversely, and the diminish in length from above downwards. They are distinguishe as proximal, intermediate, and distal, or ungual, except in the cas of the thumb, where the second is wanting. It is inadvisable t speak of the rows as first, second, an third, as mistakes often arise in thi way.

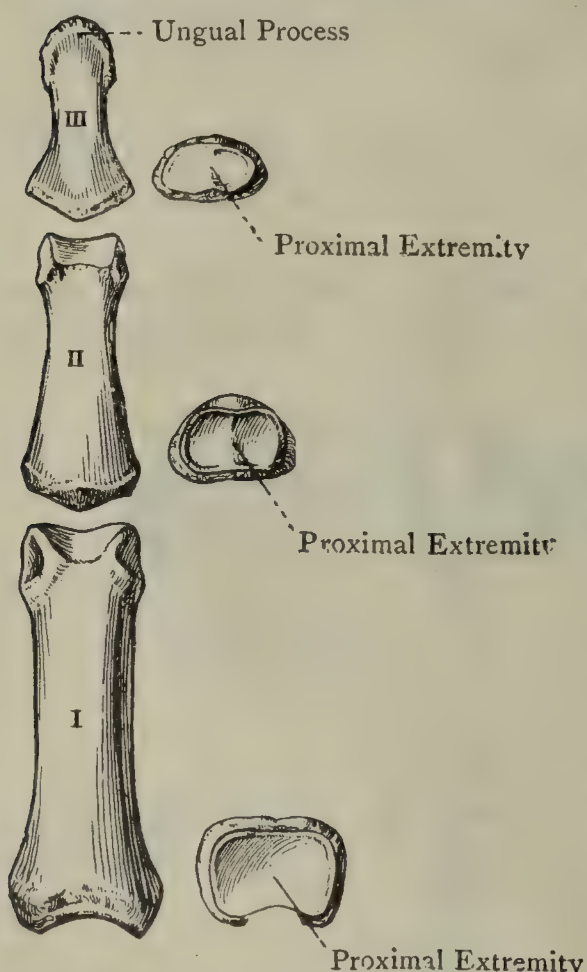


Fig. 209.—The Phalanges of the Middle Finger (Dorsal View).

The Proximal Phalanx.—The **shaft** i compressed from before backwards, fla and concave longitudinally on the palma aspect, and convex on the dorsal. Th palmar surface presents at either side rough border for the sheath of the flexo tendons. The **proximal end** or **base** i enlarged, and presents superiorly a con cave articular surface, transversely ova for the head of a metacarpal bone, an at either side a slight tubercular enlarge ment. The **distal end** is small, and pre sents a trochlear surface, grooved at th centre and elevated at either side of thi into a small condyle, for articulation wit the middle phalanx, except in the case o the thumb, where it articulates with th distal phalanx. The cartilage of the dista end is prolonged more on the palma aspect than on the dorsal. At either sid it presents a depression for the collatera ligament of the interphalangeal joint.

The Middle Phalanx.—This is shorter and smaller than the proximal from which it is distinguished by having on its **proximal end** or **bas** two shallow articular depressions, separated by a median antero posterior ridge, for the distal end of the proximal phalanx. Th

distal end resembles that of a first phalanx, except that it is smaller. The **shaft** resembles that of a proximal. Its palmar surface presents at the centre of the lateral borders two rough impressions, one at either side, which give insertion to the divisions of a superficial flexor tendon. The dorsal surface of the base is marked by a rough transverse ridge for the insertion of the middle division of a common extensor tendon.

The Distal Phalanx.—This is of small size. The **proximal end** or **base** resembles that of a middle phalanx, and has in front a rough transverse ridge for the insertion of a deep flexor tendon, whilst the dorsal surface gives insertion to the two lateral divisions of a common extensor tendon. The **distal end** presents a rough, tapering, convex border, the roughness being continued for a little on the palmar aspect. This roughness, which is semilunar, is called the *ungual process*, and it supports the nail and the tissues forming the pulp of the finger.

The two phalanges of the thumb are of large size.

Special Muscular Attachments.—The base of the proximal phalanx of the thumb gives insertion laterally to the abductor pollicis brevis and the flexor pollicis brevis, medially to the first palmar interosseous, oblique and transverse heads of adductor pollicis, and posteriorly to the extensor pollicis brevis. The base of the distal phalanx gives insertion anteriorly to the flexor pollicis longus, and posteriorly to the extensor pollicis longus. The base of the proximal phalanx of the index finger gives partial insertion to the first dorsal interosseous laterally, and the first palmar interosseous medially. The base of the proximal phalanx of the middle finger gives partial insertion to the second dorsal interosseous laterally, and the third dorsal interosseous medially. The base of the proximal phalanx of the ring finger gives partial insertion to the third palmar interosseous laterally, and the fourth dorsal interosseous medially. The base of the proximal phalanx of the little finger gives partial insertion to the fourth palmar interosseous laterally, and insertion to the abductor digiti minimi (partially) and flexor digiti minimi medially.

The **nutrient foramen** of each phalanx is situated on the palmar aspect of the shaft, not far from the distal end. It may be single, in which case it is mesially placed, or there may be two, one close to each lateral border. In all cases the direction of the foramen and the canal to which it leads is *downwards* towards the distal end. The nutrient arteries are furnished by the corresponding palmar digital arteries.

The Sesamoid Bones.—These are usually two in number, and are placed on the palmar aspect of the head of the first metacarpal bone. They are originally nodules of cartilage, one of which is developed in the tendon of insertion of the superficial head of the flexor pollicis brevis, and the other in that of the oblique head of adductor pollicis. Similar ossicles are sometimes met with on the palmar aspects of the heads of the second and fifth metacarpal bones, and are a reversion to the arrangement in the lower mammals, in which each digit has two sesamoid bones.

Ossification of the Metacarpal Bones and Phalanges.—Each of these bones ossifies in cartilage from **one primary,** and **one secondary, centre.**

The metacarpal bones begin to ossify about the ninth week, centres appearing

in the middle of the shafts. At birth the heads are cartilaginous, epiphysial centres appearing here during the second to third year; in the thumb the epiphysis is at the proximal end, but an additional one at the distal end, ossifying later, is present in about 6 per cent. of cases. Occasional additional centres may be found for the proximal end of the index metacarpal and the styloid process of the third; this last may be present as a separate bone.

In girls the epiphysial ossification seems to appear somewhat earlier, and to fuse with the shaft about puberty; in the male fusion occurs about eighteen. This sexual difference applies also to the phalanges.

The phalanges ossify first, curiously enough, in the *distal* row, in the seventh to eighth week, the last phalanx of the thumb usually being the first bone in the hand to show an ossific centre. Centres for the first phalanges follow in about a fortnight, and for the second after a like interval. The *proximal* ends are cartilaginous at birth, and here epiphysial centres appear in the second year in the first row, and in the fifth in the others.

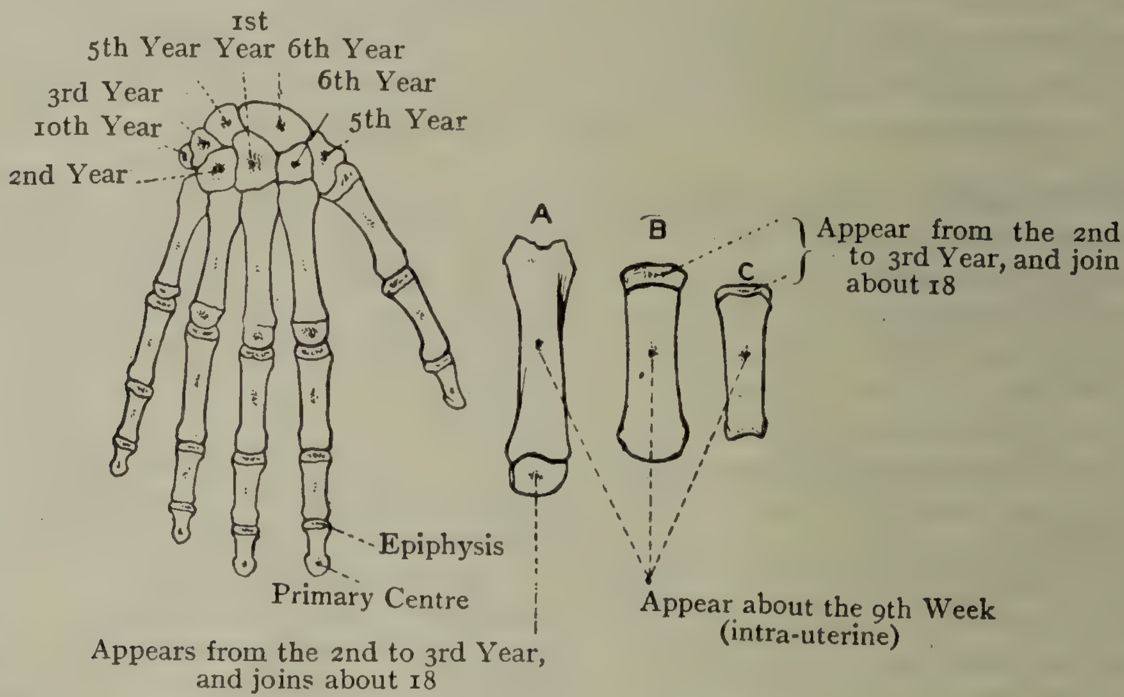


FIG. 210.—OSSIFICATION OF THE BONES OF THE HAND.
A, 2nd metacarpal; B, 1st metacarpal; C, 1st phalanx.

It will now be obvious why, on p. 306, the statement was made that 'the nutrient artery nearly always runs towards the elbow,' and that these phalanges and first metacarpal bones are exceptions. At the same time it will be seen that there is no exception to the rule that the nutrient artery always runs away from the growing end of a bone. A very little thought will show that this must be so.

The Hand as a Whole.

The hand presents two surfaces, dorsal and palmar; two borders, outer and inner; and two extremities, proximal and distal.

The **dorsal surface** is convex, both longitudinally and transversely.

The **palmar** or **volar surface** is concave, both longitudinally and transversely.

The **outer** or **radial border** is in line with the thumb or pollex, and is formed by the scaphoid, trapezium, and the phalanges of the thumb.

The **inner** or **ulnar border** is in line with the little finger, and is formed by the triquetral, hamate, and the phalanges of the little finger. This border has the **tubercle** on the inner side of the base of the fifth metacarpal bone for the tendon of the extensor carpi ulnaris.

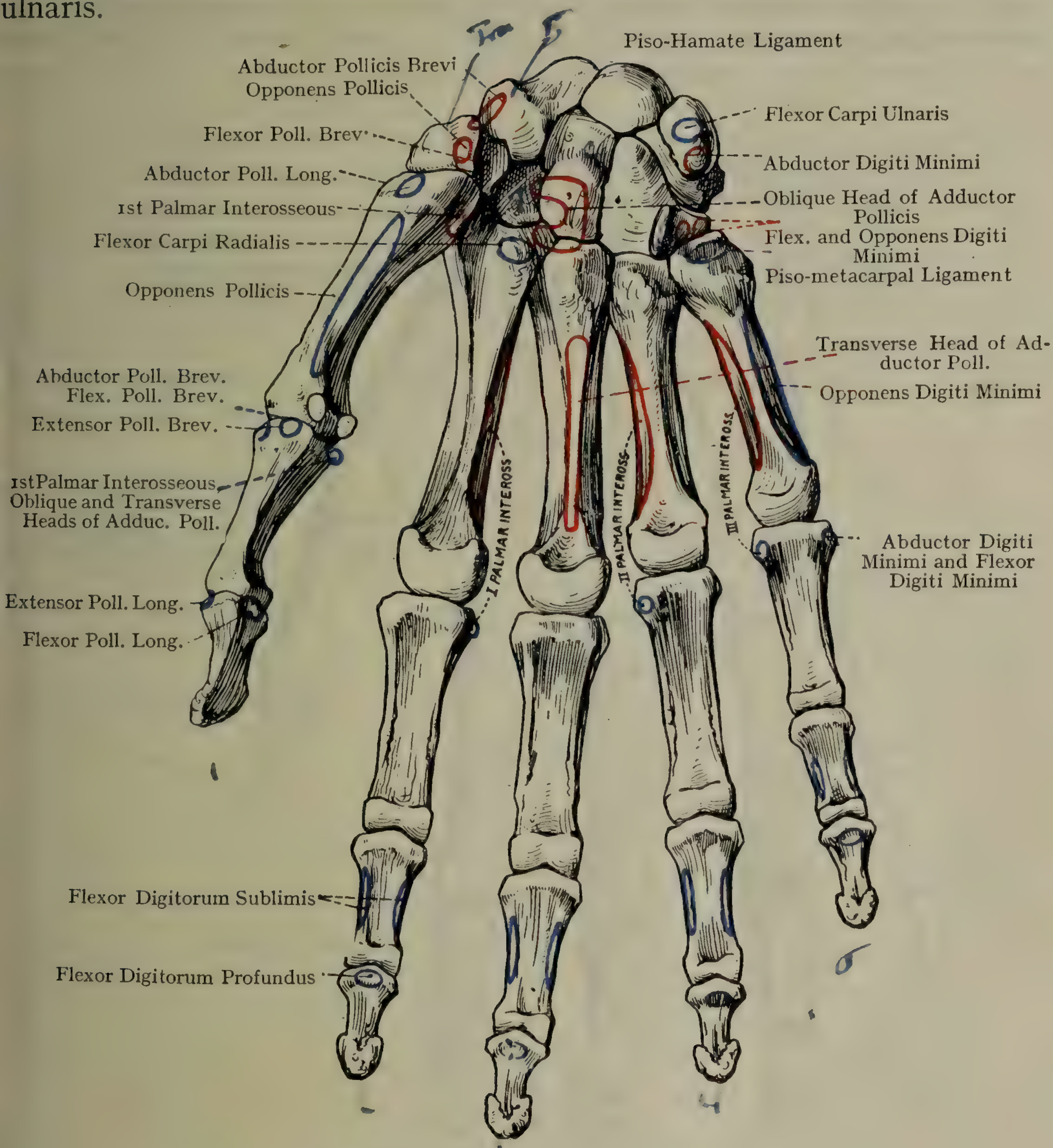


FIG. 211.—THE RIGHT HAND (PALMAR SURFACE).

The **proximal extremity** is formed by the scaphoid, lunate, and triquetral bones.

The **distal extremity** is formed by the distal phalanges.

It is to be noted (1) that the thumb is the shortest of all the digits; (2) that it stands off at an angle from its fellows; and (3) that it occupies a more anterior plane than its fellows, in which respects it presents a striking contrast to the great toe.

The **palmar aspect** of the *carpus* is rendered concave by the tubercl of the scaphoid and trapezium *laterally*, and the pisiform and the hoo of the hamate *medially*. These four projections give attachment t the flexor retinaculum. This ligament, along with the palmar co cavity of the carpus, constructs a fibro-osseous passage, called th **anterior palmar canal,** which transmits (1) the tendons of the flexo

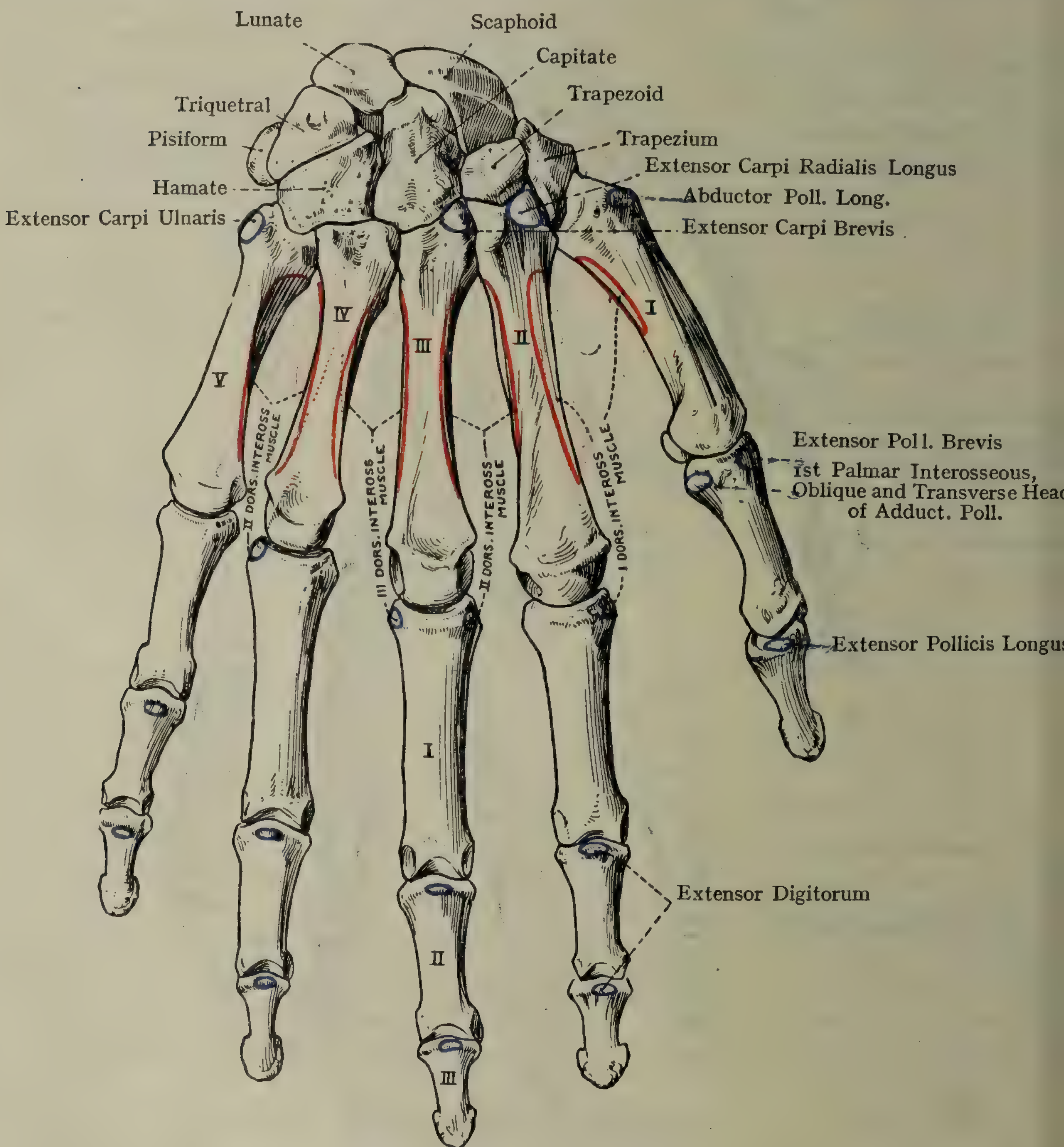


FIG. 212.—THE RIGHT HAND (DORSAL SURFACE).

digitorum sublimis and profundus, and the median nerve lyin within the large *inner compartment* of the **great palmar synovial sheath** and (2) the tendon of the flexor pollicis longus lying within the smal *outer compartment* of the sheath.

The **tubercle** of the *scaphoid* gives partial attachment to the flexo retinaculum, and partial origin to the abductor pollicis brevis muscle.

The **crest** of the *trapezium*, which forms the outer lip of the groove, gives partial attachment to the flexor retinaculum, as well as to (1) the abductor pollicis brevis, (2) the opponens pollicis, and (3) the flexor pollicis brevis.

The **groove** on the palmar surface of the *trapezium* transmits the tendon of the flexor carpi radialis, which lies in a special compartment in the outer part of the flexor retinaculum, and is invested by a special synovial membrane.

The **pisiform bone** gives attachment to (1) part of the flexor retinaculum, (2) the tendon of the flexor carpi ulnaris, (3) the piso-hamate and piso-metacarpal ligaments, and (4) the abductor digiti minimi muscle.

The **hook** of the *hamate* gives attachment *anteriorly* to part of the flexor retinaculum and the piso-hamate ligament, and *medially* partial origin to the flexor digiti minimi and opponens digiti minimi. The **ulnar groove** on the medial surface of the hook, close to its root, transmits the deep branch of the ulnar nerve.

CHAPTER VII

THE BONES OF THE LOWER LIMB

THE **lower limb** is arranged in four divisions—namely, hip or pelvic girdle, thigh, leg, and foot. The **pelvic girdle** consists of the hip bone; the **thigh** comprises the femur, with which is associated the patella; the **leg** is composed of the tibia and fibula; and the **foot** is subdivided into a *tarsus*, consisting of seven bones, a *metatarsus*, comprising five bones, and *phalanges*, which are fourteen in number.

The Hip Bone or Innominate Bone.

The **hip bone** (**os coxæ**) forms the lateral, and one half of the anterior, wall of the pelvis. It is much twisted, quadrilateral, and constricted about the centre. The lateral surface is characterized by the acetabulum, and below and medial to this is the obturator foramen. In early life the bone is composed of three parts—**ilium, ischium,** and **pubis**—which unite in the acetabulum, and in the adult it is described under these three divisions.

The **ilium** is the expanded portion above the acetabulum, of which it forms rather less than the upper two-fifths. It presents three borders and two surfaces.

The **superior border** or **crest** is thick over its anterior and posterior thirds, but thin over the middle third. It presents two curves—anterior with the concavity directed inwards, and posterior with the concavity outwards. Anteriorly it terminates in the *anterior superior spine*, which gives attachment to the inguinal ligament and a portion of the sartorius. Posteriorly it ends in the *posterior superior spine*, which gives attachment to the long posterior sacro-iliac ligament. The crest has two lips and an intervening space. The *outer lip* presents a tubercular prominence about 3 inches from the anterior superior spine. Over its whole extent this lip gives attachment to the fascia lata; for $1\frac{1}{2}$ inches in front, to the tensor fasciæ latæ; over its anterior half, to the obliquus externus abdominis; and a little behind this, to the latissimus dorsi. The *intervening space* over its anterior two-thirds gives origin to the obliquus internus abdominis, and over its posterior fifth to the sacro-spinalis. The *inner lip* over its anterior two-thirds gives origin to the transversus abdominis, and for about 2 inches posteriorly to the ilio-lumbar ligament and quadratus lumborum. Immediately within the inner lip, over its anterior two-thirds, the fascia transversalis and fascia iliaca take attachment.

The **anterior border** extends from the anterior superior spine to the

ilio-pubic eminence. Superiorly it presents the anterior interspinous notch, the upper part of which gives partial origin to the sartorius. Below this notch is the *anterior inferior spine*, which gives origin anteriorly to the straight head of the rectus femoris, and inferiorly to the ilio-femoral ligament. Medial to this spine there is a groove for the passage of the ilio-psoas, and medial to the groove is the *ilio-pubic eminence*, which marks the junction of the ilium and superior

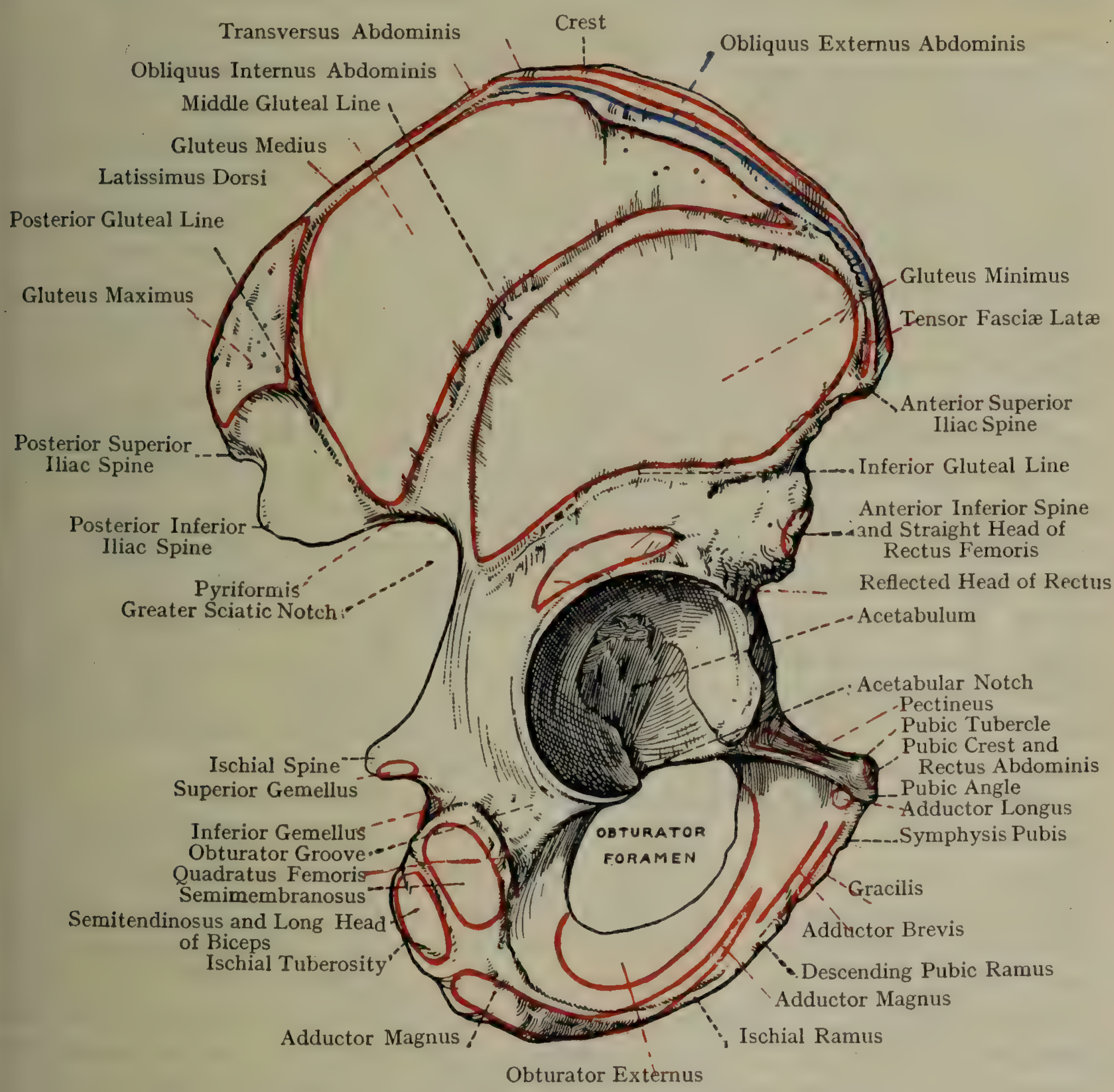


Fig. 213.—The Right Hip Bone (Lateral Aspect).

pubic ramus. This eminence gives attachment to the ilio-pectineal intermuscular septum, and, it may be, partial insertion to the psoas minor.

The **posterior border** extends from the posterior superior spine to a point a little below the deepest part of the greater sciatic notch, where there is usually a faint transverse line on the lateral surface, indicating the place of junction of the ilium and ischium. Superiorly it presents the posterior interspinous notch, and below this the *posterior inferior*

spine, which gives attachment to the sacro-tuberous ligament, whi immediately below this it gives origin to fibres of the pyriform Inferiorly the posterior border forms the upper part of the great sciatic notch, over which the pyriformis passes as it leaves the pelvi

The **gluteal surface** or **dorsum ilii,** concavo-convex from behi forwards, is traversed by three ridges, called the posterior, midd and inferior gluteal, or curved, lines. The *posterior gluteal line* co mences at the outer lip of the crest about 2 inches in front of t posterior superior spine, and passes downwards to the upper part the greater sciatic notch. The semilunar area of gluteal surface abo and behind this line gives origin to the gluteus maximus. The *midd gluteal line* starts at the outer lip of the crest 1½ inches behind t anterior superior spine, and passes backwards and downwards to t upper part of the greater sciatic notch, where it terminates close to t superior line. The surface included between the middle gluteal lin crest, and posterior gluteal line, which is falciform, gives origin to t gluteus medius. The *inferior gluteal line* begins at the lower part of t anterior interspinous notch, whence it passes backwards to the deepe part of the greater sciatic notch. The space between the inferi and middle gluteal lines gives origin to the gluteus minimus. Betwee the front part of the inferior gluteal line and the margin of the acetab lum there is a short transverse roughness, which gives origin to th reflected head of the rectus femoris. The iliac portion of the bone very thin and translucent toward the upper part of the middle thir where it is sometimes perforated, and it presents a strong rounde ridge, leading upwards from the margin of the acetabulum to th tubercular eminence on the outer lip of the crest. There is also strong bar of bone extending from the upper margin of the acetabulu to the auricular surface on the medial aspect.

The **sacro-pelvic surface** is divisible into an anterior and a posteri portion. The *anterior division,* which occupies two-thirds, is su divided into a small lower and large upper part by the iliac portio of the arcuate line, the direction of which is forwards and downward The part below and behind the line enters into the lateral wall of th true pelvis, and gives origin to a portion of the obturator internu The part above the line is extensive and concave, and forms the **ilia fossa,** which lodges the iliacus muscle. The iliac portion of the arcuat line gives attachment to the iliac fascia. It may also give parti insertion to the psoas minor near the ilio-pubic eminence. The *posteri division* is subdivided into auricular, ligamentous, and muscular po tions. The *auricular area,* antero-inferior in position, is broad in fro and narrow behind, where it extends over the inner aspect of th posterior inferior spine. It is covered by cartilage in the recent state and articulates with the auricular surface of the sacrum. The *liga mentous area,* situated above and behind the auricular, is rough an tubercular for the posterior sacro-iliac ligament. The *muscular are* placed superiorly, gives origin to fibres of the multifidus. Below th auricular facet the ' auricular groove ' is seen in the female, but not i

he male; sometimes it extends behind and sometimes in front of the urface as well. It is formed by ligaments, and is a very valuable exual distinction of the hip bone.

The **ischium** forms the lower and back part of the bone, and is livisible into a body, tuberosity, and ramus. The **body** contributes ather more than two-fifths to the acetabulum, and forms the greater ortion of its non-articular part. It is prismatic, and its surfaces are

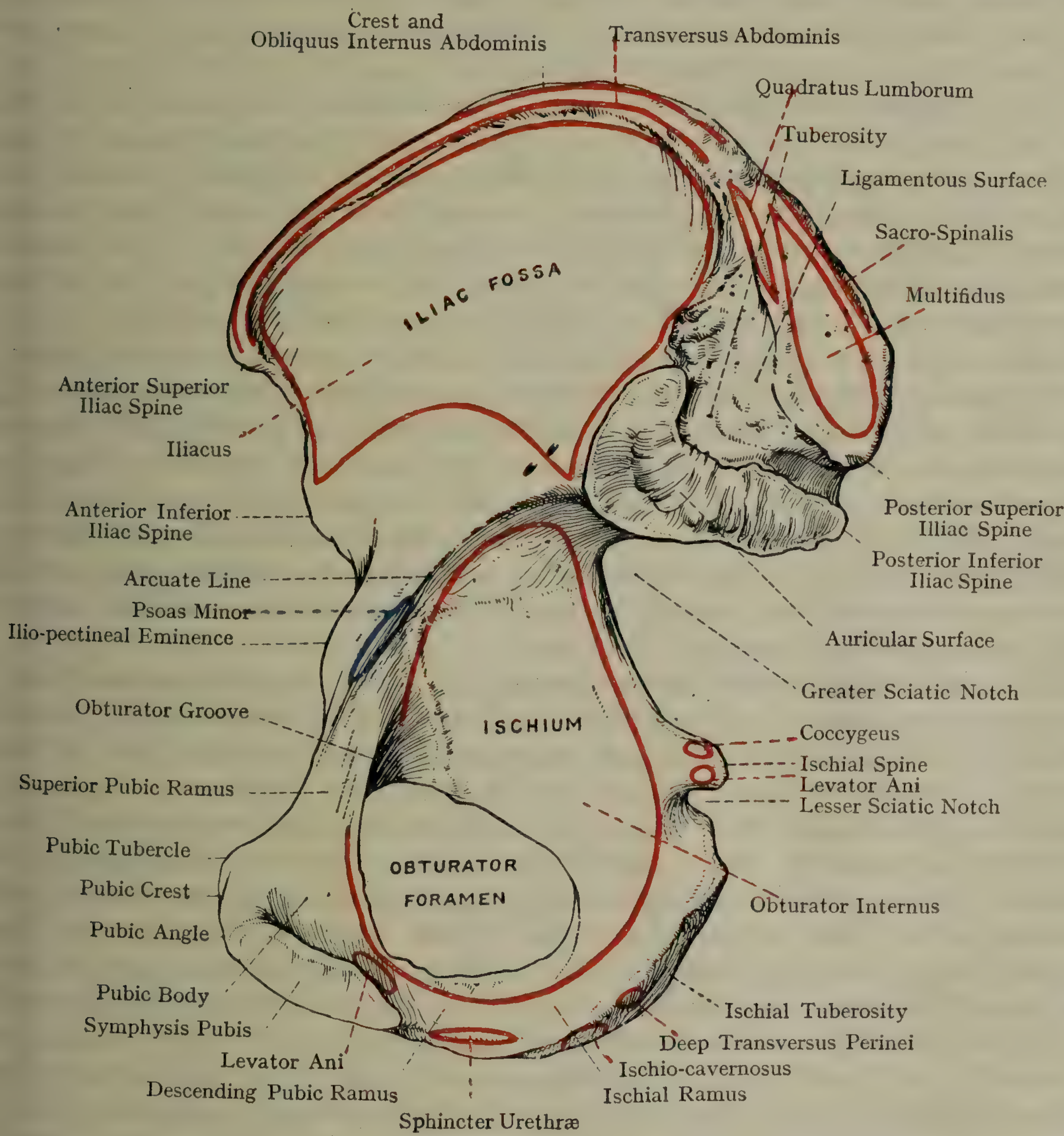


FIG. 214.—THE RIGHT HIP BONE (MEDIAL ASPECT).

nedial, lateral, and posterior. The *medial surface* extends from near he centre of the arcuate line to the ischial spine, and is narrow above, ut widens inferiorly before reaching the spine. Its place of junction vith the ilium is indicated by a line passing from the ilio-pubic eminence ackwards and downwards to a point a little below the deepest part f the greater sciatic notch. Its junction with the superior pubic amus is marked by a line passing from the ilio-pubic eminence down-

wards to the posterior margin of the obturator foramen about $\frac{3}{4}$ in[c] below its upper end. This surface gives origin to part of the obturat[or] internus. The *lateral surface* enters into the acetabulum, and betwe[en] that cavity and the tuberosity it presents an obturator groove f[or] the tendon of the obturator externus. The upper part of this groo[ve] gives attachment to the ischio-femoral ligament. The *posterior surfa[ce]* is limited laterally by the brim of the acetabulum, behind by t[he] posterior border, and below by the upper border, of the tuberosit[y]. At the lower part is a portion of the obturator groove, and it suppor[ts] the pyriformis, and the sciatic nerves and vessels.

The **borders** are anterior, lateral, and medial. The *anterior bord[er]* forms a portion of the posterior margin of the obturator foramen, an[d] is sharp. It separates the medial from the lateral surface. The *later[al] border* forms the posterior part of the margin of the acetabulum, an[d] gives attachment to a part of the labrum acetabulare. The *medi[al] border* is continuous with that of the ilium. Superiorly it forms th[e] lower part of the greater sciatic notch, below which it presents a pr[o]jection, called the *spine,* which has an inward curve towards the pelvi[s] and gives attachment to the following structures: the sacro-spinou[s] ligament at the tip, the levator ani, coccygeus, and white line of th[e] pelvic fascia on the inner surface, and the gemellus superior along th[e] lower border. The lateral surface (back) supports, from within ou[t]wards, the pudendal nerve, internal pudendal vessels, and nerve to th[e] obturator internus. Below the spine is the lesser sciatic notch, whic[h] is covered by cartilage, and is ridged in the recent state for the play o[f] the tendon of the obturator internus.

The **tuberosity** (**tuber ischii**) forms the thick dependent part, an[d] supports the body in the sitting posture. The *upper border* limit[s] inferiorly the obturator groove and lesser sciatic notch, and in th[e] latter situation it gives origin to the gemellus inferior. The *inne[r] border* is prominent and sharp, and gives attachment to the sacro-tuberous ligament. The *outer border* gives origin to the quadratu[s] femoris. The *anterior border* is sharp and prominent, and forms th[e] lower part of the posterior margin of the obturator foramen. Th[e] surfaces are posterior, lateral, and medial. The *posterior surface* lie[s] between the outer and inner borders, and is somewhat quadrilatera[l], and is subdivided into two parts by a diagonal line directed downwards, forwards, and outwards. The upper and outer part gives origin t[o] the semimembranosus, and the lower and inner to the conjoined lon[g] head of the biceps and semitendinosus. The *inferior surface,* whic[h] is in line with the inner margin of the ramus, is rough and triangula[r], and gives origin to fibres of the adductor magnus. The *lateral surfac[e]* is situated between the outer and anterior borders, and supports th[e] obturator externus. The *internal surface* is placed between the inne[r] and anterior borders. It looks towards the ischio-rectal fossa, an[d] gives origin to fibres of the obturator internus.

The **ramus** is the compressed portion which extends upwards an[d] inwards from the tuberosity on the inferior aspect of the obturato[r]

foramen, where it joins the inferior pubic ramus, the place of meeting being indicated laterally by a rough ridge. The *upper border* is sharp, and forms part of the margin of the obturator foramen. The *lower border* is thick, and anteriorly it is rough for the attachment of the deep layer of superficial perineal fascia, crus penis, and ischio-cavernosus muscle. In the female this part gives attachment to the crus clitoridis. The *outer surface* gives origin, from within outwards, to portions of the adductor magnus and obturator externus. The *inner* or *pelvic surface* gives attachment to part of the obturator internus and parietal pelvic fascia. At its lower part, near the inner border, there is a sharp ridge which gives attachment to the falciform process of the sacro-tuberous ligament.

The **os pubis** lies in the anterior wall of the pelvis, and is composed of a body and two rami, superior and inferior. The **body** is compressed from before backwards, and occupies an oblique plane, which is directed downwards and backwards. It presents three surfaces—anterior, posterior, and medial. The *anterior* or *femoral surface* has an inclination downwards. At its upper and inner part, below and lateral to the pubic angle, it gives origin to the adductor longus, and, lower down, to the following muscles, in order from within outwards: gracilis, adductor brevis, a small portion of the adductor magnus, and obturator externus. The *posterior* or *pelvic surface* has an inclination upwards, and gives attachment from without inwards to the obturator internus, parietal pelvic fascia, levator ani, and pubo-prostatic ligament. Much of the pelvic fascia, in the undissected state, is loose cellular tissue, which, in this region, forms the 'cave of Retzius.' The *medial surface* is oval, with its long axis directed downwards and backwards. It is covered by hyaline cartilage, and articulates with its fellow to form the symphysis pubis, a plate of fibro-cartilage intervening.

The borders are lateral and superior. The *lateral border*, which is sharp, looks into the obturator foramen, and gives attachment to part of the obturator membrane. The *superior border* or *crest* is thick, and about an inch long. At its outer extremity is the *pubic tubercle*, which may be blunt or sharp, for the attachment of the inguinal ligament, and medially is the *pubic angle*, which surmounts the medial surface. The crest gives attachment to the conjoint tendon, pyramidalis, and outer head of the rectus abdominis.

The **inferior ramus** passes downwards, backwards, and outwards, and corresponds in all respects with the ischial ramus, which it joins. Its *anterior surface* gives origin, from within outwards, to the adductor brevis, adductor magnus, and obturator externus. The structures attached to the *posterior surface* are portions of the obturator internus, sphincter urethræ, and parietal pelvic fascia. The lower border, which forms the subpubic arch, with its fellow of the opposite side, attaches the gracilis laterally, and the pull of this muscle everts the border in both sexes.

The **superior ramus** extends outwards and upwards from the body

to the ilio-pubic eminence and anterior part of the acetabulum, of which latter it forms one-fifth. It lies above the obturator foramen, and is prismatic. Superiorly, at the back part, is a prominent ridge, representing the pectineal portion of the *arcuate line,* which leads to the pubic tubercle, and gives attachment to the following structures: the pubic lamina of the fascia lata, pectineus, pectineal part of inguinal ligament, and conjoint tendon. In front of this line is the *superior* or *pectineal surface,* which is sloped downwards and forwards, and is triangular. It attaches the pectineus, and is limited antero-inferiorly by the *obturator crest,* which extends from the pubic tubercle to the anterior margin of the acetabular notch. The *inferior surface* presents the *obturator groove* for the obturator vessels and nerve, the direction of which is downwards, forwards, and inwards. The *posterior surface* gives partial origin to the obturator internus.

The **acetabulum** or **cotyloid cavity** is situated on the outer surface of the bone, and is directed downwards, outwards, and forwards. It is a deep, circular concavity, and articulates with the head of the femur. The ischium forms rather more than two-fifths of it, the ilium rather less, and the os pubis the remaining fifth. It is surmounted by a prominent brim, upon which the labrum acetabulare is set, except at the anterior and inferior part, where there is the *acetabular notch,* this being bridged over by the labrum and transverse ligaments. The capsular ligament is attached to the bone just outside the brim. The interior is divided into two parts—articular and non-articular. The articular portion is covered by cartilage, which is arranged in the form of a horseshoe, and surrounds the circumference, except opposite the acetabular notch. The non-articular part, which is formed mainly by the ischium, is depressed, and lodges the Haversian pad of fat.

The **obturator** or **thyroid foramen** lies below, and medial to, the acetabulum, its boundaries being formed by the ischium and pubis. Its long diameter is directed downwards and outwards, but is much more vertical in the male than in the female. Its circumference is sharp for the obturator membrane, which closes the opening, except opposite the obturator groove superiorly, where it converts that groove into the obturator canal.

The **greater** and **lesser sciatic notches** are situated on the posterior border of the bone, and are separated from each other by the spine of the ischium. The *greater* notch is formed partly by the ilium, and partly by the ischium; and the *lesser* notch lies between the ischial spine and tuberosity.

In the recent state these notches are converted into foramina by the sacro-tuberous and sacro-spinous ligaments. For the structures which pass through these foramina, see the description of the gluteal region.

The hip bone is pierced by a great number of nutrient foramina for arteries, the chief of which are situated as follows: along the inner aspect of the crest for branches of the deep circumflex iliac; in the iliac fossa near the auricular surface, where there are one or two for branches

of the ilio-lumbar; on the lateral surface of the ilium and around the margin of the acetabulum for branches of the gluteal; between the acetabulum and ischial tuberosity for branches of the obturator; on the ilio-pectineal eminence for branches of the deep circumflex iliac;

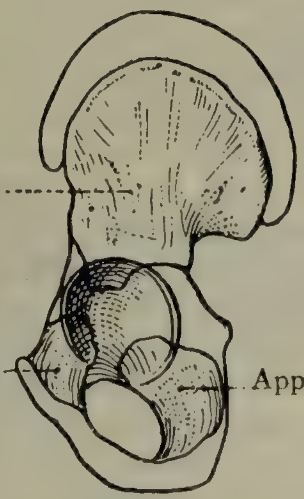


FIG. 215.—OSSIFICATION OF THE HIP BONE.

and over the body of the os pubis for branches of the obturator, and of the pudendal branches of the femoral.

Articulations.—*Posteriorly* with the sacrum, *laterally* with the femur, and *medially* with its fellow.

Ossification.—The hip bone is ossified *in cartilage* from **three primary** and **nine secondary centres.** The **primary centres** are iliac, ischial, and pubic. The

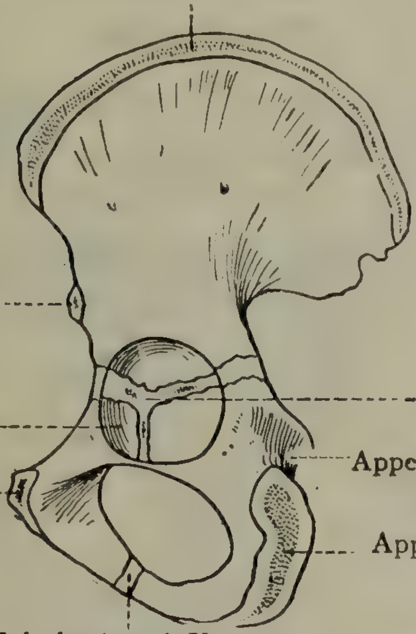


FIG. 216.—OSSIFICATION OF THE EPIPHYSES OF THE HIP BONE.

iliac centre appears in the *eighth week*; the **ischial centre** in the *third month*; and the **pubic centre** in the *fifth month* in the superior pubic ramus.

The **ischial** and **inferior pubic rami** join about the *seventh year* (M.) or *fifth year* (F.).

The **ilium** and **ischium** join about puberty.

Acetabulum.—The **superior pubic ramus** is shut out from this cavity for some time by a triangular portion of cartilage, called the **pars acetabularis.** From its apex there is prolonged backwards a strip of cartilage (*ilio-ischial*),

The entire cartilage resembles the letter Y laid on its side. The open part of the Y is directed forwards, and forms the **pars acetabularis.** The Y cartilage has three *secondary centres.* One, called the *acetabular centre,* appears in the *twelfth year* in the **pars acetabularis,** and ossification is completed by the *fourteenth year.* It then forms a distinct bone, called the **os acetabuli,** which joins the superior pubic ramus about the *sixteenth year.*

The *other two secondary centres* for the Y cartilage appear about the *fourteenth year,* one of them in the **ilio-ischial strip** or stem of the Y; and the other at the meeting of the two limbs and stem of the Y. The ossification of the bottom of the acetabulum is completed from the *sixteenth* to the *eighteenth year.*

Other Secondary Centres.—These are as follows: (1) One, or more often two, for the **crest,** one for the **anterior inferior iliac spine,** one (a thin scale) for the *surface* of the **ischial tuberosity,** each of these centres appearing about the *fifteenth year*; (2) one for the **pubic tubercle,** and one for the **pubic angle,** each of these two centres appearing about the *eighteenth year.* These epiphyses usually join about the *twenty-first year.* For medico-legal purposes it is most important to realize that the *times of appearance and junction of these secondary centres are most variable,* and that, as a rule, they are *earlier in females than in males.*

The centre for the anterior inferior spine is interesting in that it only occurs in man; and in man alone do we find a straight head to the rectus femoris. It will be seen, therefore, that the sequence of events is (1) the assumption of the erect position; (2) the necessity of a straight head for the rectus; (3) a traction epiphysis, due to the pull of the newly formed straight head. The spines of the ischium and pubes may be epiphyses or apophyses; in any case they are practically human structures, and their appearance is probably due to traction coming into play in the upright position.

The epiphysis on the tuberosity of the ischium is atavistic, and marks the remains of the hypo-ischium or os cloacæ of reptiles, while that at the angle of the pubes is the remnant of the prepubis of amphibians.

The Pelvis.

The **pelvis** is formed by the hip bones, sacrum, and coccyx, the hip bones constructing the anterior and lateral walls, whilst the sacrum and coccyx lie in the posterior wall. It is divided into two parts, called false pelvis and true pelvis, the division being effected by a plane passing through the upper border of the symphysis pubis, arcuate line, and sacral promontory.

The **false pelvis,** which lies above this plane, is formed by the iliac fossæ, and constitutes a part of the abdomen proper.

The **true pelvis** is situated below the plane referred to, and presents a brim or inlet, a cavity, and an outlet. The **brim** is formed in front by the upper border of the symphysis pubis, behind by the sacral promontory, and between these two points by the following parts from before backwards: the angle and crest of the pubis, the arcuate line, and the antero-inferior border of the ala of the sacrum. In the male it is cordate, the base of the heart, which is encroached upon by the sacral promontory, being directed backwards. In the female it is oval, the long diameter being transverse. The **diameters** of the brim are *antero-posterior* or *conjugate, transverse, right oblique,* and *left oblique.* The antero-posterior or conjugate diameter extends from the upper border of the symphysis pubis to the sacral promontory; the transverse from one arcuate line to the opposite, across the widest part of the

brim; and the oblique, from one sacro-iliac articulation to the ilio-pubic eminence of the opposite side. The oblique diameters are called right and left from the sacro-iliac articulations whence they extend.

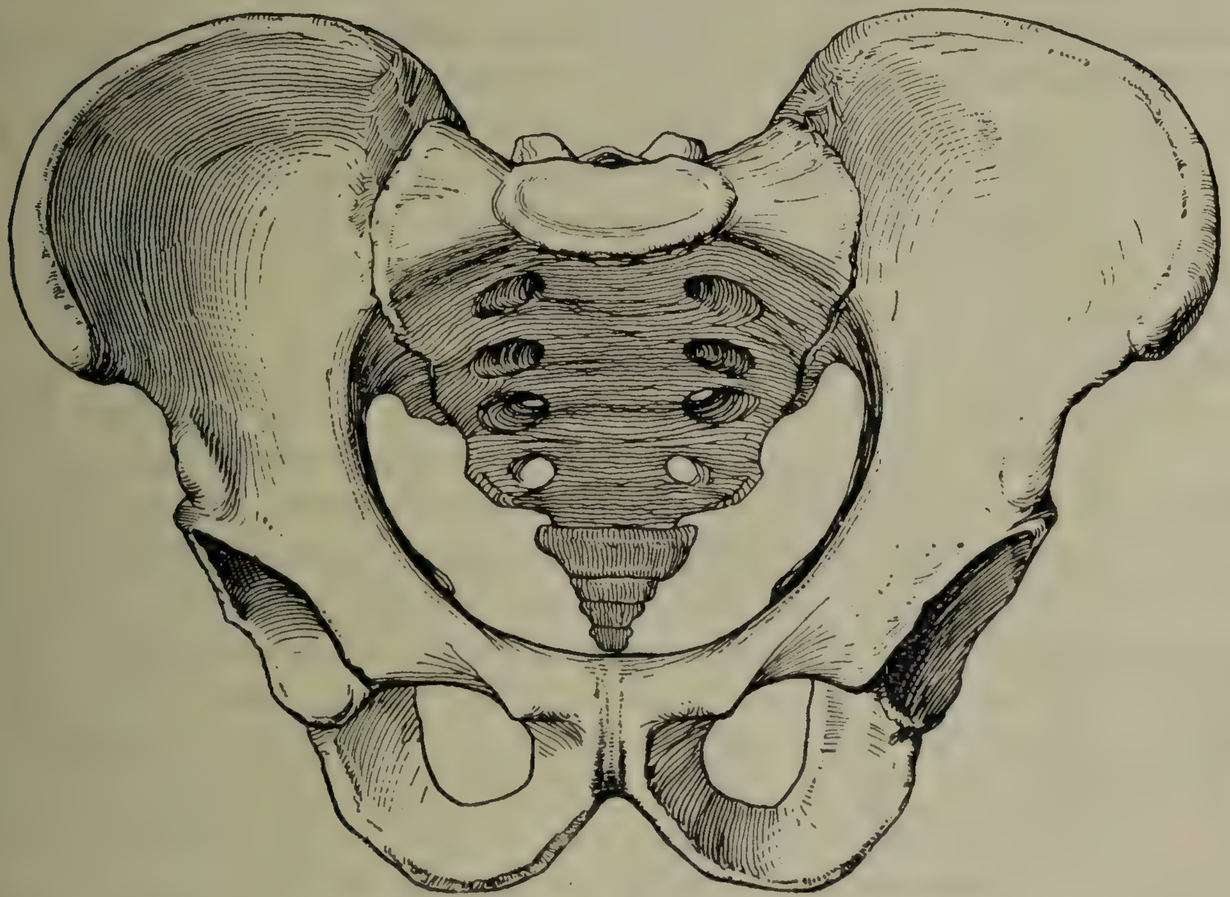


FIG. 217.—THE MALE PELVIS.

FIG. 218.—THE FEMALE PELVIS.

The **cavity** is bounded in front by the bodies and rami of the pubic bones, behind by the sacrum and coccyx, and laterally by an extensive osseous plane, formed chiefly by the pelvic surface of the ischium, but also by that of the ilium, and terminating below in the incurved ischial

spine. It is shallow in front, where its depth is from $1\frac{1}{2}$ to 2 inches but deep behind, where it measures about $5\frac{1}{2}$ inches, following th curve of the sacrum. The plane of the anterior wall is oblique, bein directed downwards and backwards. The posterior wall is curved and at its upper part looks mainly downwards. The *antero-posterio diameter* of the cavity extends from the centre of the symphysis pubi to the upper margin of the third sacral segment; the *transverse*, from point corresponding to the lower margin of the acetabulum on on side to the corresponding point on the other; and the *oblique*, from th centre of the greater sciatic foramen on one side to the centre of th obturator membrane on the other.

The **outlet** presents three prominences—namely, the ischial tuber osity at either side, and the tip of the coccyx in the median line pos teriorly. Its boundaries, at either side from before backwards, ar as follows: the lower border of the symphysis pubis, inferior ramus o the pubis, ramus of ischium, ischial tuberosity, sacro-tuberous ligamen in the recent state, and tip of the coccyx. In front of an imaginar line connecting the ischial tuberosities is the *subpubic arch*, which i bounded at either side by the ischio-pubic ramus and above by thei meeting to form the *subpubic angle*. The arch is occupied by th perineal membrane, the plane of which slopes downwards and back wards. The *antero-posterior diameter* of the outlet extends from th lower border of the symphysis pubis to the tip of the coccyx; the *trans verse*, from one ischial tuberosity to the other; and the *oblique*, fron the middle of the lower border of the sacro-tuberous ligament on one side to the place of union between the inferior pubic and ischial ram on the other.

The Inclination of the Pelvis.—In the erect posture the plane of th pelvic brim forms with the horizontal an angle of from 50 to 60 degrees and the base of the sacrum is about $3\frac{3}{4}$ inches above the upper borde of the symphysis pubis. The brim, therefore, is disposed obliquely sloping upwards and backwards. An idea of this obliquity may be obtained by placing a pelvis against a wall in such a way that the sacro-iliac joint is directly above the acetabulum. A line connecting the tip of the coccyx with the lower border of the symphysis pubis forms with the horizontal an angle of about 11 degrees, and the tip of the coccyx is about $\frac{3}{4}$ inch above the subpubic angle. The direction of the plane of the outlet slopes downwards and backwards, principally downwards. The plane of the symphysis pubis forms with the horizontal an angle of from 35 to 40 degrees. It is worthy of note that the sacro-vertebral angle is estimated at 117 degrees in the male, and as much as 130 in the female.

The Axes of the Pelvis.—The axes represent imaginary lines intersecting the planes of the brim, cavity, and outlet at right angles through their central points. The *axis of the brim* corresponds with a line drawn from the umbilicus to the sacro-coccygeal articulation, and its direction is downwards and distinctly backwards. The *axis of the outlet* represents a line drawn from the sacral promontory through the

centre of the outlet, and its direction is downwards and very slightly backwards. The *axis of the cavity* intersects planes having different inclinations, and is necessarily curved, the concavity being directed forwards. It is described as 'the perpendicular of a line drawn from the middle of the symphysis pubis to the centre of the sacro-coccygeal curve.' The average measurements of the axes of the female pelvis are as follows:

	Antero-Posterior.	Transverse.	Oblique.
Brim	$4\frac{1}{2}$	$5\frac{1}{4}$	5
Cavity	5	5	$5\frac{1}{4}$
Outlet	5*	$4\frac{3}{4}$	$4\frac{3}{4}$

Sexual Differences.—The differences in the two sexes are as follows:

Female.	**Male.**
Bones smoother and more slender.	Bones rougher and more massive.
Acetabula wide apart.	Acetabula not so wide apart.
True pelvis wider and shallower.	True pelvis narrower and deeper.
Obturator foramen triangular.	Obturator foramen oval.
Ischial tuberosities wider apart and everted.	Ischial tuberosities not so wide apart and inverted.
Span of subpubic arch wide.	Span of subpubic arch narrow.
Lower border of ischio-pubic ramus comparatively smooth and thin.	Lower border of ischio-pubic ramus strongly marked and thick.
Brim transversely oval.	Brim cordate.
False pelvis narrower.	False pelvis wider.
Sacral promontory less projecting.	Sacral promontory more projecting.
Sacrum broader, shorter, and straighter.	Sacrum narrower, longer, and more curved.
Coccyx more movably articulated with sacrum.	Coccyx less movably articulated with sacrum.
Symphysis pubis shallower.	Symphysis pubis deeper.
Acetabulum less than 5 cm. in diameter.	Acetabulum more than 5 cm. in diameter.
Auricular groove present.	Auricular groove absent.
Ischial spine not very projecting.	Ischial spine projecting markedly into pelvic cavity.
Body of pubis quadrilateral.	Body of pubis triangular.

The Pelvis of the Child.—The pelvis is of small size in the child. The iliac alæ are expanded, and the cavity is of small dimensions; a large part of the urinary bladder in both sexes, therefore, lies in the hypogastric region of the abdomen. The sacro-vertebral angle is relatively greater, and the pelvis has consequently a greater inclination.

The Femur.

The **femur** extends from the hip to the knee, its direction being downwards, inwards, and slightly backwards. It is a long bone, and is divisible into a shaft and two extremities, upper and lower.

The upper extremity consists of a head, neck, and two trochanters. The **head** forms rather more than half a sphere, and is covered by

* The position of the coccyx makes this variable.

articular cartilage except at a point a little below and behind its centre, where a rough depression, known as the **pit for ligament of head of femur**. Roughly speaking, a head which is more than 45 mm. in diameter is that of a male, less than 45 mm., of a female. For medico-legal purposes 46 mm. and over is almost certainly male, while 42 mm. and below is almost equally certainly female. This, of course, applies to adult English bones.

The **neck** is directed inwards, upwards, and backwards; it averages about 65 mm. in length in males, and 56 mm. in females, and the angle which it makes with the shaft is 126 degrees, though the range of variation may be anything from 113 to 140 degrees. Generally speaking, long femurs have the most vertical necks, though in old age the angle diminishes and the neck appears shorter.

When viewed from in front or behind the neck appears pyramidal with the base towards the shaft, but when looked at from above or below the pyramid has the base towards the head.

Where the neck joins the shaft, in front, is a rough line which may be traced down in front of the lesser trochanter to the back of the shaft; it is known as the **trochanteric line,** and attaches the capsule of the hip-joint.

At its upper end, and also opposite the lesser trochanter, are two specially rough markings, called the upper and lower tubercles of the neck, which attach the two limbs of the ilio-femoral or Y-shaped ligament of the hip.

The trochanteric line was formerly called the spiral line, which is probably a better name, since the line passes well in front of the lesser trochanter.

In front of the neck, close to the head, there is usually a rough, irregular area, which may be caused by the pressure of the margin of the acetabulum in extreme flexure of the hip.

It will be seen from the above description that the whole of the front of the neck is intracapsular.

Posteriorly the neck is only intracapsular in its inner two-thirds, the outer third being smooth for about a finger's breadth where the obturator externus muscle plays over it, and, at the junction of the intra- and extra-capsular parts, the posterior portion of the capsule is practically non-adherent.

The intracapsular part of the neck has many foramina, and is longitudinally ridged for the retinacula of the hip-joint.

The **greater trochanter** is a lever, for the attachment of muscles, projecting directly upwards from the shaft. Perhaps the most convenient way of studying it is to regard it as cuboidal and to look at it consecutively from six points of view.

Anteriorly is a triangular surface for the attachment of the gluteus minimus laterally and for a bursa medially.

Posteriorly the bone shows little more than a rounded border, which, where it joins the shaft, is heaped up into an eminence known as the quadrate tubercle.

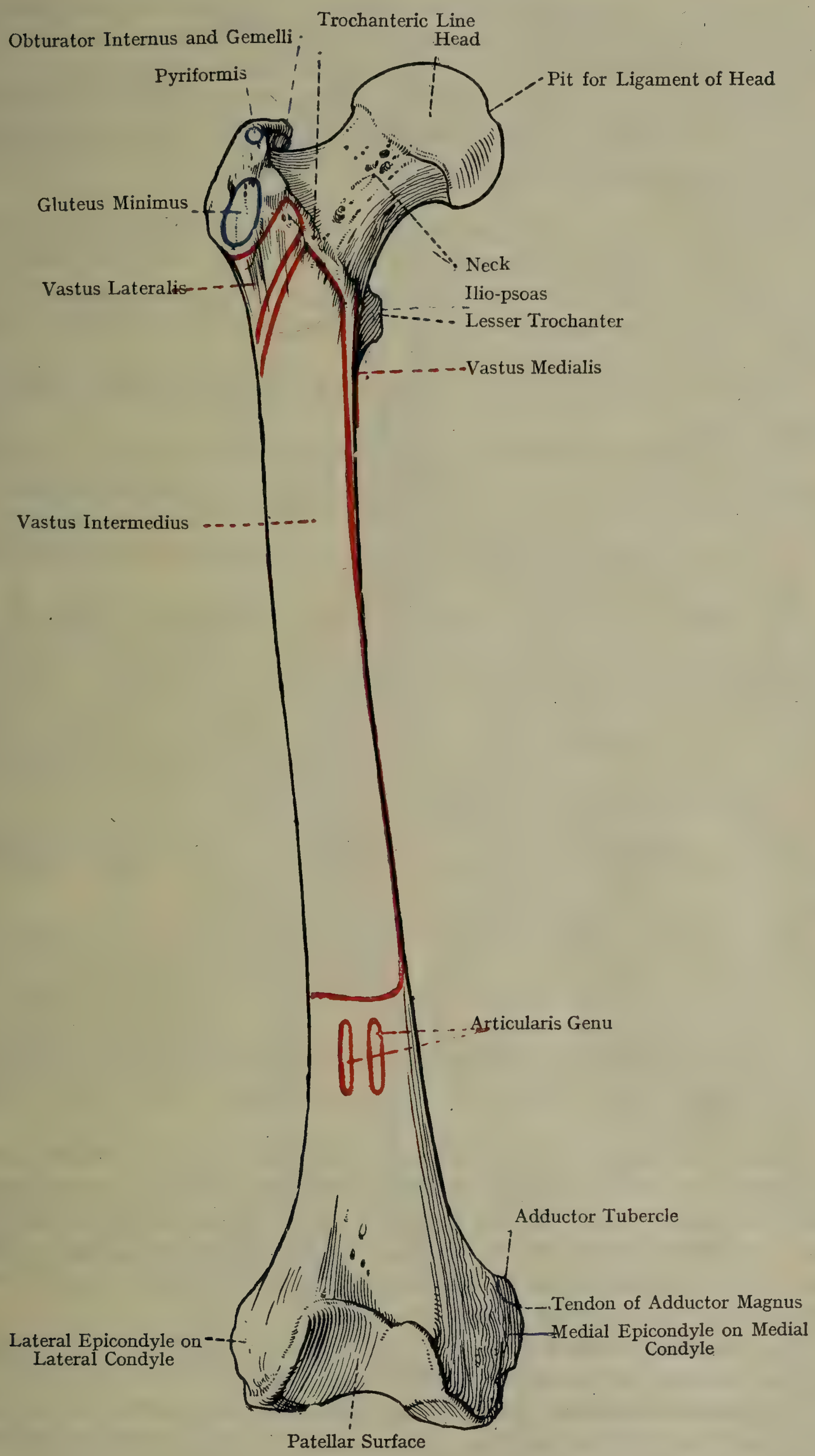


FIG. 219.—THE RIGHT FEMUR (ANTERIOR VIEW).

Laterally is a quadrilateral surface bisected by the diagonal lin which runs from the postero-superior to the antero-inferior angle, an attaches the gluteus medius. Above this line is a bursa.

Medially the surface is only free posteriorly where it is hollowed ou to form the digital or trochanteric fossa for the attachment of th obturator externus tendon and, in front of this, the obturator internu and gemelli.

Superiorly the trochanter is little more than a border, to the greate part of which the pyriformis is attached. It may be useful here t notice that, when the femur is in position, a line drawn horizontall inwards from the top of the great trochanter will pass through th middle of the head of the femur.

Inferiorly, of course, the trochanter is continuous with the shaf of the femur.

The **lesser trochanter** is a pyramidal process with a rounded ape projecting backwards and inwards from the shaft about a hand's breadth below the top of the head; it forms a lever for the psoas muscle for the attachment of which its apex is roughened, while just below it is a rough surface for the iliacus.

The **shaft** is directed obliquely downwards and inwards, and the obliquity is slightly greater in the female than in the male. It is narrowest in the centre and widens above and below. In its middle third the shaft is prismatic, having an anterior, lateral, and medial surface and a posterior, lateral, and medial border; of these, the posterior border is very strong and rough, and is known as the linea aspera, while the other two borders are hardly noticeable.

In the upper and lower thirds the shaft becomes quadrilateral in section owing to the divergence of the lips of the linea aspera forming a posterior surface in addition to the other three.

The anterior surface of the femur begins above at the upper tubercle of the neck where the trochanteric line leaves the greater trochanter; in this triangular area the vastus lateralis is attached very strongly, but farther down the trochanteric line the vastus intermedius gains a short attachment, and still farther the vastus medialis, so that all three of these deep constituents of the quadriceps femoris are attached to the trochanteric line.

About the level of the lesser trochanter the vastus intermedius occupies the whole of the anterior surface, which it continues to do until the lower third of the bone is reached, rising by a series of horizontal, fleshy strips with cellular tissue between them. Below the vastus intermedius the articularis genu takes origin from the anterior surface by two or more bundles.

The **lateral surface** attaches the vastus lateralis in its upper third and the vastus intermedius in its middle third.

The **medial surface** is singularly smooth, and has no muscle attached to it, but the vastus medialis plays over it and is separated from it by cellular tissue.

The **posterior surface**, as has been noticed, is only present in the

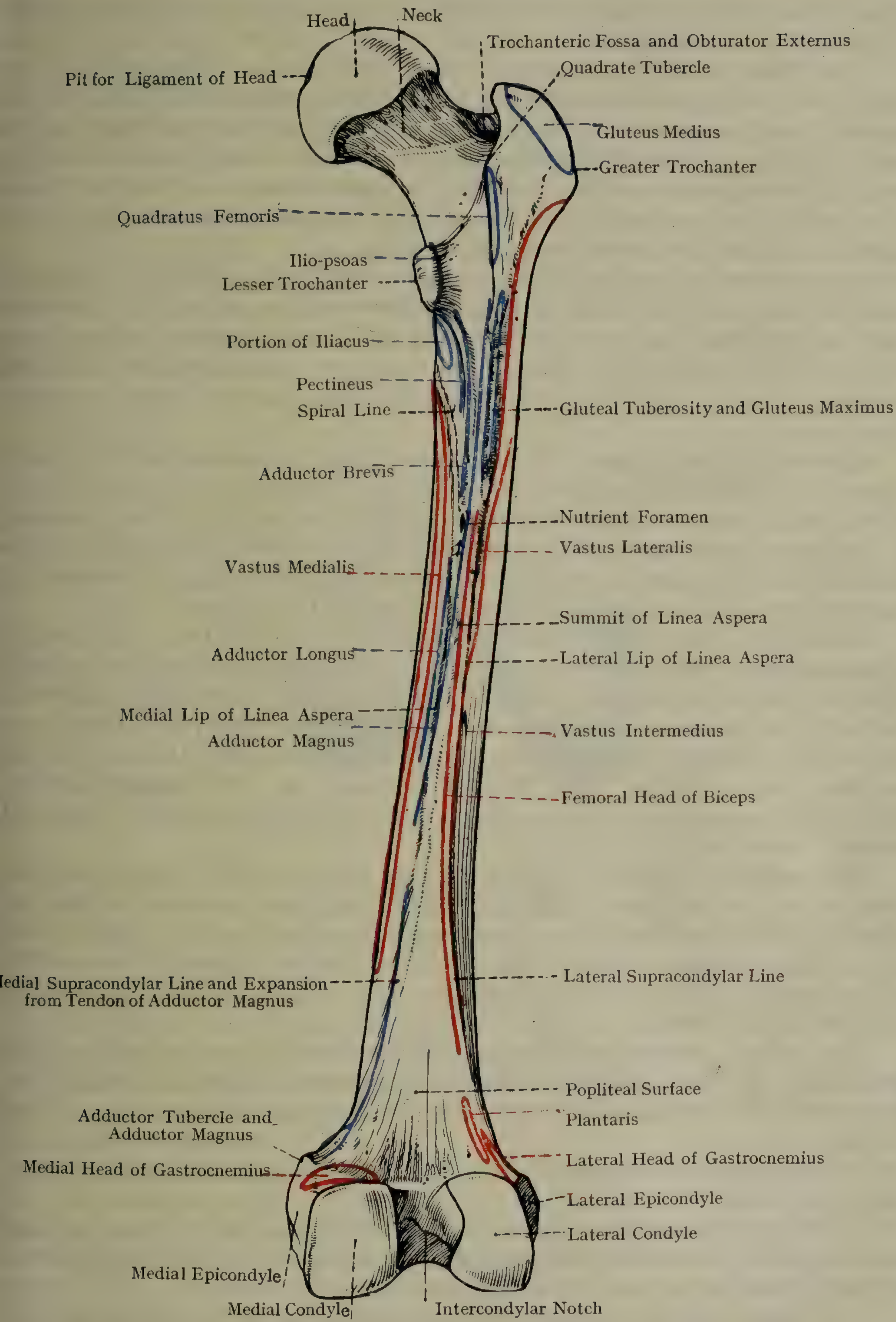


FIG. 220.—THE RIGHT FEMUR (POSTERIOR VIEW).

upper and lower thirds of the shaft, being represented in the middle third by the linea aspera.

The **linea aspera,** although it attaches several lines of muscles, has a medial and a lateral lip, of which the latter is always the better marked, and again it may be well to repeat that the true linea aspera only occupies the middle third of the shaft and is only about 6 inches long. In its course will be seen one, or more often two, nutrient foramina which, as is usual in the lower limb, run away from the knee and, therefore, from the growing end of the bone.

Since the middle third of the femur is the densest mass of compact bone in the body it often remains after all the rest of the skeleton has disappeared, and for medico-legal or other purposes the side to which it belonged may usually be told by the nutrient foramina running upwards and the outer lip of the linea aspera being the more prominent.

Above the linea aspera divides into three or, in very well marked bones, four lines; these are, from within outwards: the spiral line, which winds round to the trochanteric line; the pectineal line, running to the lesser trochanter; the quadrate line, to the quadrate tubercle, though this line is only occasionally seen; and the gluteal tuberosity, passing upwards and outwards to the greater trochanter.

Below the linea aspera bifurcates and forms the lateral and medial supracondylar lines, of which the outer is well marked for the attachment of the short head of the biceps, while the inner ends below in the adductor tubercle, situated above the medial condyle. This inner line is particularly faint about a hand's breadth above the top of the condyle, being rubbed out by the pressure of the femoral artery, which here passes into the popliteal space and becomes the popliteal artery.

The posterior surface of the femur, between the supracondylar lines, forms the popliteal surface, and is rough and covered by the fat which fills the popliteal space and separates the bone by ½ inch from the popliteal artery. In the space, about a finger's breadth above the medial condyle, is a rounded, rough elevation which attaches the medial head of gastrocnemius.

The rather difficult attachments of the muscles to the back of the femur may now be studied, and perhaps the best method is to realize that there are six lines of muscular attachments. These are, from within outwards:

1. The spiral line and medial lip of the linea aspera, attaching the vastus medialis.

2. The pectineal line from the lesser trochanter to the linea aspera, attaching the pectineus; and the linea aspera in the middle third of the femur, attaching the adductor longus.

3. A short line occupying the second quarter of the shaft, for the adductor brevis.

4. The feeble quadrate line, attaching the quadratus femoris, for about 2 inches below the quadrate tubercle, and, continuing this, the

attachment of the adductor magnus, which runs right down to the adductor tubercle, with a break where the artery pierces it at the upper part of the medial supracondylar line.

5. The gluteal tuberosity, for the gluteus maximus, and, continuing this, the attachment of the short head of the biceps, which goes so high that sometimes the two muscles overlap, and below is attached to the lateral supracondylar line. It is this muscle which causes the outer lip of the linea aspera to be so well marked.

6. The lateral lip of the linea aspera, along which the vastus lateralis runs from the greater trochanter, following the gluteal tuberosity, to about the middle of the bone, and is then succeeded by the vastus intermedius, while at its lower end, just above the condyle, the plantaris is attached.

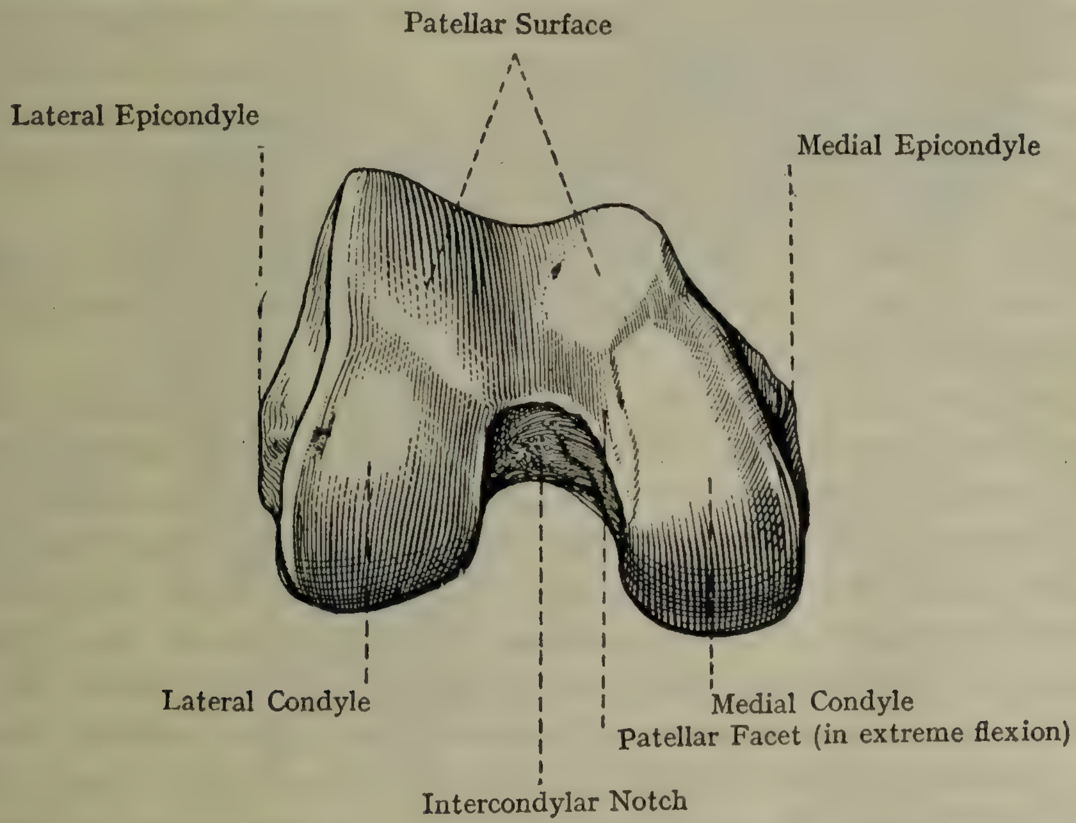


FIG. 221.—THE LOWER EXTREMITY OF THE RIGHT FEMUR.

Sometimes, on the lateral supracondylar line, a definite tubercle for a specially strong bundle of the biceps is formed.

It may be useful to recognise that the level of the lesser trochanter indicates the upper limit of attachment of the gluteus maximus and the adductor magnus.

The **lower extremity** presents an extensive articular surface, which is divided into three parts—anterior or patellar, and two postero-inferior or condylar. All three surfaces are continuous in front, but the condylar surfaces are widely separated behind by the intercondylar notch. The *patellar surface* is trochlear, and presents a vertical groove with a convexity on either side. The groove is to the inner side of the centre, and the part lateral to it is broader, more prominent, and extends higher than the medial part. The upper border is therefore sloped inwards and slightly downwards. The greater forward prominence

of the outer part of the surface explains why the patella is inclined inwards in extension of the knee-joint and why it is not more often dislocated outwards.

The **condyles** are convex from before backwards and from side to side. Posteriorly they become prominent, and on this aspect the lateral condyle extends a little higher than the medial. As viewed from below the lateral condyle is broad and short, the medial being long and narrow. When the femur is held vertically the medial condyle projects lower down than the lateral, and this brings the two condyles upon the same horizontal plane when the bone occupies its natural sloping position. The outer border of the lateral condyle is very nearly in the same line with the outer border of the patellar surface, and the outer border of the medial condyle is in the same line with the inner border of the patellar surface. The inner border of the medial condyle has a convex outline, and at its anterior part it turns outwards to the patellar surface. For the most part the condyles are parallel, the exception being the front part of the medial condyle, which inclines outwards to meet the patellar surface.

From the above it will be realized that the antero-posterior axis of the lateral condyle is straight, while that of the medial is curved, with its concavity outward.

The demarcation between the condylar surfaces and the patellar surface is clearly marked at either side. The lateral condyle is separated from the patellar surface by a slightly elevated line and groove, extending outwards and slightly forwards from the front and outer part of the intercondylar notch to the outer border of the cartilaginous surface, where there is a depression which receives the anterior part of the lateral semilunar fibro-cartilage during extension of the knee-joint. The medial condyle is separated from the patellar surface by a line and groove, extending from near the front and inner part of the intercondylar notch forwards and slightly inwards to the inner border of the cartilaginous surface, at a point about 1 inch below the inner end of the upper border of the patellar surface. At this latter point there is a depression which receives the anterior part of the medial semilunar fibro-cartilage during extension of the knee-joint. The line and groove just referred to do not extend quite close to the intercondylar notch. The groove subsides, but the line sweeps backwards in a curved manner along the outer part of the inner condylar surface, thus marking off a narrow semilunar zone from the general tibial surface. This zone lies close to the inner part of the intercondylar fossa, and is known as the *semilunar patellar facet.*

The *outer surface* of the lateral condyle towards the back part presents the *lateral epicondyle,* which gives attachment to the lateral ligament of the knee-joint. Immediately above and behind the epicondyle is a depression for the lateral head of gastrocnemius, and behind and below it there is a groove, called the *popliteal groove,* which is directed downwards and forwards. The tendon of the popliteus arises from the front part of the horizontal portion of the groove, and

it is lodged in the groove only when the knee is flexed; at other times it plays over the bevelled lower lip of the groove.

The *inner surface* of the medial condyle presents at its centre a large blunt eminence, called the *medial epicondyle*, for the attachment of the medial ligament of the knee. Posteriorly, where the medial supracondylar line joins the internal condyle, the adductor tubercle is situated, and the line of origin of the medial head of gastrocnemius extends upwards and outwards from this tubercle above the medial condyle.

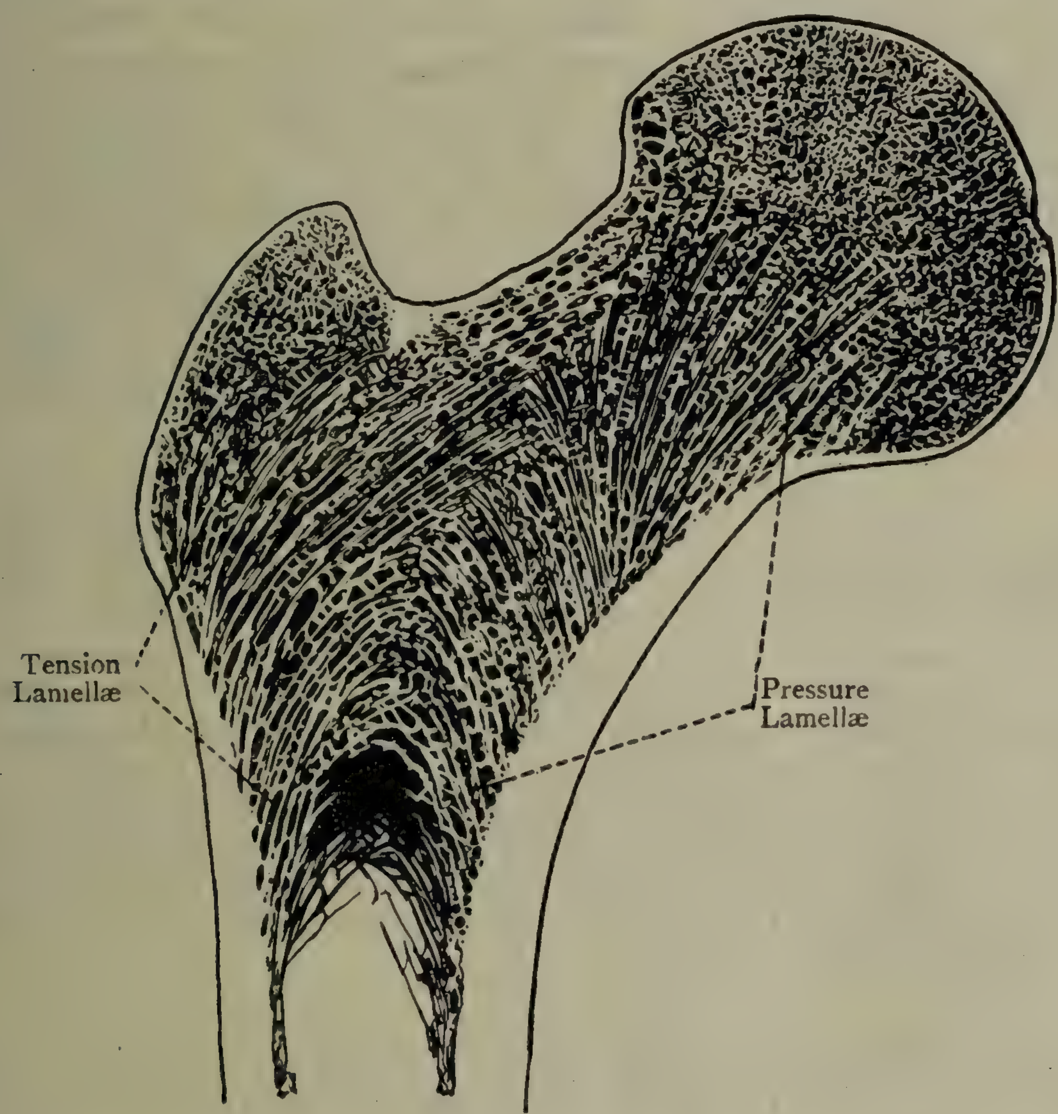


FIG. 222.—LONGITUDINAL SECTION THROUGH THE UPPER END OF THE FEMUR, SHOWING THE PRESSURE LAMELLÆ AND TENSION LAMELLÆ.

The markings in connection with the *intercondylar notch* are for the cruciate ligaments. The impression for the *anterior* cruciate ligament is at the back part of the inner surface of the lateral condyle, whilst that for the *posterior* cruciate ligament is at the front part of the outer surface of the medial condyle, and adjacent portion of the front of the intercondylar notch. At the front of that fossa in the middle line the ligamentum mucosum is attached.

Structure.—The structure is that of a long bone. The medullary canal extends from a point just below the lesser trochanter to the level of the apex of the popliteal surface. Above and below these points the bone is composed of cancellated tissue, except externally, where there is a shell of compact bone. The cancellous tissue at the

upper extremity has its lamellæ arranged in a series of curves disposec in three systems, one of which represents the pressure lamellæ, anothe the tension lamellæ, while the third, or bolting lamellæ, run at righ angles to the others and transfer strain or stress. The *pressure lamellc* extend from the lower part of the neck and upper part of the shaf internally in a radiating manner, passing inwards to the head. Th tension lamellæ intersect the pressure lamellæ almost at right angles and in many places render the presence of bolting lamellæ unnecessary They run from the upper part of the shaft to the greater trochanter and thus carry the pull of the muscles from the trochanter to th compact tissue. Additional strength is afforded by an almost verticall disposed plate of compact bone, called the *calcar femorale,* which run upwards and downwards in front of, and above, the small trochanter and lies in the line in which weight is transmitted. The cancellou tissue at the lower extremity has its lamellæ arranged in vertical anc horizontal planes, the former being tension lamellæ for the most part though those coming from the intercondylar notch will take th traction of the crucial ligaments; the horizontal ones are obvious boltin lamellæ.

Varieties.—(1) The lower part of the gluteal tuberosity may assume the forn of a depression, called the *fossa hypotrochanterica.* (2) There may be a *thirc trochanter,* situated at the upper part of the gluteal tuberosity. (3) The line aspera may be unduly prominent, this condition being known as the *pilasterec femur.* (4) The amount of antero-posterior convexity of the shaft forward always noticeable, may be greatly exaggerated, and it is this condition whicl usually leads to pilastering. Antero-posterior bowing is usually found in ver thick-set, muscular men. (5) Sometimes a femur is flattened and widened i the upper part of its shaft. This is known as *platymeria,* and is much mor common in uncivilized and prehistoric races. There seems reason to associat it with a squatting posture. (6) The adductor tubercle may be unusually large and is then known as ' rider's bone.'

The Femur of the Female.—(1) The bone is smoother and slighte than in the male. (2) The head is usually less than 45 mm. in diameter (3) The bones are farther apart above, more sloped inwards, and neare to each other below, than in the male. (4) The lower end is usuall less than 71 mm. in breadth.

Relation to Stature.—The femur is said to form 0·275 of the bod stature, but in fifty cases examined in St. Thomas's, Guy's, and King' College dissecting rooms it was found to be 0·2725 in males and 0·27c in females. This was obtained from the maximal length of the femur when it is measured in the oblique position which it occupies in the body its length is some 3 mm. less.

The men averaged 5 feet 6 inches (1,676 mm.), and the maxima average length of their femurs was 456 mm., or just 18 inches. The women only average 5 feet 1 inch (1,550 mm.), and their femurs 416 mm., or 16½ inches.

Usually one femur is longer than the other by 3 or 4 mm., and usually it is the left which is the longer.

Ossification.—The femur ossifies in cartilage from **one primary,** and **four secondary, centres.** The primary centre appears at the middle of the shaft in the *seventh week* of intra-uterine life. The centre for the lower end appears nearly always before birth; in girls it may begin to form during the eighth (or even seventh) month, in boys in the eighth to ninth month, and even at or after birth in some rare but apparently full-time cases. The three upper epiphyses are cartilaginous at birth. The centre for the head appears in the first year, that for the greater trochanter at four (M.) or three (F.), while that for the lesser trochanter, which only forms the summit of the process, comes at ten or eleven, or perhaps a little later. The upper epiphyses join the shaft about eighteen (M.) or seventeen (F.), or a little earlier; the lower epiphyses join about nineteen or twenty (M.), in women about eighteen (variable). The neck is ossified from the centre for the shaft. The line indicating the junction of the lower epiphysis and shaft cuts the adductor tubercle into two, one portion belonging to the lower epiphysis, and the other to the shaft.

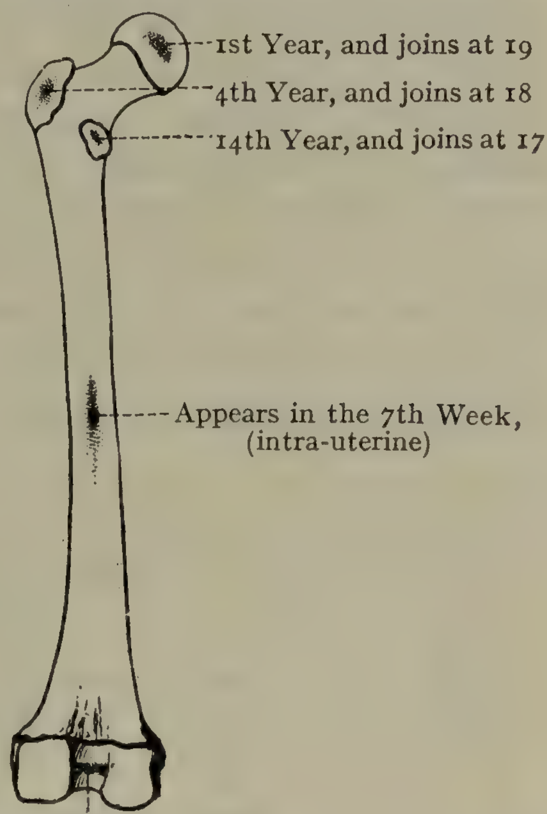


FIG. 223.—OSSIFICATION OF THE FEMUR.

The Patella.

The **patella,** or knee-cap, is situated in front of the knee-joint, where it articulates with the patellar surface in the femur. It is originally a sesamoid cartilage developed in the tendon of the quadriceps femoris. The bone is triangular, with the apex downwards, and is compressed from before backwards. The *superior border* or *base* is broad, and its plane is inclined forwards and slightly downwards. It gives insertion anteriorly to the rectus femoris and vastus intermedius from before backwards, and posteriorly it is covered by a portion of the synovial membrane of the knee-joint. The *lateral borders* are sloped towards the apex, the outer being at first rather more prominent than the inner. The *outer border* over its upper third gives insertion to a portion of the vastus lateralis, and the *inner* over its upper half to a portion of the vastus medialis. The *apex* is blunt, and, together with the adjacent marginal parts, gives attachment to the ligamentum patellæ, by which the bone is connected with the tubercle of the tibia.

The *anterior surface,* which is slightly convex, is vertically ridged and covered by a prolongation of the tendon of the quadriceps femoris. It is perforated by numerous nutrient foramina, and is subcutaneous, being separated from the integument by the prepatellar bursa.

The *posterior surface* is divided into two parts—articular and non-articular. The *non-articular part* represents the lower fourth, and is rough and depressed. It lodges a collection of fat covered by synovial membrane. The *articular part* corresponds with the upper three-

fourths, and is divided into two unequal parts by a round vertical ridge, which is received into the groove of the patellar surface of the femur. The *lateral division* is broad and concave from side to side, whilst the *medial* is narrow and convex in the transverse direction. Excluding a narrow vertical zone at the inner part of the inner division, each division is subdivided by two slight transverse ridges into three horizontal zones—upper, middle, and lower, of which the middle is the largest and broadest. These six horizontal facets articulate with the patellar surface of the femur, the lower facets being in contact with the upper part of the patellar surface in extension of the knee-joint, the middle patellar facets with the middle portion of the patellar surface

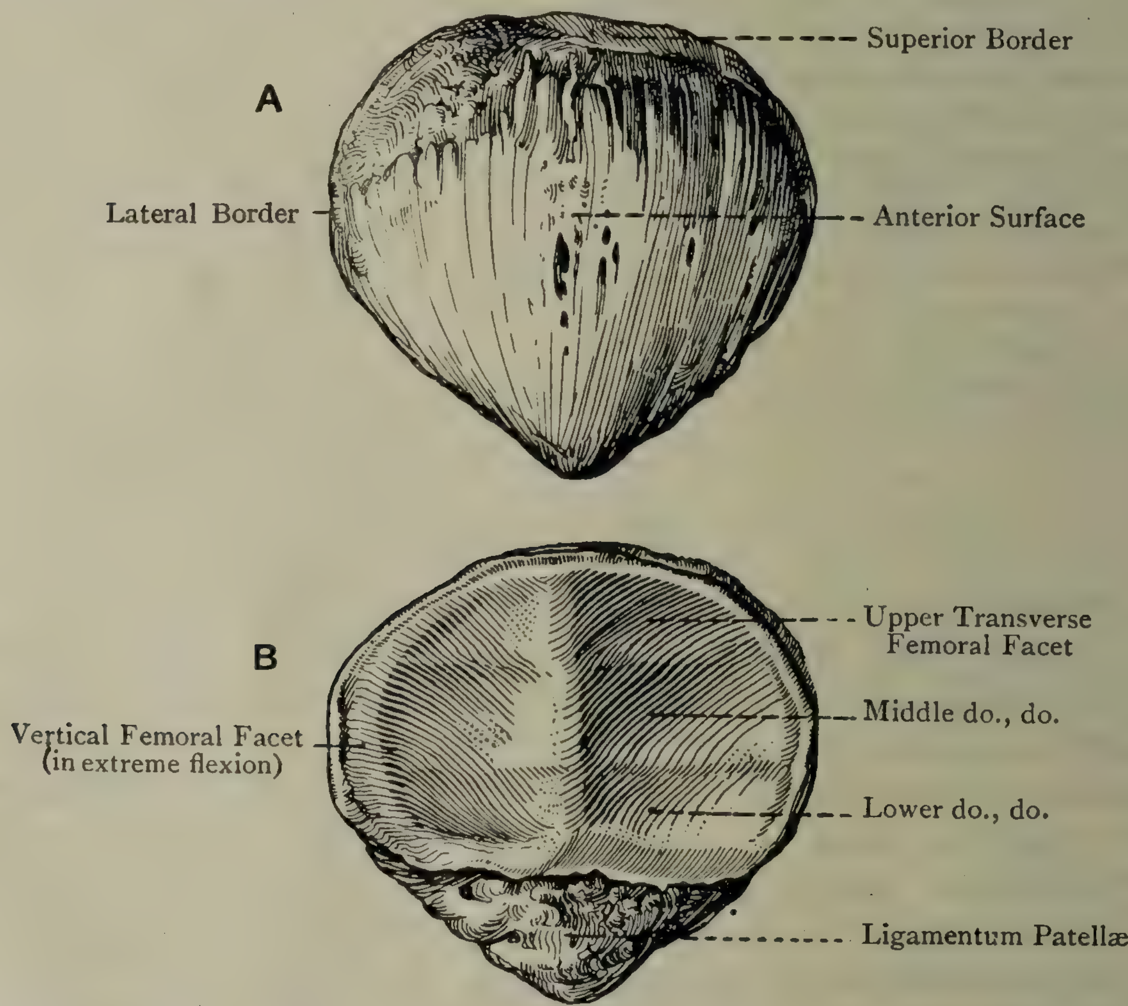


FIG. 224.—THE RIGHT PATELLA.
A, anterior surface; B, posterior surface.

of the femur in semiflexion, and the upper patellar facets with the lower parts of the patellar surface of the femur in flexion of the knee-joint. The vertical zone at the inner part of the inner division of the articular surface (close to the inner border of the bone) constitutes a seventh facet. In extreme flexion of the knee-joint this facet articulates with the semilunar facet on the outer part of the tibial surface of the medial condyle of the femur close to the intercondylar notch, whilst the upper and outer horizontal facet is in contact with the front part of the lateral condyle.

Structure.—The patella, being a short bone, is composed principally of dense cancellous tissue with close meshes, surrounded by compact

bone, which is much thicker in front than behind. The traction lamellæ are specially marked in the front of the bone, while the pressure lamellæ are at right angles to these to take the weight of the body in kneeling.

Ossification.—The original cartilage is deposited in the tendon of the quadriceps femoris in the *third month* of intra-uterine life. In this cartilage a **single centre** appears in the *third year* in girls, a little later in boys; ossification is completed about the age of puberty.

The Tibia.

The **tibia,** or shin bone, is the inner and larger of the two bones of the leg, and alone transmits the weight of the body to the foot. The posterior surfaces of the shafts of the tibia and fibula are on the same horizontal plane above and below, but over about the middle three-fifths the fibula projects slightly farther back on account of the anterior curvature of the tibia. Anteriorly the tibia is on a more anterior plane than the fibula, a point to be borne in mind in making flaps by transfixion. The tibia is a long bone, and is divisible into a shaft and two extremities, upper and lower.

The **upper extremity,** known as the **head,** is broader from side to side than from before backwards. Antero-laterally it is convex, but posteriorly it is rendered concave by the *popliteal notch* at its centre. The enlargements of the bone on either side of the head are called the condyles, lateral and medial. The *lateral condyle* is rather smaller than the medial, and at its posterior and under aspect it presents a flat circular facet, directed downwards, backwards, and outwards, which articulates with the head of the fibula. The cartilage of this facet is occasionally continuous with that of the lateral condylar surface. At the junction of the anterior and outer surfaces the lateral condyle has an elevation for the attachment of the ilio-tibial tract of the fascia lata, below which the extensor digitorum longus often gains a small attachment. The *medial condyle* is larger than the lateral, and has a distinct inclination backwards as well as inwards, a point to be noted in setting fractures of this bone. On its posterior aspect it presents a horizontal groove for the insertion of the chief portion of the tendon of the semimembranosus muscle. On the anterior aspect of the superior extremity, at the junction of the head and shaft, there is a well-marked projection, called the *tubercle*. It is fully 1 inch in length, and its upper border is about $\frac{3}{4}$ inch below the level of the upper surface of the head. It is divisible into two nearly equal parts, upper and lower. The lower division is rough, and is usually strongly ridged in the vertical direction for the attachment of the ligamentum patellæ. The upper division is smooth, and is separated from that ligament by a synovial bursa.

The *superior surface* of the head presents the two condylar articular surfaces, separated from each other by an irregular interval, which, amongst other markings, presents the bifid intercondylar eminence. Each surface surmounts the corresponding condyle. The *lateral*

condylar surface is broad from side to side, and is almost circular. It is very slightly concave from side to side. Its cartilage rises towards the middle line to coat the lateral surface of the lateral intercondylar tubercle, and posteriorly it dips down for a little on the outer part of the back of the lateral condyle, where the tendon of the popliteus glides over it. It is in this situation that the cartilage is occasionally continuous with that of the fibular facet. The *medial condylar surface* is oval and decidedly more concave than the outer, being elongated from before backwards, but narrow from side to side. The cartilage of this surface rises towards the middle line to coat the medial surface of the medial intercondylar tubercle. Each condylar surface is deepened by a semilunar fibro-cartilage, which is placed round its peripheral part.

The interspace between the articular surfaces presents the intercondylar eminence, which is distant from the posterior border about

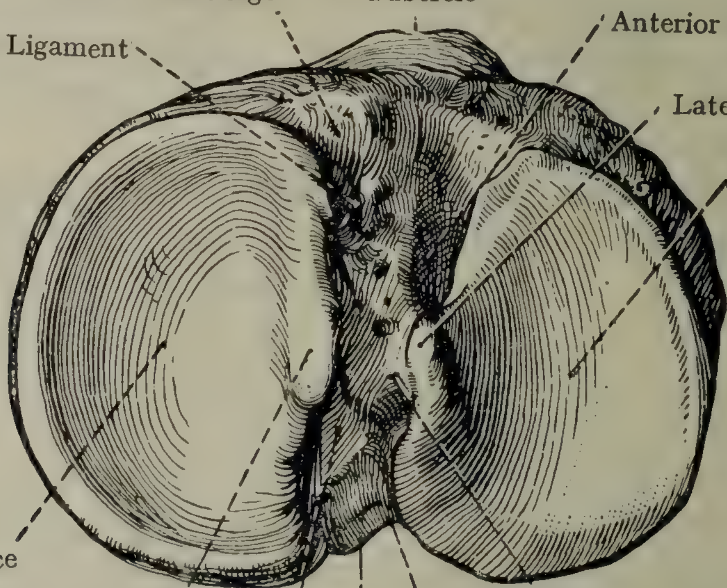


FIG. 225.—THE HEAD OF THE RIGHT TIBIA (SUPERIOR VIEW).

one-third of the antero-posterior measurement. The **intercondylar eminence** is formed by an upward rising of the contiguous borders of the articular surfaces, and is bifid, ending in two tubercles, of which the medial is the better marked and longer of the two. The interspace between these tubercles gives attachment to the posterior horn of the lateral semilunar fibro-cartilage, which continues to be attached to a depression behind the lateral tubercle. The surfaces of the tubercles which face each other are free from cartilage, but the other surfaces have each a cartilaginous covering.

In front of the eminence there is a rough depression where important structures are found; in front of the lateral intercondylar tubercle the anterior horn of the lateral semilunar fibro-cartilage is attached, and in front of the medial tubercle the anterior cruciate ligament is attached to the bone. At the extreme anterior and inner part there is an impression for the anterior horn of the medial semilunar fibro-

cartilage. On the outer side of the impression for the anterior cruciate ligament, and in front of that for the anterior horn of the lateral semilunar fibro-cartilage, there is a depression which is partially occupied by a small collection of fat. At its outer part, however, there is a groove which receives a portion of the lateral semilunar fibro-cartilage in extension of the knee-joint. The immediately adjacent portion of the lateral articular surface is specially faceted for the play of part of the lateral condyle of the femur in extension of the joint. Behind the intercondylar eminence there is a more limited rough depression, which leads backwards to the popliteal notch. The posterior horn of the medial semilunar fibro-cartilage is attached to the inner part of this depression, and the posterior cruciate ligament is attached to its back part, as well as to the popliteal notch.

Order of Structures attached to the Head.—The structures, enumerated as nearly as possible in order from before backwards, are as follows:

1. Anterior horn of medial semilunar fibro-cartilage.
2. Anterior cruciate ligament.
3. Anterior horn of lateral semilunar fibro-cartilage.
4. Posterior horn of lateral semilunar fibro-cartilage.
5. Posterior horn of medial semilunar fibro-cartilage.
6. Posterior cruciate ligament.

The head is pierced all round by many nutrient foramina for branches of the inferior genicular arteries of the popliteal, and of the posterior and anterior tibial recurrents of the anterior tibial.

The **shaft** is massive and prismatic. It diminishes in size from above downwards over its upper two-thirds, and then gradually enlarges towards its lower end. It presents three borders and three surfaces. The *anterior border* extends from the outer side of the tubercle above to the anterior margin of the medial malleolus below. Over the upper two-thirds, where it occupies the middle line, it is prominent, and is known as the *crest* or shin-ridge. This is doubly curved, the convexity of the upper curve being directed inwards, and that of the lower outwards. Over the lower third the anterior border inclines inwards, and the lateral surface of the shaft is thus allowed to come forwards. The crest is subcutaneous, and gives attachment to the deep fascia of the leg. The *medial border* extends from the inner and back part of the medial condyle to the posterior margin of the medial malleolus. For 3 or 4 inches superiorly it is rough, and gives attachment to the medial ligament of the knee-joint. Over its middle third it is prominent, and it here gives origin to a portion of the soleus as low as the centre of the bone. The *lateral* or *interosseous border* extends from the front of the fibular facet above to a point about 2 inches from the lower end, where it bifurcates. The two divisions pass to the front and back of the fibula, and enclose between them a rough triangular surface for the interosseous tibio-fibular ligament. This border is sharp and wiry, and gives attachment to the interosseous membrane.

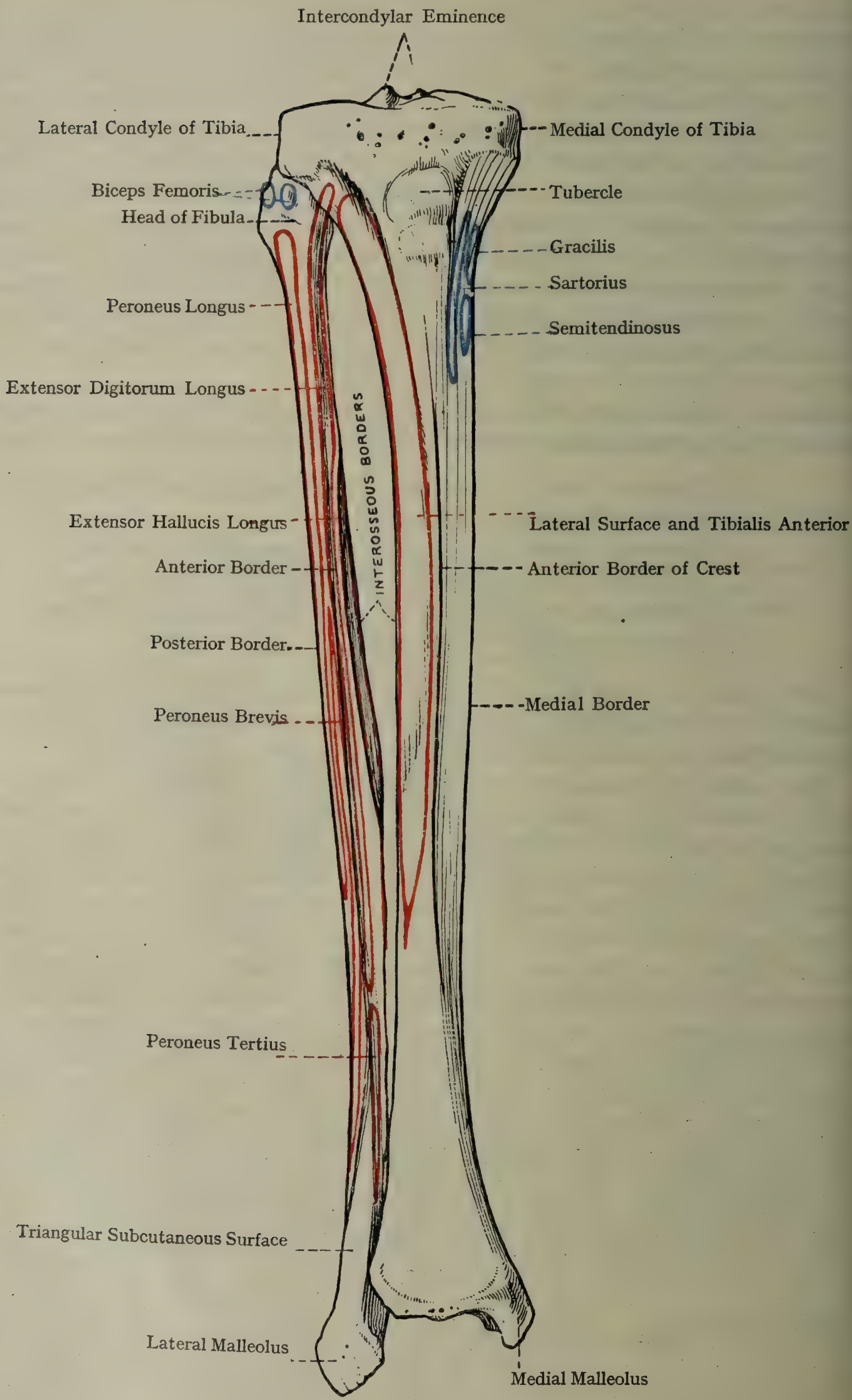


FIG. 226.—THE RIGHT TIBIA AND FIBULA (ANTERIOR VIEW).

The *medial surface* is situated between the crest and medial border. It is for the most part subcutaneous, and slightly convex. Superiorly, where it becomes expanded and flattened, it presents a vertical rough area, behind the tubercle, for the insertion of the sartorius, and behind this two vertical rough impressions in the same line with each other, the upper of which gives insertion to the gracilis, and the lower to the semitendinosus. The *lateral surface* is situated between the crest and interosseous border. It is concave over its upper two-thirds, where it gives origin to the tibialis anterior. Over the lower third, where it is convex, it turns to the front and supports the extensor tendons, and anterior tibial vessels and nerve. The *posterior surface* lies between the interosseous and medial borders. Superiorly it is crossed by the *soleal* or *oblique line*, which is rough, and extends from the fibular facet downwards and inwards to the medial border at about the junction of the upper third and lower two-thirds. This line gives attachment to the popliteal fascia and part of the soleus, whilst the triangular popliteal surface above gives insertion to the popliteus muscle. The posterior surface below the soleal line presents over its middle third the **vertical line** which divides it into two parts. The outer portion is narrow, and gives origin to the tibialis posterior as low as a point just below the centre of the bone. The inner portion is broad, and gives origin to the flexor digitorum longus over the middle two-fourths of the bone. A little below the soleal line, close to the outer side of the vertical line, is the **nutrient foramen** for a large branch of the posterior tibial artery. This foramen, which is the largest of its class, and the canal to which it leads are directed *downwards*. The posterior surface in its lower third supports the flexor tendons, and posterior tibial vessels and nerve.

The **lower extremity** is cuboidal, and below presents a quadrilateral articular surface, concave from before backwards, and wider in this direction laterally than medially. It is broader in front than behind, and articulates with the superior surface of the talus. The posterior border projects somewhat lower than the anterior. The anterior surface, immediately above the anterior border, is depressed for the anterior ligament of the ankle-joint, and just above this has a transverse, rounded ridge marking the position of the epiphysial line. The posterior surface gives attachment to the posterior ligament of the ankle-joint as far inwards as the groove behind the medial malleolus. It presents the following grooves: one, very faint, for the tendon of the flexor hallucis longus near the outer end; and one, mainly situated on the back of the medial malleolus, for the tendons of the tibialis posterior and flexor digitorum longus.

The inner aspect of the lower extremity presents the *medial malleolus*, which is a strong process having a downward direction. Its medial surface is rough, convex, and subcutaneous. The lateral surface is covered by cartilage, continuous with that which coats the lower extremity. The plane of this surface is vertical, and the cartilage coats it more deeply in front than behind. It articulates with the

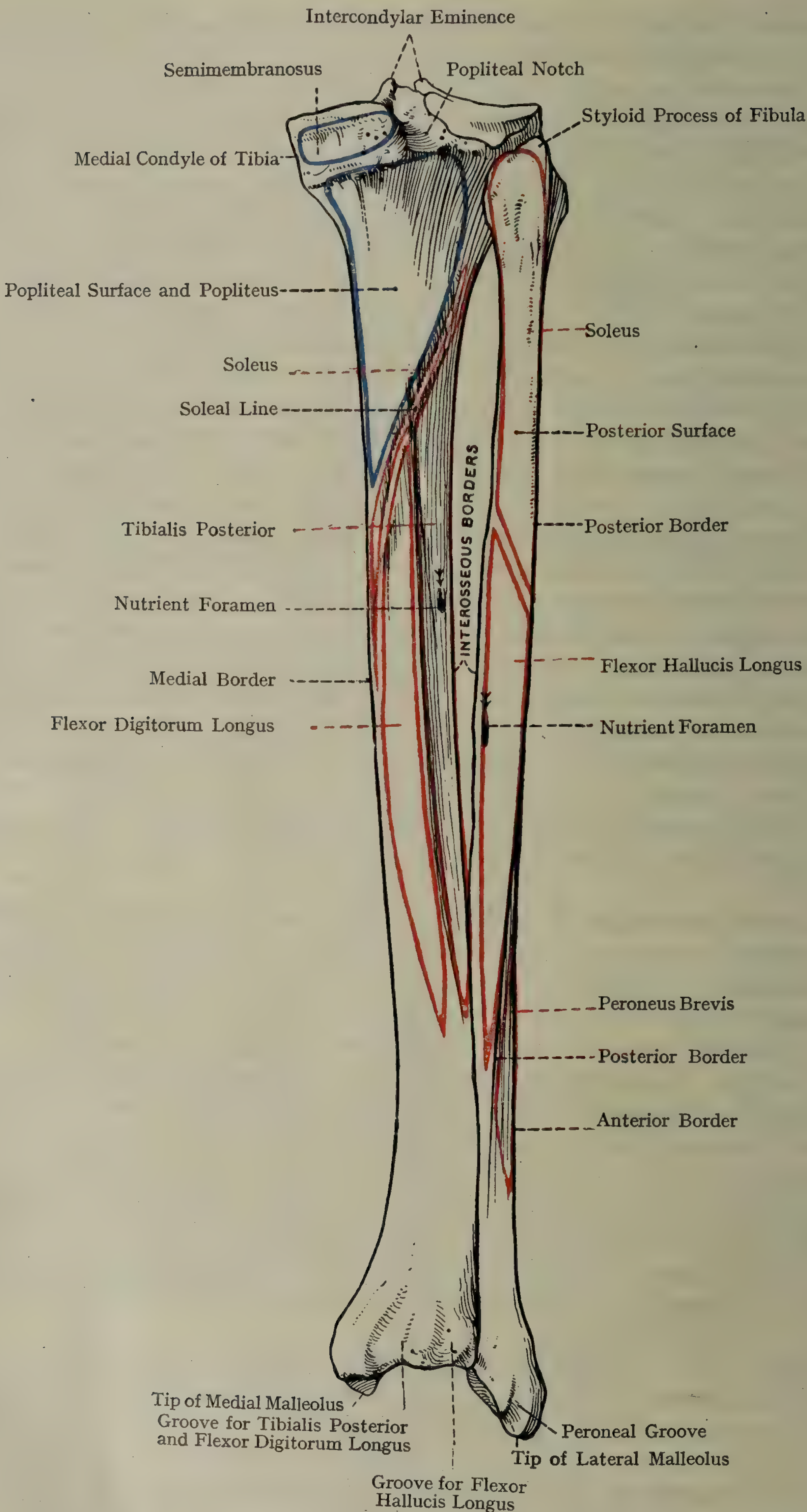


FIG. 227.—THE RIGHT TIBIA AND FIBULA (POSTERIOR VIEW).

medial surface of the talus. The anterior border is rough and round for the attachment of the anterior and medial ligaments of the ankle-joint. The lower border is indented by the **fibular notch,** in front of which is the projection known as the *tip,* the medial ligament being attached to both of these parts. Posteriorly is the groove for the tendons of the tibialis posterior and flexor digitorum longus. The outer aspect of the lower extremity may show a concave facet for the fibula, and above this a concave triangular rough surface about $1\frac{1}{2}$ inches long for the interosseous tibio-fibular ligament.

The inferior extremity of the tibia has many nutrient foramina.

Structure.—The structure is that of a long bone. The medullary canal extends above to a point about $1\frac{1}{2}$ inches below the lower margin of the anterior tuberosity, and inferiorly to a point about 1 inch below the lower extremity of the crest. The cancellous lamellæ display the characteristic arrangement of pressure and bolting lamellæ, and during the whole of life the positions of the epiphysial lines are indicated by a greater density of the tissue.

Varieties.—(1) The tibia is sometimes much compressed laterally, which leads to an increase in its antero-posterior diameter. In these cases the vertical line posteriorly becomes unduly prominent, a condition which is associated with a large development of the tibialis posterior muscle. Such a bone is spoken of as being *platycnemic,* and the condition is known as *platycnemia.* (2) The anterior aspect of the lower extremity of the bone sometimes presents a *pressure facet* at its outer part for articulation with the upper surface of the neck of the talus in extreme flexion of the ankle-joint. This frequently accompanies platymeria and platycnemia. (3) Retroversion of the head of the tibia and (4) great torsion of the shaft are met with especially in prehistoric bones.

Ossification.—The tibia is ossified *in cartilage* from **one primary** and **three secondary centres.**

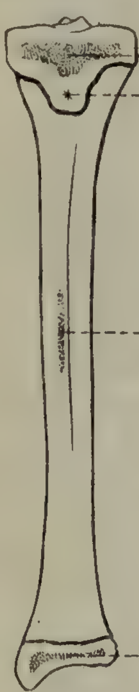


FIG. 228.—OSSIFICATION OF THE TIBIA.

The **primary centre** appears at the centre of the shaft about the *seventh week.* The **three secondary centres** are disposed as follows: two are *superior,* one for the **head,** and the other for the **tubercle;** and one is *inferior* for the *lower extremity* and *medial malleolus.* **Upper Extremity.**—The **centre for the head** appears *just after birth,* or at this time (M.), or before birth (F.). The epiphysis extends down in front to include the tubercle; this may become ossified totally by extension of the epiphysial centre, or an additional centre may appear in its lower rough part about the age of twelve. The whole epiphysis joins the shaft about nineteen to twenty (M.), or in women seventeen to eighteen. **Lower Extremity.**—The **centre for the lower extremity** and **medial malleolus** appears towards the end of the *second year,* and this **lower epiphysis** joins about the *eighteenth year* (M.) or sixteenth to seventeen (F.).

The Fibula.

The **fibula,** or **peroneal bone,** is situated on the outer side of th tibia. It is very slender for its length, and is a rudimentary bone It takes no part in transmitting the weight of the body, but serve chiefly to afford attachment to muscles, though it also forms part o the ankle-joint, and acts as a brace or support to the tibia. It is long bone, and is divisible into a shaft and two extremities, upper an lower.

The **upper extremity,** or *head,* is cuboidal, its upper surface bein somewhat flattened and sloping. It is situated about $\frac{3}{4}$ inch belov the level of the head of the tibia. Posteriorly it is prolonged upward into the *styloid process,* to the tip of which the lateral ligament of th knee-joint is attached. In front of this process the upper surface o the head is sloped downwards and forwards, and is divisible into a articular and a non-articular part. The articular division is media in position, and takes the form of a flat circular facet, which is directe upwards, inwards, and forwards, to articulate with the facet on th posterior and under aspect of the lateral condyle of the tibia, by whic latter it is overhung. The non-articular division is lateral in position and takes the form of a rough depression, into which the tendon o the biceps femoris, previously divided into two parts by the ligamen of the knee, takes insertion. Posteriorly the head gives origin to th soleus. Laterally it gives origin to the peroneus longus, and a a point nearly $\frac{1}{2}$ inch anterior to the styloid process its outer margi gives attachment to the lateral ligament. Anteriorly it gives origi to the extensor digitorum longus. The constricted part below th head is called the *neck.*

The **lower extremity** is prolonged downwards into a massive pro jection, called the *lateral malleolus,* which is not only larger, but lowe down and farther back, than the medial malleolus. It is pyramidal the base being directed upwards. The lateral surface is rough, convex and subcutaneous. The medial surface is divisible into two parts articular and non-articular. The articular division is anterior in posi tion, and occupies about two-thirds of the surface. It is triangular with the apex downwards, and it mainly articulates with the oute surface of the talus. Superiorly, however, for about $\frac{1}{4}$ inch it occasion ally assumes a somewhat semilunar outline, and this portion may articulate with the lateral aspect of the tibia. The non-articular divisio is posterior in position, and occupies about one-third of the surface. It is rough and depressed, and is known as the *malleolar fossa.* Superiorly the posterior ligament of the ankle-joint and inferiorly the posterio fasciculus of the lateral ligament of the ankle-joint are attached to the posterior margin of this fossa. Above the lateral malleolus on the inner aspect there is a rough, convex, triangular surface with its apex upwards, about $1\frac{1}{2}$ inches long, for the interosseous tibio-fibular liga ment. The anterior border projects at first forwards, and then slopes downwards and backwards to the tip. The projecting part gives

attachment to the anterior tibio-fibular ligament, and the lower portion of the sloping part to the anterior fasciculus of the lateral ligament of the ankle-joint. To the anterior border, just in front of the apex, the middle fasciculus of the lateral ligament is attached. The posterior surface is shorter than the anterior, and is vertical. It presents the *peroneal groove* for the tendons of the peroneus longus and peroneus brevis.

The **shaft** is slightly curved, the convexity being directed backwards in the upper part, and inwards lower down. It is quadrilateral in section in its upper three-fourths, where it presents four borders and four surfaces, but it is somewhat triangular in the lower fourth. The *anterior border*, which is the most prominent, commences in front of the head, and passes straight downwards until it reaches the lower fifth, where it turns outwards and backwards and bifurcates. One division passes to the anterior margin of the lateral malleolus, and the other to the posterior margin, lateral to the peroneal groove. These two divisions enclose between them a triangular area which is continuous with the outer surface of the lateral malleolus. This border gives attachment to the anterior intermuscular septum. The *anterior medial* or *interosseous border*, which gives attachment to the interosseous membrane, also commences in front of the head, where it is very near the anterior border. As it descends it keeps near to that border at first, but beyond the upper third it gradually diverges from it, and on reaching a point about 2 inches above the lateral malleolus it bifurcates. One division passes to the anterior margin of the malleolus, becoming incorporated with

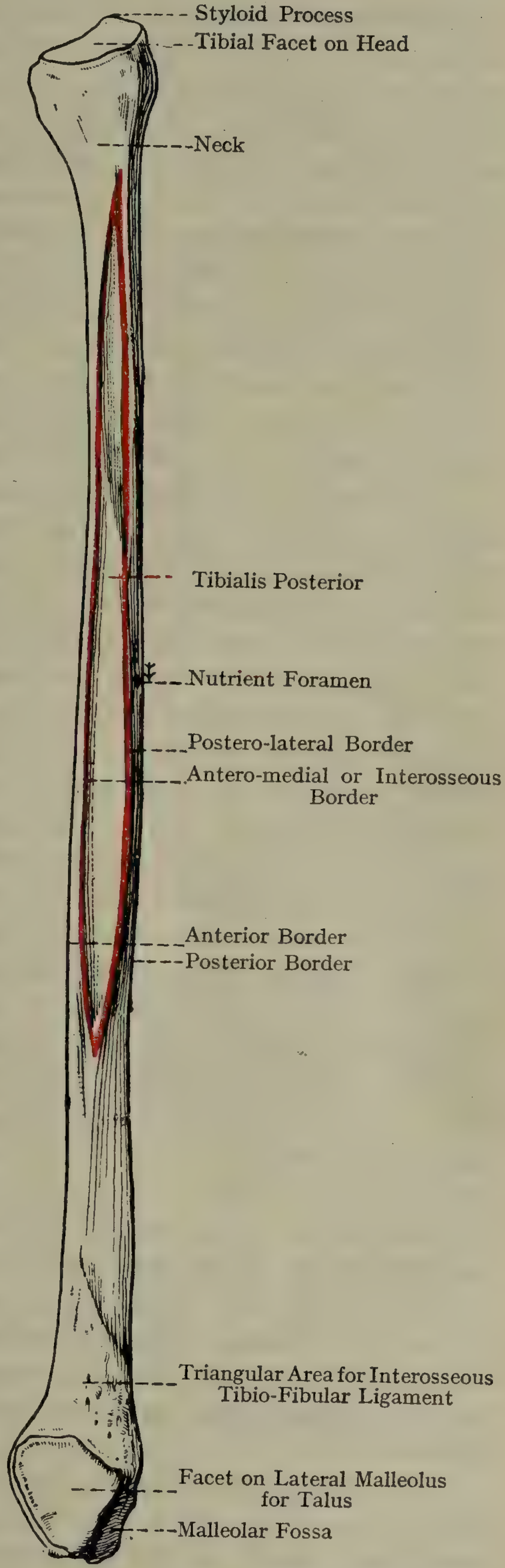


FIG. 229.—THE RIGHT FIBULA (MEDIAL ASPECT).

one of the divisions of the anterior border, whilst the other passes to the posterior margin of the malleolus, medial to the upper end

of the peroneal groove. The two divisions, as they diverge, enclos a rough triangular area, which is slightly convex and gives attach ment to the interosseous tibio-fibular ligament. The *postero-media border* commences on the inner side of the head, not far from th interosseous border. It descends in a backwardly-curved manner gradually leaving the interosseous border, but subsequently approachin it, until on reaching the junction of the upper two-thirds and lowe third it ends by joining it. This border gives attachment to an inter muscular septum, which separates the tibialis posterior from the soleu and flexor hallucis longus. The *posterior border* extends from th back of the head to the back of the lateral malleolus, medial to th peroneal groove, and in its lower part it turns inwards. It give attachment to the posterior intermuscular septum.

The *anterior surface* is situated between the anterior and interosseou borders. It is very narrow over about its upper half, but become wider below. It gives origin over about its upper three-fourths to th extensor digitorum longus, over its lower fourth (except about 1 incl below) to the peroneus tertius, and over about its middle two-fourth to the extensor hallucis longus, which is nearest to the interosseou border. The *medial surface* is situated between the interosseous anc postero-medial borders. It is concave and fusiform, being narrow above and below, but wide at the centre, and it gives origin to th tibialis posterior. On this surface the *oblique line of the fibula*, fo attachment of a tendinous plate of origin in the tibialis posterior, run obliquely downwards and backwards. The *posterior surface* is limitec by the postero-medial and posterior borders, and in its lower fourtl it undergoes a twist, and turns round to become internal. Over it upper third it gives origin to a part of the soleus, and over its lowe two-thirds, except the last inch or more, to the flexor hallucis longus A more or less distinct groove for the peroneal artery may often be seen on this surface. The *lateral surface* lies between the anterior anc posterior borders. It is the broadest, and in muscular subjects is deeply grooved over rather more than its upper half. Inferiorly it undergoes a twist, and turns round to become posterior, where it leads directly to the peroneal groove on the back of the lateral malleolus. In this manner the two peroneal tendons are guided to this groove. The upper two-thirds of this surface give origin to the peroneus longus, and the lower two-thirds, except the last 2 inches, to the peroneus brevis, these two muscles overlapping towards the centre of the bone.

The **nutrient foramen,** which is small, is usually situated on the posterior surface, but may be on the medial, a little above the centre, and there may be an additional one a little higher up. It is for a branch of the peroneal artery, and the direction of the foramen and the canal to which it leads is *downwards* towards the ankle.

Articulations.—*Superiorly* with the lateral condyle of the tibia, and *inferiorly* with the outer aspect of the tibia, and the lateral surface of the talus.

Structure.—The structure is that of a long bone, and the medullary canal is limited to about the middle three-fifths of the shaft.

Varieties.—(1) There may be a small facet at the antero-superior angle of the articular facet for the talus, articulating with the tibia. (2) The oblique line may be double. (3) The peroneal surface may be very concave, forming the 'channelled fibula.'

Ossification.—The fibula ossifies in cartilage from **one primary,** and **two secondary, centres.** The primary centre for the shaft appears in the *seventh week* of intra-uterine life. At birth the shaft is ossified, but the extremities are cartilaginous. The centre for the lower extremity appears in the *second year,* and that for the upper extremity about the *fourth year.* Both centres are earlier in girls. The lower epiphysis joins the shaft about *eighteen,* and the upper about *twenty,* girls being one to two years earlier. The fibula forms no exception to the general law of ossification applicable to long bones with an epiphysis or epiphyses at either end, which may be here restated as follows: '*The epiphysis or epiphyses, at the end towards which the nutrient foramen and the canal to which it leads are directed, are the last to show signs of ossification.*' It does, however, form an exception to the less constant coincidence that the epiphysis which joins last, and is therefore at the growing end of the bone, appears first.

FIG. 230.—OSSIFICATION OF THE FIBULA.

The law seems to be that the end which has the larger mass of cartilage develops a centre of ossification first, and usually this larger mass is at the growing end of the bone. In the fibula, however, the cartilaginous mass of the malleolus is greater than that of the head, though this has been acquired recently, and is a human characteristic.

At about the seventh month of intra-uterine life the tibial and fibular malleoli are of nearly equal proportions, but by the second year, previous to the appearance of its centre of ossification, the fibular malleolus has attained the large relative size which characterizes it throughout life.

The Tarsus.

The **tarsus** is composed of seven short bones—namely, the talus, calcaneum, navicular, three cuneiforms, and cuboid.

The first two constitute the proximal row, the talus lying above the calcaneum, and the last four comprise the distal row, the order from the inner or tibial to the outer or fibular side being medial, intermediate, and lateral cuneiform bones, and cuboid. The navicular occupies an intermediate position.

The Talus.

The **talus,** or **astragalus,** is characterized by having a head, neck, and body. It is situated between the tibia above and the calcaneum below, is grasped laterally by the tibial and fibular malleoli, and has the navicular in front. It is the only tarsal bone which receives

directly the weight of the body, and it lies with its long axis directed forwards and inwards. In point of size it comes next to the os calcis.

The **head** forms the anterior part of the bone, and presents an extensive convex articular surface, which looks forwards and also downwards. It is divided into three facets, called navicular, calcaneal, and ligamentous. The *navicular facet*, which is placed on the anterior surface, is pyriform, and its long axis is directed downwards and inwards. The *calcaneal facet*, which may be subdivided (see Fig. 231, B), continuous with the foregoing, is situated on the inferior surface. It is convex and elliptical, and its long axis is directed forwards and outwards. It is often crossed by an elevated ridge a little anterior to the centre, which may divide it into two, and it articulates with the sustentacular facet on the upper surface of the calcaneum. The *ligamentous facet* is situated on the inner aspect of the inferior surface, and is in contact with the superior surface of the plantar calcaneo-navicular or ' spring ' ligament.

The **neck** is the constricted part behind the head. It is conspicuous superiorly, and passes inferiorly into the *interosseous groove*. This groove is directed forwards and outwards, its inner part being narrow and deep, and the outer wide and shallow. It gives attachment to the strong interosseous talo-calcaneal, which binds the talus to the os calcaneum. The neck is perforated all round with numerous nutrient foramina for offsets of the dorsalis pedis artery and its tarsal branch.

The **body** is cuboidal, and has six surfaces. The *superior surface* presents an extensive trochlear facet, which is concave from side to side, and convex from before backwards. Posteriorly it slopes downwards, and its outer border is bevelled for the play of the transverse tibio-fibular ligament. The inner border is straight and slightly depressed, and as a rule it extends rather farther back than the outer. The surface is broader in front than behind. The *lateral surface* is deep, and has a large triangular facet for the lateral malleolus, the apex being downwards. It is concave from above downwards, and, immediately in front of it, the anterior fasciculus of the lateral ligament of the ankle-joint takes attachment. The *medial surface* presents superiorly a sickle-shaped facet, broad in front and pointed behind, for the medial malleolus. This facet in the fœtus encroaches on the inner side of the neck, a condition which is associated with the inversion of the foot at that period of life. This sometimes occurs in the adult, and, if it does so to any marked extent, it usually accompanies the condition known as talipes varus. The *inferior surface* presents a large oval facet, concave from within forwards and outwards, for articulation with the calcaneum. The *posterior surface* is short, stout, and oblique, its direction being inwards and forwards. It presents a groove, which is directed downwards and inwards, for the tendon of the flexor hallucis longus. On either side of this groove there is a tubercle, the medial being rudimentary, whilst the posterior is well developed and gives attachment superiorly to the posterior fasciculus of the lateral ligament of the ankle-joint.

Articulations.—*Superiorly* with the shaft, and *medially* with the medial malleolus, of the tibia; *laterally* with the lateral malleolus of the fibula; *inferiorly* with the calcaneus; *anteriorly* with the navicular, and occasionally with the lower and inner angle of the cuboid.

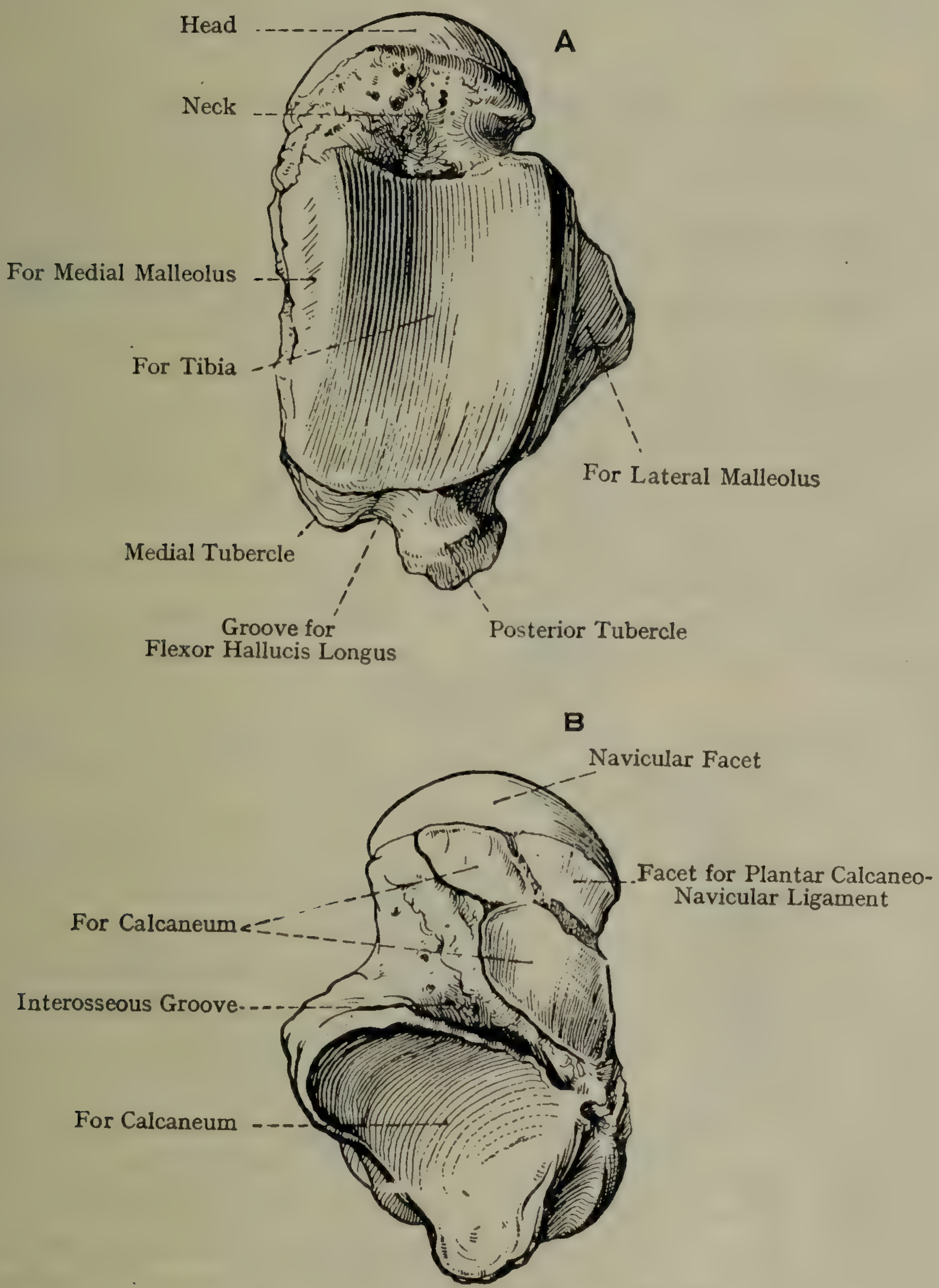


FIG. 231.—THE RIGHT TALUS.
A, superior view; B, inferior view.

Structure.—The talus, being a short bone, is composed of cancellated tissue, surrounded by a thin shell of compact bone. The lamellæ of the cancellated tissue are arranged in a curved manner, and in two sets. Some pass downwards and backwards from the superior surface to the posterior calcaneal facet, whilst others arch downwards and forwards from the superior surface to the neck, these being the directions in which weight is transmitted.

Varieties.—(1) The posterior tubercle on the posterior border may form a separate ossicle, called the *os trigonum*. (2) There may be a facet on the upper surface of the neck at its outer part, due to forcible contact with the anterior margin of the lower end of the tibia. This facet is always present in the fœtus and usually persists in squatting races.

The Calcaneum.

The **calcaneum,** or **os calcis,** is the largest bone of the tarsus, and is characterized by its elongation, lateral compression, and enlargement posteriorly into a tuberosity. It is situated below the astragalus and behind the cuboid, where it lies with its long axis directed forwards and outwards. It presents two extremities and four surfaces.

The **posterior extremity,** which is enlarged, forms the *tuberosity* or *tuber calcis*, and constitutes the prominence of the heel. Posteriorly it is divided into three zones—an upper, which is smooth and separated from the tendo calcaneus (Achillis) by a bursa; a middle, rough and vertically ridged, for the insertion of the tendo calcaneus (Achillis); and a lower, which is continuous with the tubercles on the plantar aspect and supports the fat of the heel.

The **anterior extremity** presents a large, somewhat triangular facet, narrow towards the sole, which is concave from above downwards and outwards, and convex from side to side, for articulation with the cuboid.

The *superior surface* presents over its anterior part two facets for the talus, separated by an oblique groove, and posteriorly a non-articular surface. The antero-medial or sustentacular facet surmounts the sustentaculum tali. It is concave and somewhat elliptical, its long axis being directed forwards and outwards. It is often constricted in front of the centre, and is sometimes broken up into two facets by a rough groove. The postero-lateral facet is large, oval, and convex from behind forwards and outwards, and is directed as much forwards as upwards. The intervening groove, which is directed forwards and outwards, becomes wide and shallow laterally, and in front of the outer part of the groove the upper surface gives origin to a portion of the extensor digitorum brevis and the inferior extensor retinaculum. When the talus is in position this groove is converted into a short canal called the *tarsal tunnel*, widening into the *sinus tarsi*. The groove is occupied by the interosseous ligament and the sinus by the Y-shaped part of the inferior extensor retinaculum and the origin of the extensor digitorum brevis. The superior surface behind the articular portion is rough, and supports a collection of fat.

The *plantar surface* is narrow and rough. Posteriorly it presents two tubercles, the *lateral* of which is small but prominent, whilst the *medial* is large and blunt. The lateral tubercle gives attachment to the lateral division of the plantar aponeurosis, and a portion of the abductor digiti minimi, whilst the inner gives attachment to the central and medial divisions of the plantar aponeurosis, the outer part of the abductor hallicus, the flexor digitorum brevis, and a portion of

the abductor digiti minimi. The greater part of the plantar surface gives attachment to the long plantar ligament, and anteriorly it presents a small round eminence, called the *anterior tubercle,* to which the short plantar ligament is attached.

The *medial surface* is concave, and is overhung at its antero-superior part by the *sustentaculum tali.* This latter is concave and

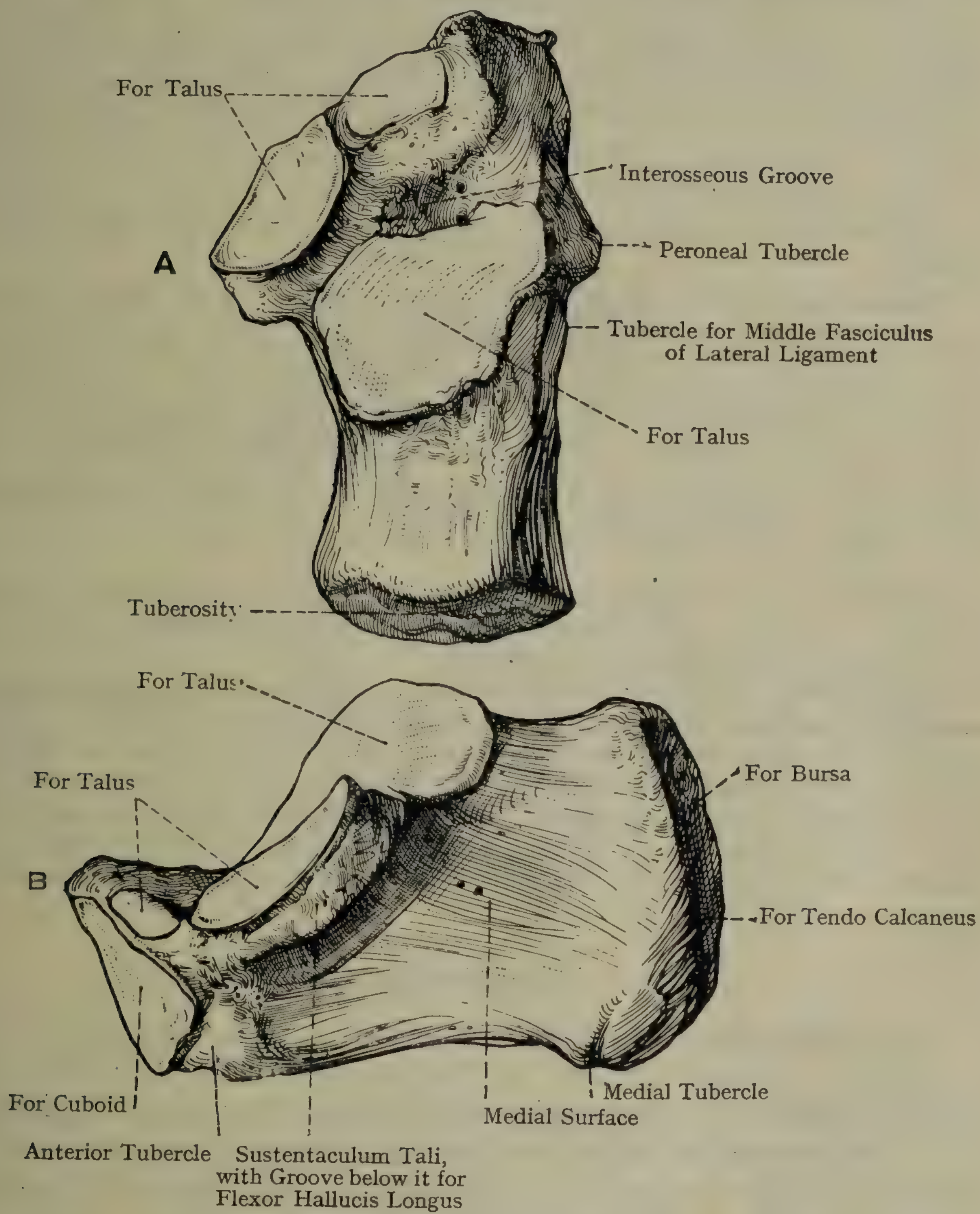


FIG. 232.—THE RIGHT CALCANEUM.
A, superior aspect; B, medial aspect.

articular above for the talus, and below it presents a groove for the flexor hallucis longus. Anteriorly it gives attachment to the plantar calcaneo-navicular ligament, below which a slip of the tibialis posterior is attached, and its inner margin gives attachment to fibres of the medial ligament of the ankle-joint, while its inner margin is grooved by the tendon of the flexor digitorum longus. It is worth while

noticing carefully the relation of the sustentaculum tali to the thre long tendons: the flexor hallucis longus below it, the flexor digitorun longus on a level with it, and the tibialis posterior above it. Th general concavity of the medial surface of the calcaneum is in contac with the plantar vessels and nerves, and anteriorly it affords origin t the inner head of the flexor accessorius.

The *lateral surface* is somewhat convex. Towards its anterio and lower part it may present a short oblique ridge, called the *peronea tubercle,* which separates two grooves. The upper groove transmit the tendon of the peroneus brevis, and the lower that of the peroneu longus. There is a small tubercle, about the centre of the surface for the middle fasciculus of the lateral ligament of the ankle-joint.

Articulations.—*Superiorly* with the talus and *anteriorly* with the cuboid.

Structure.—The structure is that of a short bone. Some of the pressure lamellæ of the cancellated tissue arch downwards and backwards from the large postero-lateral facet on the superior surface to the prominence of the heel, others pass forwards from this facet to direct the pressure to the facet for the cuboid; while traction lamellæ pass from the point of attachment of the tendo calcaneus forwards and downwards to the lower surface of the bone.

Varieties.—(1) Ossification of plantar aponeurosis extending from the medial posterior tubercle. (2) Variability of development of the peroneal tubercle. (3) Occasional synostosis with cuboid.

Ossification.—The os calcis ossifies in cartilage from **one primary,** and **one secondary, centre.** The primary centre appears in the *sixth month* of intra-uterine life. The secondary centre appears in the *tenth year* or earlier, and forms a thin epiphysial scale over the posterior surface of the tuber calcis, which joins in the *fifteenth* (F.) to *eighteenth* (M.) *years.* This epiphysis includes the outer, and a large part of the inner, tubercle on the under surface, and only occupies the lower two-thirds of the posterior surface, forming a typical traction epiphysis.

The Navicular Bone.

The **navicular** or **scaphoid bone** is distinguished by its resemblance to a boat. It is situated on the inner side of the foot, where it is placed in front of the talus, and behind the three cuneiform bones. It is compressed from before backwards, and its long axis is directed inwards and downwards. The *anterior surface* presents a large convex articular surface, divided into three facets by two ridges which converge inferiorly. The inner facet, for the medial cuneiform, is pyriform, with the narrow end upwards. The middle facet, for the intermediate cuneiform, is triangular, with the truncated apex downwards. The outer facet, for the lateral cuneiform, resembles the middle, except that it is rather shorter and has a rounder apex. The *posterior surface* is characterized by a large concave, pyriform facet for the front of the head of the talus, its narrow end being directed downwards and inwards. The *dorsal surface,* extensive and rough, is sloped downwards and inwards. The *plantar surface,* narrow and rough,

gives attachment to the plantar calcaneo-navicular ligament, and about its centre there is usually a knob-like projection, called the *ligamentous tubercle*, and between this and the tuberosity is usually a groove lodging one of the expansions of the tibialis posterior tendon. The *lateral surface* is broad and rough, and it sometimes presents a small facet for the cuboid, contiguous to the outer facet on the anterior surface. The *inner extremity* (prow of the boat) is inclined downwards, and forms a stout, round projection on the inner side of the sole, called the tuberosity, which gives insertion to the principal portion of the tendon of the tibialis posterior.

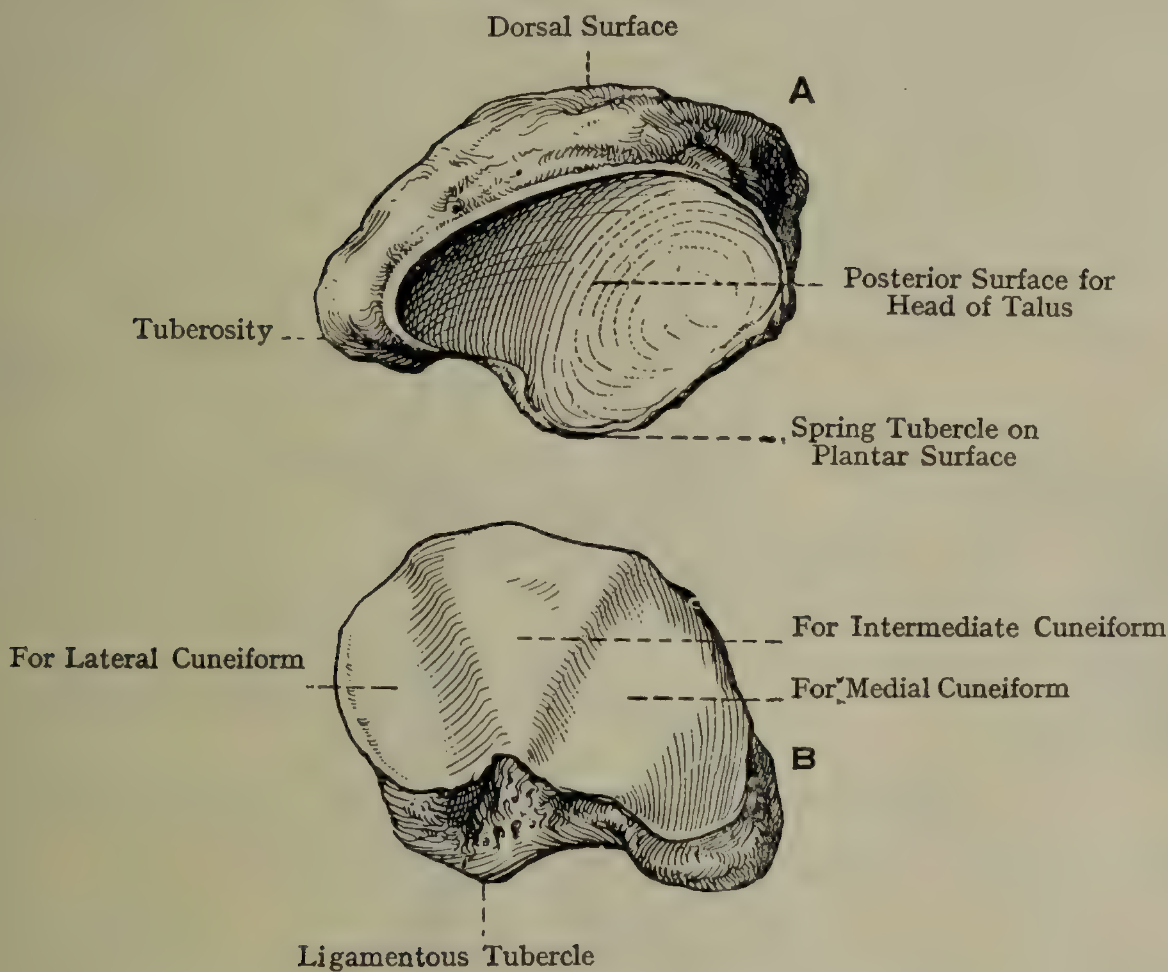


Fig. 233.—The Right Navicular Bone.
A, postero-superior view; B, antero-inferior view.

Articulations.—*Posteriorly* with the talus, *anteriorly* with the three cuneiform bones, and sometimes with the cuboid *laterally*.

Structure.—The structure is that of a short bone.

Variety.—The tuberosity sometimes forms a separate ossicle.

The Cuneiform Bones.

The **cuneiform bones** are three in number—namely, medial, intermediate, and lateral. They are situated between the navicular and the inner three metatarsal bones, and are characterized by their wedge shape. The medial cuneiform is the largest, and the intermediate is the smallest.

The **medial cuneiform bone** is situated on the inner side of the foot where it lies with the narrow end of the wedge upwards, and it supports the first metatarsal. The *dorsal surface* is narrow and rough. The *plantar surface* is thick and convex, and posteriorly it presents an eminence for a slip of the tendon of the tibialis posterior. The *medial surface* is traversed by an oblique facet, directed downwards and forwards, for the tendon of the tibialis anterior, the principal portion of which is inserted into an impression situated at its lower part. The *lateral surface* presents, close to its superior and posterior borders, an L-shaped facet for the intermediate cuneiform, at the anterior extremity of which there is a small facet for the inner side of the base

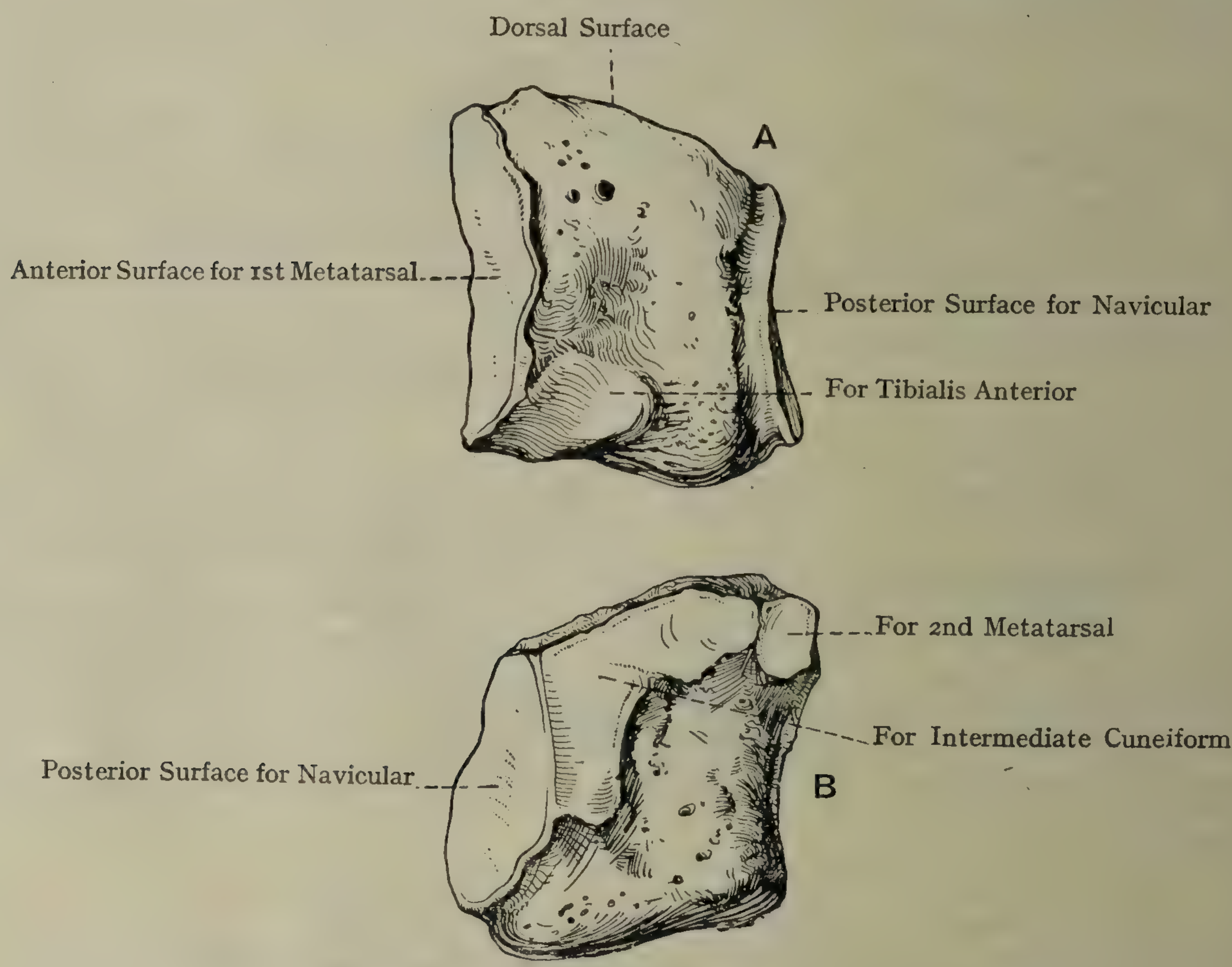


FIG. 234.—THE RIGHT MEDIAL CUNEIFORM BONE.
A, medial aspect; B, lateral aspect.

of the second metatarsal. The rest of the surface is concave and rough for strong ligaments, except at the lower and anterior part, where it gives insertion to a slip of the tendon of the peroneus longus. The *anterior surface* is deep, and presents a convex reniform facet for the first metatarsal, the concave border being directed outwards. The *posterior surface*, much smaller than the anterior, is characterized by a concave pyriform facet for the navicular, the narrow end being upwards.

Articulations.—*Posteriorly* with the navicular, *anteriorly* with the first metatarsal, and *laterally* with the intermediate cuneiform and second metatarsal.

Variety.—The medial cuneiform may be divided partially or completely into two parts, dorsal and plantar.

The **intermediate cuneiform bone** lies with the broad end of the wedge upwards, and it supports the second metatarsal. The *dorsal surface* is rough and nearly square. The *plantar surface*, also rough, is narrow, and gives insertion to a slip of the tendon of the tibialis posterior. The *medial surface* presents, close to its superior and posterior borders, an L-shaped facet for the medial cuneiform, the remainder of the surface being rough and ligamentous. The *lateral surface* has a vertical facet posteriorly for the lateral cuneiform, and elsewhere it is rough and ligamentous. The *anterior* and *posterior surfaces* are triangular and covered by cartilage, the former articulating with the second metatarsal, and the latter with the navicular. They are distinguished from each other in the following manner: the anterior surface is convex, whilst the posterior is concave; the apex of the anterior surface is more pointed than that of the posterior; and the posterior surface, rather broader than the anterior, has one of the limbs of the L facet close to it.

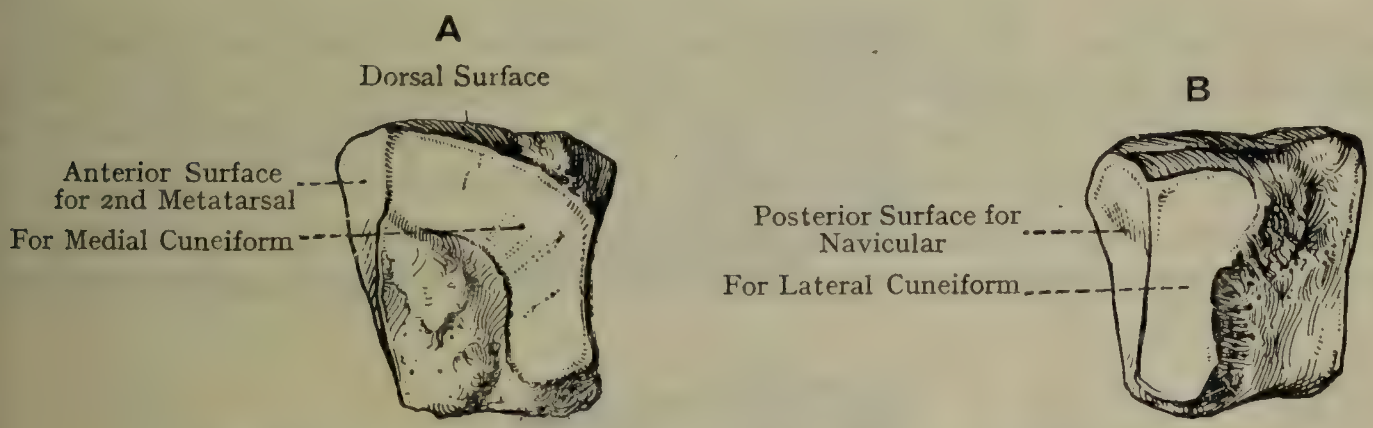


FIG. 235.—THE RIGHT INTERMEDIATE CUNEIFORM BONE.
A, medial aspect; B, lateral aspect.

The intermediate cuneiform is sometimes considered a difficult bone to determine the side of the body to which it belongs. As a matter of fact, it may be done quite easily by the finger alone if it is noticed that the posterior articular facet is more concave than the anterior; and the inner surface, which fits into the concavity of the medial cuneiform, is correspondingly convex.

Articulations.—*Posteriorly* with the navicular, *anteriorly* with the second metatarsal, *medially* with the medial cuneiform, and *laterally* with the lateral cuneiform.

The **lateral cuneiform bone,** like the middle, lies with the broad end of the wedge upwards, and it supports the third metatarsal. The *dorsal surface* is rough, quadrilateral, and elongated from before backwards. The *plantar surface*, also rough, is narrow, and gives insertion to a slip of the tendon of the tibialis posterior. The *medial surface* presents a vertical facet posteriorly for the intermediate cuneiform, and two semi-oval facets anteriorly for articulation with the proximal pair of facets on the outer side of the base of the second metatarsal.

The remainder of the surface is rough and ligamentous. The *lateral surface* has a large, almost circular, facet near the postero-superior angle for the cuboid, and there may be a small semi-oval facet at the antero-superior angle for the inner side of the base of the fourth metatarsal, but this facet is not constant. Elsewhere the surface is rough

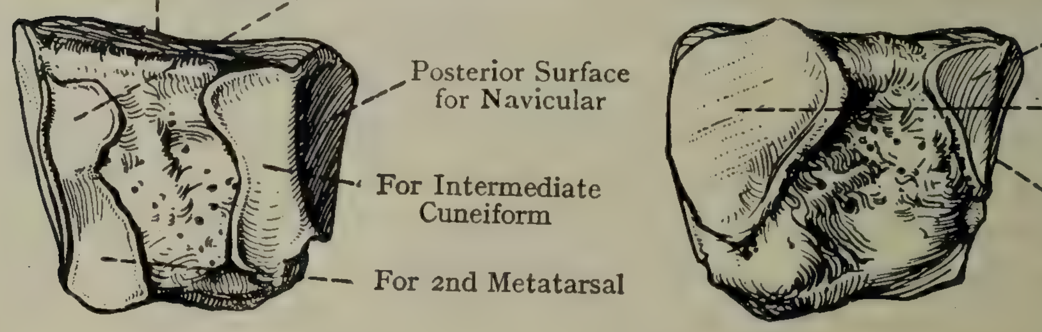


FIG. 236.—THE RIGHT LATERAL CUNEIFORM BONE.
A, medial aspect; B, lateral aspect.

and ligamentous. The *anterior* and *posterior surfaces* are triangular, and covered by cartilage, the former articulating with the third metatarsal, and the latter with the navicular. They are distinguished from each other in the following manner: the anterior facet is deeper than the posterior, and its apex is more pointed; the cartilage of the anterior surface extends over its entire length, but the lower part of the posterior

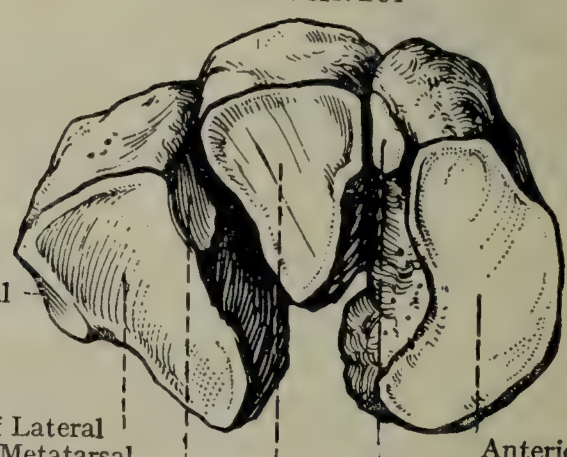


FIG. 237.—THE RIGHT CUNEIFORM BONES (ANTERO-SUPERIOR VIEW).

surface is non-articular; the anterior facet is slightly concavo-convex from below upwards, but the posterior is concave, and it has the large, almost circular, facet on the lateral surface contiguous to it.

Articulations.—*Posteriorly* with the navicular, *anteriorly* with the third metatarsal, *medially* with the intermediate cuneiform and outer side of the base of the second metatarsal, and *laterally* with the cuboid,

and, it may be, with the inner side of the base of the fourth metatarsal.

Structure of the Cuneiform Bones.—The structure of each is that of a short bone.

When the cuneiform bones are in position their posterior surfaces are on the same transverse plane, but the anterior surfaces of the medial and lateral project farther forwards than that of the intermediate. In this manner a recess is formed, into which the base of the second metatarsal bone is received.

The Cuboid Bone.

The **cuboid bone** is characterized by its irregularly cubical shape, and by the groove and ridge on its plantar aspect. It is situated on the outer border of the foot, where it lies between the calcaneum and the fourth and fifth metatarsal bones. The *anterior surface* has its

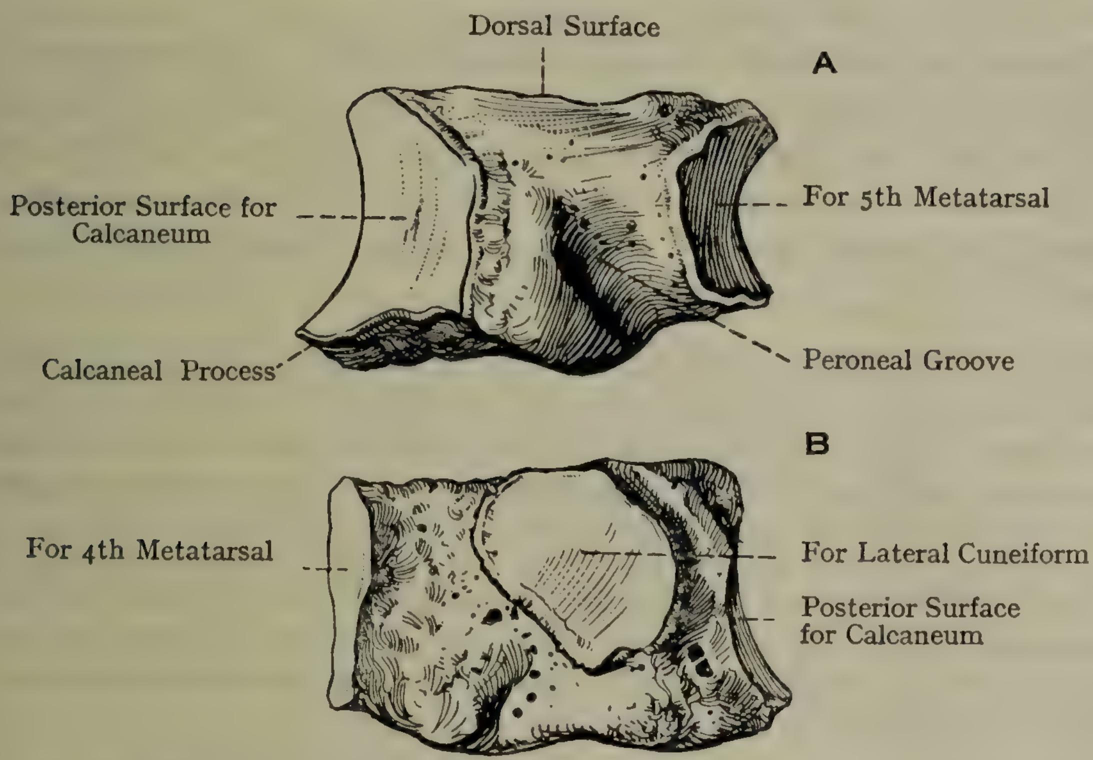


FIG. 238.—THE RIGHT CUBOID BONE.
A, lateral aspect; B, medial aspect.

cartilage divided by a vertical ridge into two facets—an inner quadrilateral for the fourth metatarsal, and an outer triangular for the fifth metatarsal. The *posterior surface* presents a large, somewhat triangular facet, narrow towards the sole and deep medially. It articulates with the calcaneum, and its medial and inferior angle, called the *calcaneal process*, projects backwards for a little beneath that bone. Below and inside the calcaneal process there may be a facet for the head of the talus. The *medial surface*, which is extensive and vertical, presents a large, almost circular, facet for the lateral cuneiform, near the centre and extending to the dorsal surface. Behind this, and usually continuous with it, there may be a small facet for the navicular, the remainder of the surface being rough for ligaments. The *lateral surface*

is very short and narrow, and presents a notch leading to the peronea groove on the plantar surface. The *dorsal surface* is rough, and i directed upwards and outwards. The *plantar surface* has in front th deep *peroneal groove*, which is directed inwards and forwards, an lodges the tendon of the peroneus longus in certain positions of th foot. Behind the groove is a stout, oblique ridge for the long planta ligament. This ridge becomes enlarged laterally into the *tuberosity* which is covered by cartilage on its anterior and outer aspects for th play of the sesamoid cartilage, usually present in the tendon of th peroneus longus. The surface behind the ridge gives attachment t the short plantar ligament, a slip of the tendon of the tibialis posterior and some fibres of the flexor hallucis brevis, but the latter may spring from the medial surface.

Articulations.—*Posteriorly* with the calcaneum, *anteriorly* with th fourth and fifth metatarsal bones, *medially* with the lateral cuneiform and sometimes with the navicular, and at the lower and inner angl occasionally with the talus.

The **tarsus as a whole** is convex superiorly, and concave inferiorly from before backwards as well as from side to side. The part in fron of the talus and calcaneum constitutes the *instep*, and the entire tarsu forms two arches—an inner, comprising the calcaneum, talus, navicular and three cuneiform bones; and an outer, formed by the calcaneum and cuboid.

Varieties.—The number of tarsal bones is sometimes increased to eight, whicl is brought about in one or other of the following ways: (1) The posterior tubercl on the posterior border of the astragalus may form a separate ossicle, callec the *os trigonum*; (2) the tuberosity of the navicular may form a separate ossicle (3) the medial cuneiform may be divided into two parts, dorsal and plantar; o (4) there may be an additional ossicle in the space at the antero-medial part o the calcaneum, or between the medial cuneiform and the second metatarsal.

Ossification.—The tarsal bones ossify in cartilage, each from **one centr** (except the os calcis, which has one primary, and one secondary, centre), anc at the following periods approximately:

Calcaneum, 6th month (intra-uterine).
Talus, 7th month (intra-uterine).
Cuboid, 9th month (intra-uterine).
Lateral cuneiform, 1st year.
Medial cuneiform, 3rd year.
Intermediate cuneiform, 4th year.
Navicular, 4th year.

All these times may be much earlier in female children.

The Metatarsus.

The **metatarsus** is composed of five long bones, which are namec numerically from within outwards, that of the great toe being the first. Each bone is divisible into a shaft and two extremities, proximal and distal. The **shaft,** which is triangular, is massive in the first, slender and much compressed laterally in the second, third, and fourth, and compressed from above downwards in the fifth. Each shaft, except that of the first, is longitudinally convex on its dorsal aspect, and they are all longitudinally concave on their plantar aspects. The

shaft presents three borders and three surfaces. In the outer four bones the borders are two lateral, and a plantar. The *outer borders*, lateral and medial, extend from the side of the proximal end or base, close to the dorsal aspect, to the dorsal tubercle on either side of the distal end or head, and their outline is sharp. The *plantar border*, round behind, but sharp in front, extends from the centre of the plantar aspect of the base forwards in the middle line to near the head, where it bifurcates, the divisions passing to the condyles on the plantar aspect of the head. The *dorsal surface* lies between the lateral and medial borders, and is narrow. Each *lateral surface* is situated between the lateral and plantar borders. The lateral surfaces, which are extensive and sloped, bound the interosseous spaces, and give attachment to the interosseous muscles. In distinguishing a metatarsal from a metacarpal bone it is very important to notice that the former has a constricted neck which contrasts very markedly with the broad triangular surface on the dorsum of the metacarpal. The shaft of the **first** metatarsal is prismatic. The *dorsal surface* is convex, and is directed upwards and inwards. The *plantar surface* is concave, and is in contact with the tendon of the flexor longus and the flexor hallucis brevis. The *lateral surface*, which is practically vertical, is narrow in front, but wide behind.

The **heads** of the **four outer** metatarsal bones are much compressed laterally, thus contrasting sharply with the metacarpals. The cartilage is prolonged more on the plantar than on the dorsal aspect, and in the former situation it ends in a concave border, surmounted at either side by a prominent condyle. On either side the head presents a dorsal tubercle and plantar depression for the plantar metatarsophalangeal joint. The head of the **first** metatarsal is of large size, and elongated transversely. On its plantar aspect it presents two well-marked grooves, separated by a median antero-posterior ridge, for the sesamoid bones in the insertion of the flexor hallucis brevis.

The **bases** of the metatarsal bones articulate with the tarsus and with each other, except, as a rule, in the case of the first, and they present distinctive characters in each case.

First Metatarsal Bone.—This supports the great toe, and is the thickest and most massive of the series. The **base** is of large size, and presents a concave reniform surface, with the concavity outwards, for the medial cuneiform. Inferiorly is a projection, called the tuberosity, which gives insertion, by its outer aspect, to the principal part of the tendon of the peroneus longus, and by its inner aspect to a slip of the tendon of the tibialis anterior. There is usually no facet on its outer surface, but sometimes there may be one for the second metatarsal, and it always gives origin to the inner head of the first dorsal interosseous.

Articulations.—*Posteriorly* with the medial cuneiform, and sometimes *laterally* with the second metatarsal; *anteriorly* with the proximal phalanx of the great toe; and *inferiorly* with the two sesamoid bones.

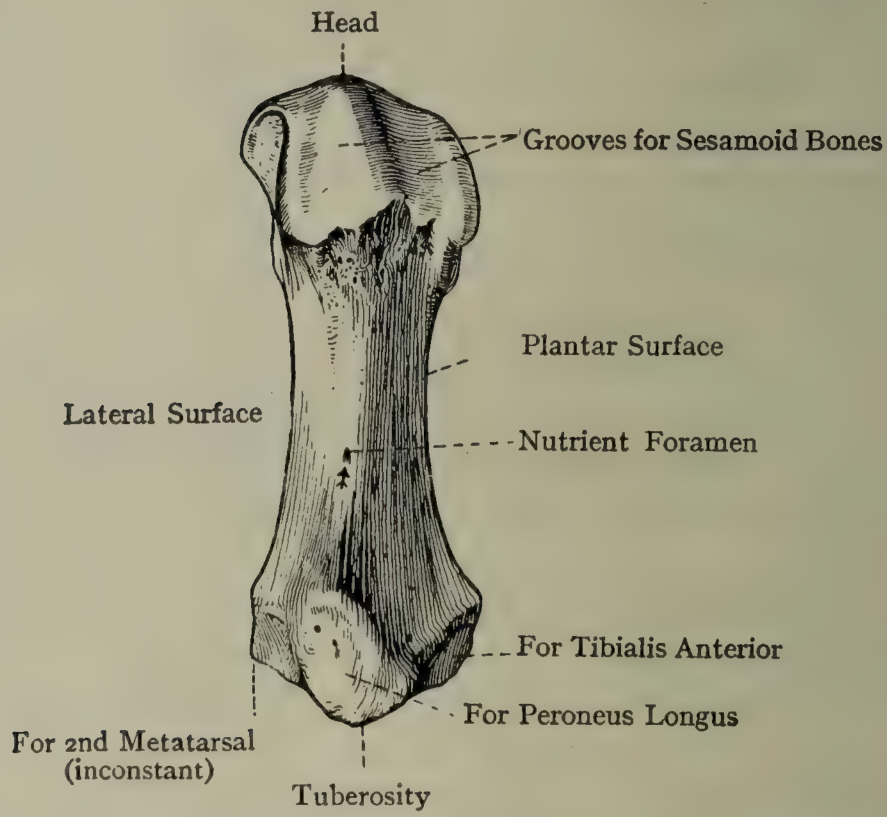


FIG. 239.—THE FIRST RIGHT METATARSAL BONE (PLANTAR VIEW).

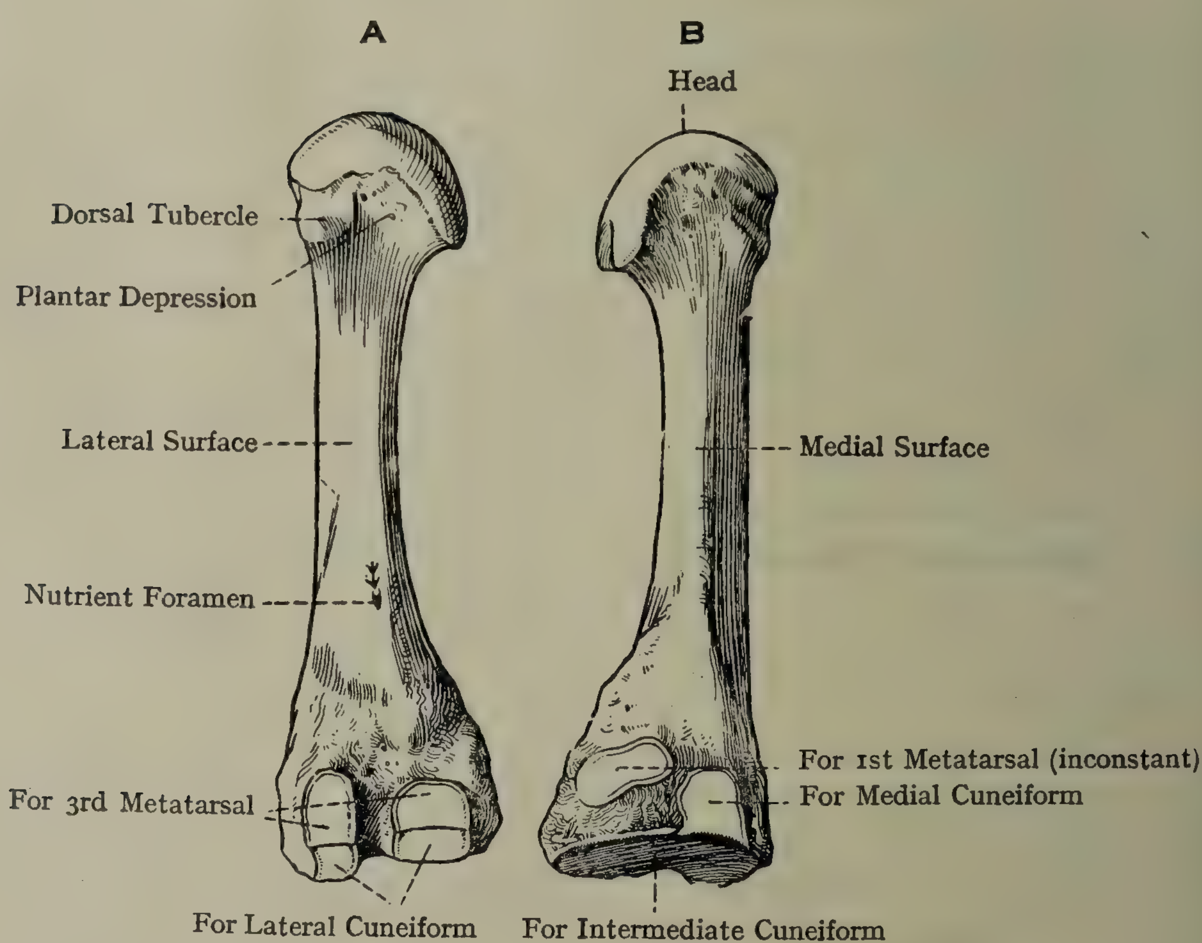


FIG. 240.—THE SECOND RIGHT METATARSAL BONE.
A, lateral aspect; B, medial aspect.

Second Metatarsal Bone.—The **base** of this bone is wedge-shaped, with the broad end upwards. It recedes between the medial and lateral cuneiform bones, and posteriorly presents a triangular facet for the intermediate cuneiform. On the inner side, close to the dorsal aspect, there is a small facet for the medial cuneiform, and sometimes there is an additional facet, below and in front of this, for the first metatarsal. The outer side presents two facets, dorsal and plantar, separated by a rough antero-posterior groove, each of these being subdivided by a vertical ridge into two semi-oval facets. There are thus four facets in all—a posterior pair for the inner side of the lateral cuneiform, and an anterior pair for the inner side of the base of the third metatarsal. The plantar surface of the base gives insertion to a slip of the

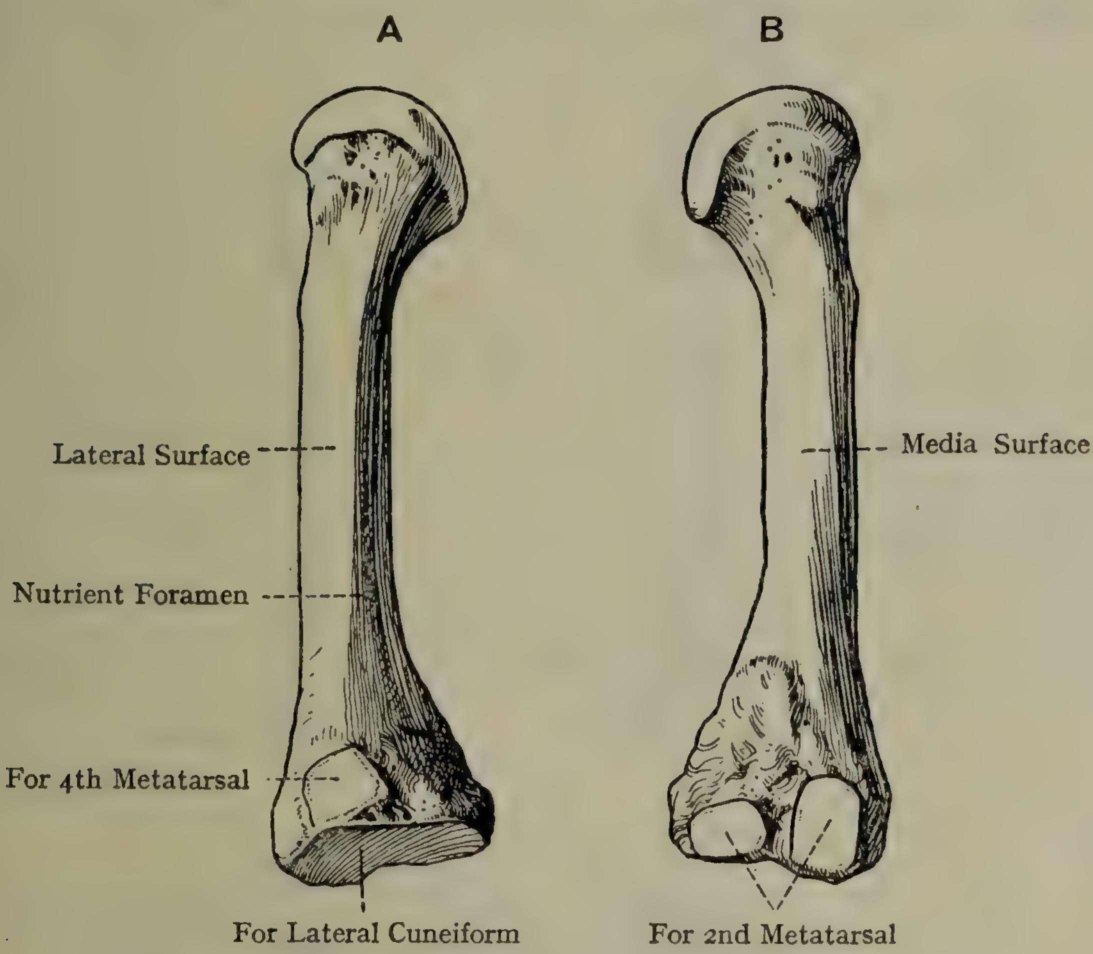


FIG. 241.—THE THIRD RIGHT METATARSAL BONE.
A, lateral aspect; B, medial aspect.

tendon of the tibialis posterior. The shaft gives partial origin to the first and second dorsal interossei.

Articulations.—*Posteriorly* with the intermediate cuneiform, *medially* with the medial cuneiform, and sometimes with the first metatarsal, *laterally* with the lateral cuneiform and third metatarsal, and *anteriorly* with the proximal phalanx of the second toe.

Third Metatarsal Bone.—The **base** of this bone resembles that of the second, the broad end being upwards. Posteriorly there is a triangular facet for the lateral cuneiform. The inner side of the base has two semi-oval facets, dorsal and plantar, separated by a rough antero-posterior groove, for the anterior pair of facets on the outer side of the base of the second metatarsal. On the outer side there is

a large oval facet, dorsally placed, for the inner side of the base of th fourth metatarsal. The plantar surface of the base gives insertion t a slip of the tendon of the tibialis posterior, and origin to a portio of the oblique head of adductor hallucis. The shaft gives origin t the first plantar interosseous, and partial origin to the second and thir dorsal interosseous muscles.

Articulations.—*Posteriorly* with the lateral cuneiform, *medially* wit the second metatarsal, *laterally* with the fourth metatarsal, an *anteriorly* with the proximal phalanx of the third toe.

Fourth Metatarsal Bone.—The **base** is quadrilateral, and is som what broader above than below. Posteriorly it presents a quadr lateral facet for the cuboid. On the inner side there is a large ov facet for the third metatarsal, and this is sometimes prolonged to th

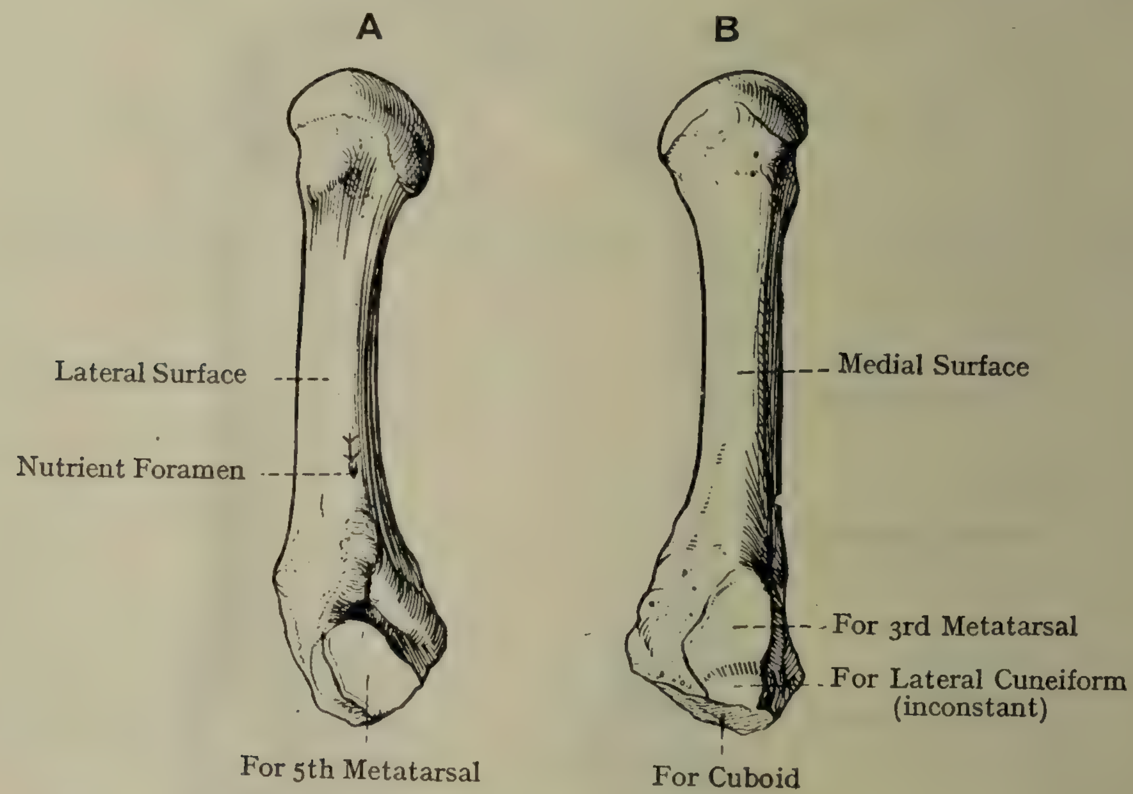


FIG. 242.—THE FOURTH RIGHT METATARSAL BONE.
A, lateral aspect; B, medial aspect.

extremity of the base, thus forming an additional facet for the oute side of the lateral cuneiform. On the outer side there is a large ova facet, dorsally placed, for the inner side of the base of the fifth meta tarsal, and below this there is a deep rough groove. The plantar surface of the base gives insertion to a slip of the tendon of the tibialis posterior and origin to a portion of the oblique head of adductor hallucis. The shaft gives origin to the second plantar interosseous, and partial origin to the third and fourth dorsal interossei.

Articulations.—*Posteriorly* with the cuboid, *medially* with the third metatarsal, and sometimes with the lateral cuneiform, *laterally* with the fifth metatarsal, and *anteriorly* with the proximal phalanx of the fourth toe.

Fifth Metatarsal Bone.—This supports the little toe. The **base** is elongated from side to side, and compressed from above downwards.

[ts leading characteristic is a stout, mammillary process, situated on ts outer aspect, called the tuberosity, which is directed outwards and backwards, and gives insertion to the tendon of the peroneus brevis. The posterior surface presents a triangular facet, with its apex outwards, for the cuboid, the plane of which is inclined inwards and forwards. This facet does not encroach upon the tuberosity. The inner surface presents a large oval facet for the outer side of the base of the fourth metatarsal. The dorsal surface, which is rough and slightly convex, gives insertion, as a rule, to the tendon of the peroneus tertius. The plantar surface, which is rough and concave, gives origin to the flexor digiti minimi. The shaft gives origin to the third plantar interosseous, and partial origin to the fourth dorsal interosseous.

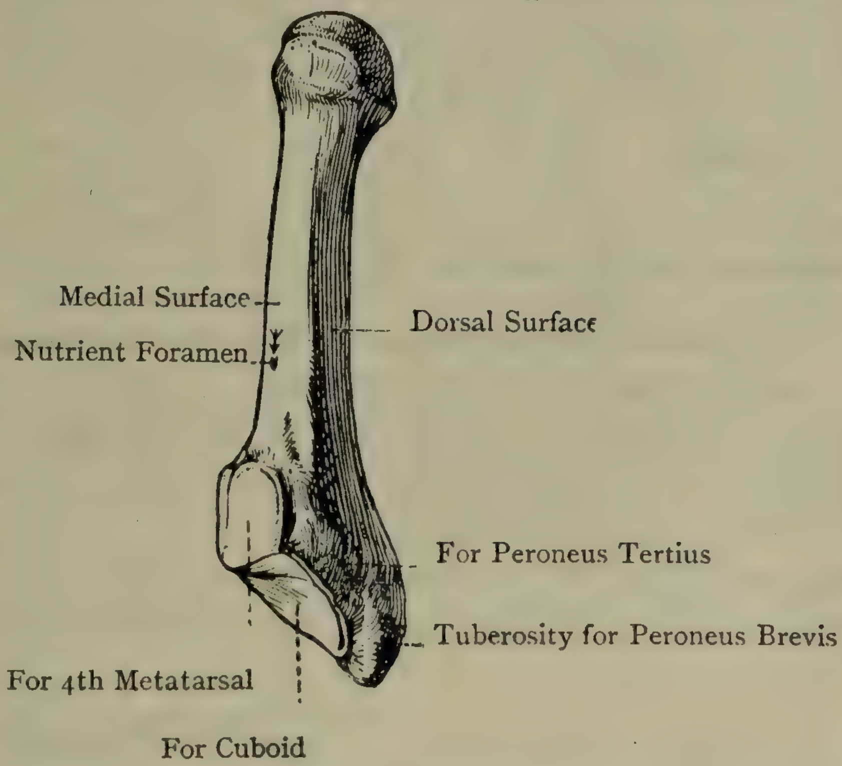


Fig. 243.—The Fifth Right Metatarsal Bone (Supero-medial Aspect).

In practice it is sometimes quite difficult to determine the dorsal from the plantar aspect of this bone, especially when the condyles are damaged, and it is useful to notice that on its plantar surface, near the base, is a longitudinal depression for the flexor digiti minimi, while the dorsal surface is comparatively flat.

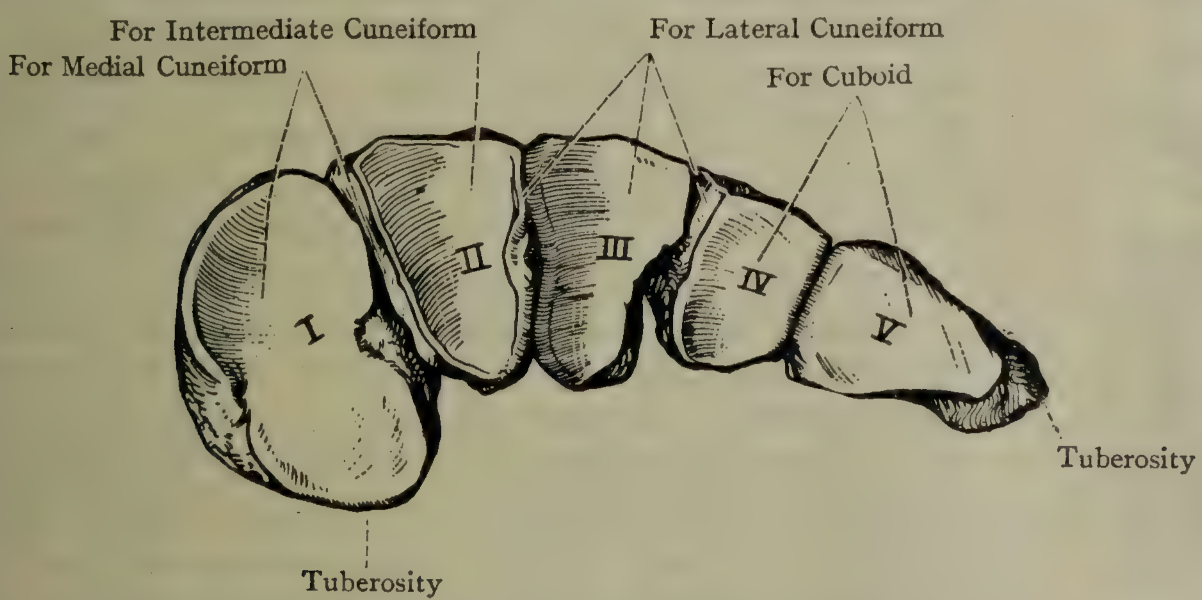


Fig. 244.—The Bases of the Right Metatarsal Bones (Posterior Aspect).

Articulations.—*Posteriorly* with the cuboid, *medially* with the fourth metatarsal, and *anteriorly* with the proximal phalanx of the little toe.

Each metatarsal bone has a **nutrient foramen,** that of the first

and second, and usually that of the third and fourth, being situated on the outer side of each shaft, whilst that of the fifth is situated on the inner side.* The foramen of the first and the canal to which it leads are directed towards the head or distal end, but that of each of the other four is directed towards the base or proximal end.

Varieties.—(1) The tuberosity on the outer side of the base of the fifth metatarsal, or the tuberosity on the plantar surface of the base of the first may form a separate ossicle. (2) An additional ossicle is sometimes met with between the bases of the first and second metatarsals.

The **metatarsus as a whole** is convex on its dorsal aspect from side to side, and also longitudinally. The transverse convexity is due to the broad ends of the bases of the second, third, and fourth metatarsals being directed upwards. On its plantar aspect it is concave from side to side, and also longitudinally. All five bones are nearly parallel with each other, being slightly divergent in front. The interosseous spaces are as in the hand, the first being the innermost.

The Phalanges.

The **phalanges** are fourteen in number—three to each of the four outer toes, and two to the great toe. The toes, from within outwards, are called great toe or hallux, second, third, fourth, and fifth or little toe. In their general characters the phalanges closely resemble those of the hand, but for medico-legal purposes it may be very important to distinguish them. The phalanges of the hallux are so large that there is not the least likelihood of mistaking them for those of the other toes, but there is sometimes the greatest difficulty in distinguishing those of a large man's thumb from those of a small woman's big toe. One point to be noticed is that the big toe always slants outwards towards the other toes, and the bases of both the proximal and distal phalanges are therefore oblique, thus enabling the side to which they belong to be distinguished without difficulty. This obliquity of the hallux was formerly ascribed to the pressure of pointed boots until it was noticed that in savage races, to whom boots are unknown, the same obliquity exists. Another difference is that although the length of the thumb and big toe phalanges is the same, the breadth of the articular ends of the latter is greater in proportion to the length than in

FIG. 245.—THE PHALANGES OF THE SECOND TOE (PLANTAR VIEW).

* Of 100 third, and an equal number of fourth, metatarsal bones examined, 73 third metatarsals had the nutrient foramen on the outer side, and 27 on the inner side; and 60 fourth metatarsals had it on the outer side, and 40 on the inner side.

he former. A final point is that the terminal phalanx of the big toe s always very rough and irregular on each side of the base.

In the case of the phalanges of the four outer toes the proximal ınd middle may be distinguished from those of the hand by the absence f the ridges for tendon sheaths and by the lateral compression of the hafts of the proximal row, while the terminal phalanges of the foot re hardly longer than they are broad.

Special Muscular Attachments.—The base of the proximal phalanx of the reat toe, which presents a tubercular enlargement at either side, gives insertion nedially to the abductor hallucis and inner head of the flexor hallucis brevis; xternally, to the outer head of the flexor hallucis brevis, oblique and transverse eads of adductor hallucis; and on its dorsal surface there is a rough transverse idge for the innermost tendon of the extensor digitorum brevis. The base of he ungual phalanx of the great toe gives insertion, on its dorsal surface, to the xtensor hallucis longus, and, on its plantar surface, to the flexor hallucis longus

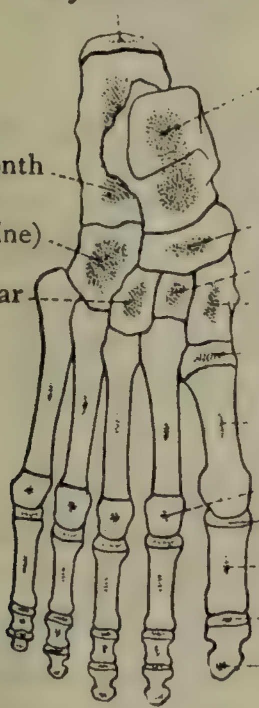


FIG. 246.—OSSIFICATION OF THE BONES OF THE FOOT.

he base of the proximal phalanx of the second toe gives partial insertion edially to the first dorsal interosseous, and laterally to the second dorsal terosseous. The base of the proximal phalanx of the third toe gives partial sertion medially to the first plantar interosseous, and laterally to the third orsal interosseous. The base of the proximal phalanx of the fourth toe gives rtial insertion medially to the second plantar interosseous, and laterally to e fourth dorsal interosseous. The base of the proximal phalanx of the fifth e gives partial insertion medially to the third plantar interosseous and laterally sertion to the abductor digiti minimi and flexor digiti minimi. The second ıd distal phalanges of each of the four outer toes give insertion to extensor ıd flexor tendons, as in the case of the corresponding bones of the four inner ıgers.

The **nutrient foramen** and the canal to which it leads are, in each ıalanx, directed towards the distal end.

Varieties.—Ankylosis of the distal and second phalanges of the fifth toe of frequent occurrence, and may even involve those of other toes, up to and

including the second. This process may be regarded as a stage in the evolu tion of a foot in which the three phalanges are being replaced by two. It mus however, be borne in mind that the boot is probably the mechanical fact of the change.

Sesamoid Bones.—These are two in number, and are of large siz They are associated with the two heads of insertion of the flexo hallucis brevis, and lie on the plantar aspect of the head of the firs metatarsal bone. The inner is the larger of the two bones, and th saddle shape of their articular surfaces should prevent their bein mistaken for ill-marked pisiform bones.

Ossification of Metatarsal Bones and Phalanges.—Each bone ossifies i cartilage from **one primary,** and **one secondary, centre,** which closely agree wit those of the corresponding bones of the hand in their disposition. The primar centres for the shafts appear about the *ninth week* of intra-uterine life, whil the secondary centres appear between the *fourth* and *eighth year.* Each ep physis joins its shaft about the *eighteenth* to *nineteenth year,* in women som two to three years earlier.

The Foot as a Whole.

The foot presents two surfaces, dorsal and plantar; two border inner and outer; and two extremities, anterior and posterior.

The **dorsal** or **superior surface** is arched, both longitudinally an transversely, and the superior surface of the talus constitutes its summi The talus is the only bone of the tarsus which articulates with th tibia and fibula.

The **plantar surface** is concave, both longitudinally and transversel in conformity with the longitudinal and transverse arches. When a articulated foot is placed upon a table, with the plantar surface down wards, the parts in contact with the table are as follows: *Posteriorl* the medial and lateral tubercles on the plantar aspect of the calcane tuberosity, and *anteriorly* the heads of the metatarsal bones.

The plantar surface presents important projections and groove which will be enumerated, as nearly as possible, in order from behin forwards.

1. The **medial** and **lateral tubercles** on the plantar aspect of th calcaneal tuberosity.

The **medial tubercle** gives attachment to the following structures:

(1) Medial division of plantar aponeurosis (part of).
(2) Central division of plantar aponeurosis.
(3) Outer head of abductor hallucis (part of).
(4) Flexor digitorum brevis (part of).
(5) Abductor digiti minimi (part of).

The **lateral tubercle** gives attachment to the following structures:

(1) Outer division of plantar aponeurosis.
(2) Abductor digiti minimi (part of).

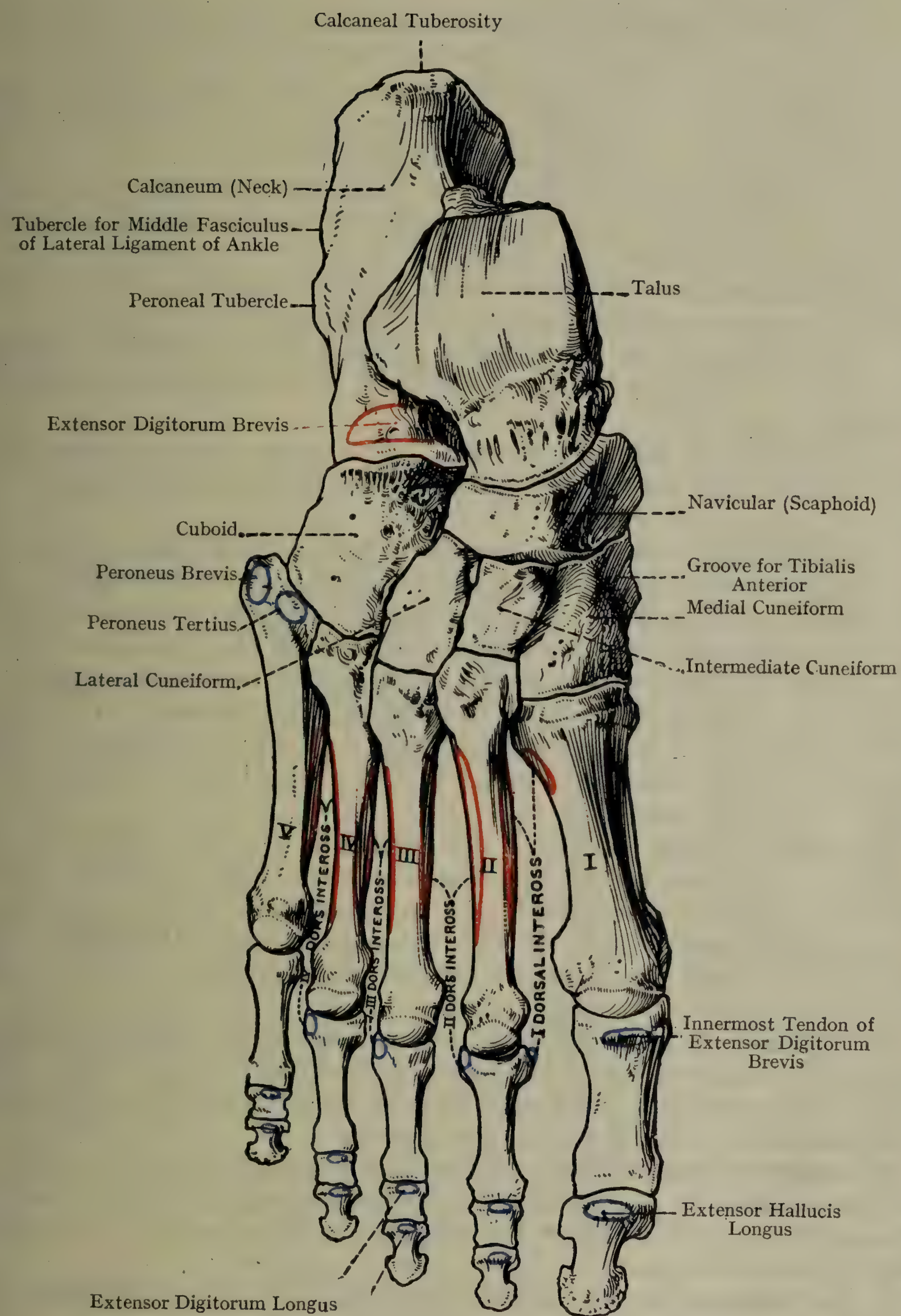


FIG. 247.—THE RIGHT FOOT (DORSAL SURFACE).

2. The **anterior tubercle** of the *calcaneum,* which gives attachme
to the short plantar ligament.

3. The **sustentaculum tali** of the calcaneum, close to the *inner bord*
of the foot, which is grooved *inferiorly* for the tendon of the flex
hallucis longus, the groove being continuous with that on the posteri
border of the talus. *Anteriorly,* the sustentaculum tali gives attac
ment to the plantar calcaneo-navicular ligament.

4. The **tuberosity** of the *navicular bone,* close to the inner bord
of the foot, which gives insertion to the principal portion of the tend
of the tibialis posterior.

5. The **ligamentous tubercle** on the plantar surface of the *navicul*
bone, for the plantar calcaneo-navicular ligament.

6. The **eminence** on the plantar surface of the *medial cuneifor*
bone, close to the *inner border* of the foot, for a slip of the tendon
the tibialis posterior.

7. The **peroneal tubercle** on the outer surface of the calcaneun
above which is the groove for the peroneus brevis, whilst that for th
peroneus longus is below it.

8. The **peroneal notch** and **groove** on the outer border and planta
surface of the *cuboid bone* for the tendon of the peroneus longus. Th
ridge *behind* the groove gives attachment to the long plantar ligamen

9. The **tuberosity** on the plantar aspect of the proximal end o
base of the *first metatarsal bone,* which gives insertion *medially* t
a slip of the tendon of the tibialis anterior, and *laterally* to the mai
part of the tendon of the peroneus longus. (A slip of the latter tendo
is inserted into the *lower* and *anterior part* of the lateral surface of th
medial cuneiform bone.)

The **inner** or **tibial border** of the foot is in line with the great toe
or hallux. It is constructed by the calcaneum, talus, navicular, media
cuneiform, and first metatarsal, and the phalanges of the great toe.

The **sustentaculum tali** of the *calcaneum,* the **tuberosity** of th
navicular bone, and the *eminence* on the plantar surface of the *media*
cuneiform bone, belong to this border.

The **medial surface** of the *medial cuneiform bone* presents an **obliqu**
groove, directed *downwards and forwards,* for the tendon of the tibiali
anterior, the principal part of which is inserted into an impressio
at the *lower* and *posterior part* of the groove.

The **outer** or **fibular border** of the foot is in line with the little toe
It is constructed by the calcaneum, cuboid, fifth metatarsal, and th
phalanges of the little toe. Its markings, enumerated from behin
forwards, are as follows:

1. The **tubercle** for the middle fasciculus of the lateral ligament o
the ankle-joint, situated about the centre of the outer surface of the
calcaneum.

2. The **peroneal tubercle,** situated a little below and anterior to the
preceding tubercle, and lying between two grooves. The **upper groove**
transmits the tendon of the peroneus brevis, and the **lower groove**
transmits the tendon of the peroneus longus, whilst the ridge gives

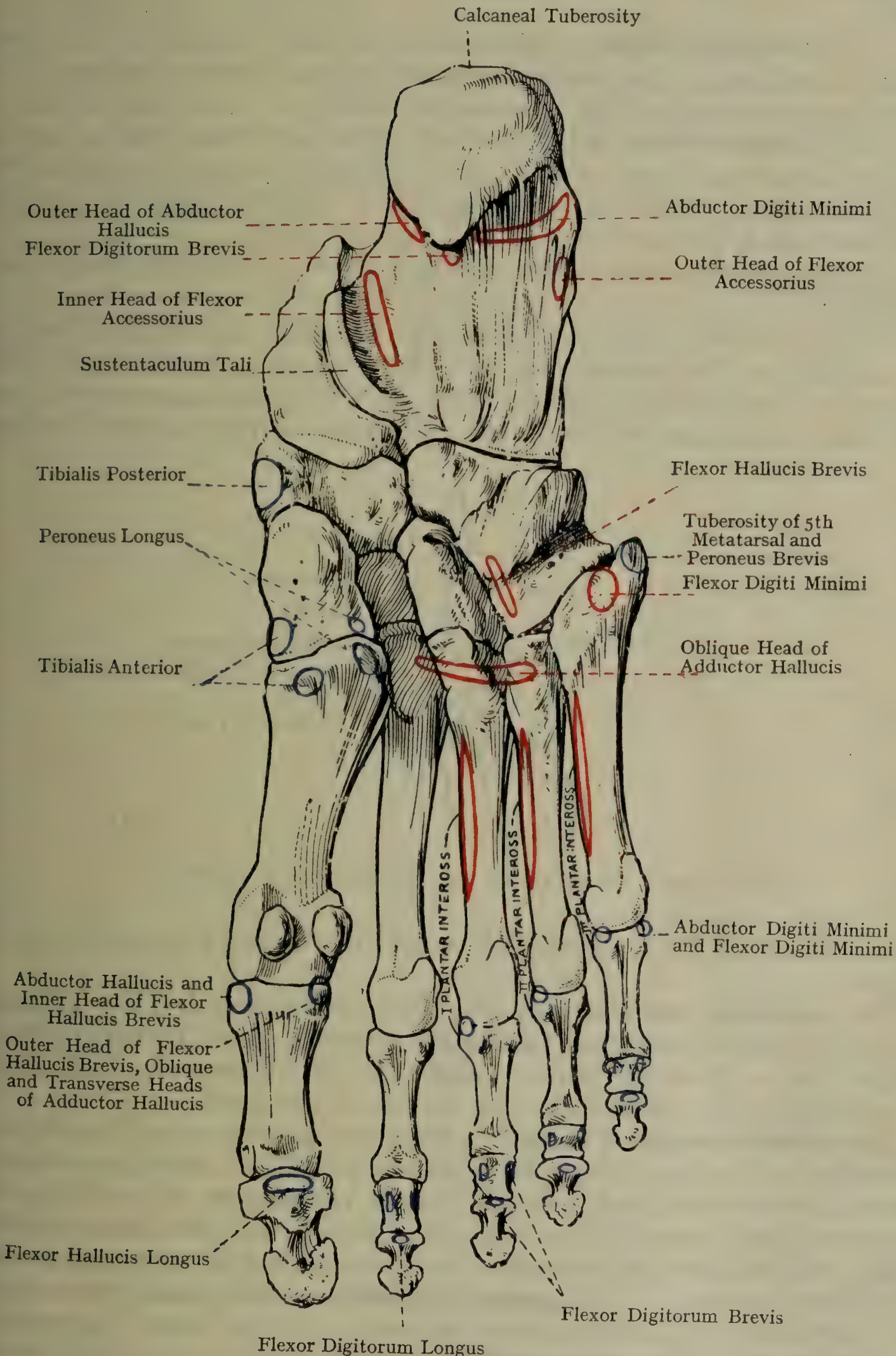


Fig. 248.—The Right Foot (Plantar Surface).

attachment to the fibrous septum, which separates the two peroneal sheaths.

3. The **peroneal notch,** situated on the outer border of the *cuboid bone,* and leading to the **peroneal groove,** on the plantar surface of the bone, for the tendon of the peroneus longus.

4. The **tuberosity** on the outer side of the proximal end or base of the *fifth metatarsal bone,* which gives insertion to the tendon of the peroneus brevis. (The peroneus tertius is usually inserted into the *dorsal surface* of the base of this metatarsal bone.)

The **anterior extremity** of the foot is formed by the distal or ungual phalanges.

It is to be noted that the great toe or *hallux* is almost as long as, and parallel to, the second toe, in which respect it presents a striking contrast to the thumb or *pollex.* This, as well as its massive structure, is evidently an adaptation to the erect position, and the inward direction

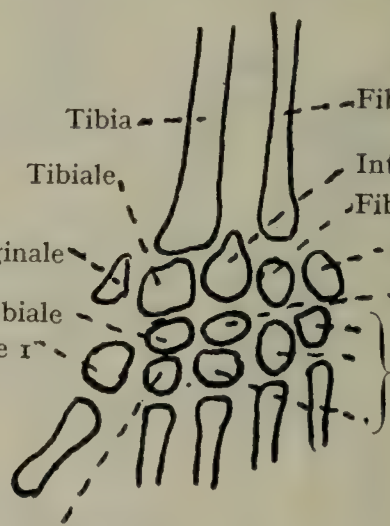


Fig. 249.—Scheme of a Generalized Tarsus.

of the neck of the talus throws the weight of the body largely on to the big toe.

The **posterior extremity** of the foot is formed by the *calcaneal tuberosity.* Posteriorly this **tuberosity** presents three transverse zones —*upper,* for a synovial bursa; *middle,* for the insertion of the tendo calcaneus (Achillis); and *lower,* for the fat of the heel.

The **posterior border** of the *talus,* though it stops short of the posterior extremity of the foot, may be referred to. The markings which it presents are a groove and two tubercles. The **groove,** which is directed *downwards and inwards,* transmits the tendon of the flexor hallucis longus, and leads to the groove on the under aspect of the *sustentaculum tali* of the calcaneum. The **posterior tubercle,** of large size, gives attachment *superiorly* to the posterior fasciculus of the lateral ligament of the ankle-joint. The **medial tubercle,** which is small, gives attachment *medially* to a few fibres of the medial or deltoid ligament of the ankle-joint.

The **sinus tarsi** or **tarsal tunnel** is the oblique canal which lies between the talus and the calcaneum. Its direction is outwards and

forwards, and it is occupied by a strong interosseous ligament, within which is the *bursa sinus tarsi*.

For the arches of the foot, see p. 672.

The foot is regarded as being built up by the fusion of elements in a generalized tarsus, the scheme of which is the same as that of the generalized carpus (Fig. 202, p. 322), the tibia taking the place of the radius and the fibula that of the ulna.

The talus represents the tibiale, and its posterior tubercle (os trigonum) is regarded as the intermedium. The fibulare is the calcaneum, while its posterior epiphysis may be the fibulare marginale. The navicular is obviously formed by the fusion of the two centralia, while the three tibial distalia remain as the cuneiform bones, and the two on the fibular side coalesce to make the cuboid.

In this way only the tibiale marginale remains unaccounted for, the fate of which is uncertain.

CHAPTER VIII

JOINTS

JOINTS may be regarded as gaps in the skeleton where movemen may take place, and it is not surprising to find that, speaking generally those joints have the simplest structure in which least movement i allowed.

If one of the sutures on the vault of the skull be examined, it wil be found that there is very little movement between the two bone bounding it, and that they are separated and at the same time helc together by a very thin film of fibrous tissue, which is, of course, the original membrane in which the cranial bones were ossified. On the surface the periosteum, covering the bones, is continued from one tc the other, but is firmly blended with the interstitial fibrous tissue.

A joint of this class, formed by a stoppage in the ossification—a stoppage, indeed, which may be only temporary—and composed o the original tissue in which the ossification had taken place, is known as a **fibrous joint,** and this class includes all joints in which parts of the skeleton are bound together by material more flexible than themselves without the intervention, at any time, of a joint cavity.

Sometimes, when greater freedom of movement is needed, the fibrous interval between the bones may be greater, and the joint, instead of being a suture, is then known as a **syndesmosis.**

Sometimes, as in the base of the skull, where chondrification has preceded ossification, the gap between the two bones is filled with uninvaded hyaline cartilage, and in that case the articulation becomes a **primary cartilaginous joint.**

It has been seen, therefore, that a fibrous joint is a very primitive form of articulation, depending on a part of the original precursor of the bone, whether it be fibrous tissue or cartilage, remaining in its original flexible condition. When two bones connected by cartilage—that is to say, primary cartilaginous joint—have to provide for a large amount of movement, the central part of the cartilage disappears and a joint cavity is formed, leaving a layer of articular or encrusting cartilage on the end of each bone, and converting the original fibrous perichondrium into a true capsule, which may be reinforced afterwards by extracapsular connective tissue whenever special strain has to be met.

Occasionally, even existing tendons may acquire attachments to both of the bones, and be converted into ligaments of the accessory capsule, though it is far from necessary to assume that all, or even most, such structures are formed in this way.

After the joint cavity has been formed, the connective tissue cells surrounding it arrange themselves into a pavement epithelium or synovial membrane, and secrete a lubricating fluid called synovia.

At first, it is said, the synovial membrane lines the whole joint cavity, but later on, when active movement begins, that part which covers the articular cartilage is worn away, and the synovial membrane now ceases wherever the cartilage begins.

A joint in which there is a constant synovial cavity is known as a **synovial joint,** and different subdivisions of this class are recognized according to the kind of movement needed and the shape which the bony ends take to adapt themselves to it.

Sometimes, when more than one perfectly distinct kind of movement is required at one joint, intracapsular fibro-cartilages or menisci are formed, and these partly or completely divide the joint into two, so that each part may be specialized for its own particular movement. These menisci are always fibrous or fibro-cartilaginous, are always thickest where they are attached to the capsule, and thinnest where they are farthest away from it. When these facts are harmonized with the teachings of comparative anatomy, which shows them appearing in certain animals as the need for them arises, and disappearing in others in which the need no longer exists, they suggest that menisci are originally ingrowths from the true capsule into the joint.

Where the movement of a synovial joint is not very pronounced, and is chiefly of a gliding nature, the joint ends are similar, and the articulation is spoken of as a **plane joint.** The clavicular and carpal joints are examples of this.

Movements round two axes, to a limited extent, combined with great strength, may be obtained by two saddle-shaped joint surfaces fitting one another reciprocally, and forming what is known as a **saddle joint.** The only example of this subdivision in man is the carpo-metacarpal joint of the thumb.

A **ball-and-socket joint,** allowing movement in any direction, is found in the shoulder and hip.

When a joint with ball-and-socket ends has its capsule so disposed that movement can only take place round two axes, it is spoken of as a **condyloid.** Examples of this are seen in the carpo-metacarpal joints of the fingers, which may be flexed or abducted, but cannot be twisted round, so that the nails look towards the palm.

Some anatomists, recognizing only form as a basis of classification, regard the knee as a double condyloid, though the function is different from that of a single one, because the second condyle plays the part of the outrigger of a native canoe, and prevents lateral movement, thus, from a physiological point of view, making the joint a hinge.

The **hinge** or ginglymus is well represented in the human body, the best examples being the elbow and interphalangeal joints. In the true hinge the axis is horizontal, as in the hinge of a box. When it is vertical, as in the hinge of a door, the articulation is spoken of as a **pivot joint.**

There are still a few joints for which it is difficult to find a place in either of these two main divisions, owing to the fact that they sometimes have synovial cavities of small extent, and sometimes none. For these a third main division, called **cartilaginous joints,** has been provided to include the symphysis pubis and the intervertebral discs, which, in the lumbar region, have a synovial cavity in the nucleus pulposus.

Having cleared the way by these remarks, a formal classification of joints may now be attempted; it is the one which is most in harmony with the views of the writers at the present time, though it must in fairness be stated that no classification has yet been produced which could stand careful destructive criticism.

Classification of Joints.

Fibrous Joints	True sutures	Serrate.
		Denticulate.
		Limbous.
	False sutures	Squamous.
		Harmonic.
		Wedge-and-groove (schindylesis).
		Peg-and-socket (gomphosis).
	Syndesmoses.	
Synovial Joints	With uni-axial movement: Hinge-joint (ginglymus).	
	With bi-axial movement	Condyloid joint.
		Saddle joint.
	With poly-axial movement: Ball-and-socket joint.	
	With gliding movement: Plane joint.	
Cartilaginous Joints	Primary cartilaginous joint.	
	Secondary cartilaginous joint.	

The explanatory notes which follow will make this classification more intelligible.

Suture.—There are two forms of suture, called true and false. When the margins of the bones present a number of projections with intervening depressions, so that they become closely interlocked, the suture is called true. When the opposed margins are more or less flat, so that there is merely apposition without interlocking, the suture is spoken of as false.

True sutures are of three kinds—serrated, denticulate, and limbous. In the *serrate suture* the margins of the bones are saw-like, as in the frontal suture; in the *denticulate suture* the margins present projections like teeth, as in the interparietal suture; and in the *limbous suture* the margins of the bones are so ridged and bevelled that they overlap, as in the lower and medial parts of the fronto-parietal suture.

False sutures are of two kinds—squamous and harmonic. In the *squamous suture* the margins are so bevelled that one overlaps the other, as in the squamo-parietal suture. In the *harmonic suture* the surfaces, which are rough, are in direct apposition, as between the maxillæ. In the **wedge-and-groove suture** a ridge on one bone is received into a cleft on another. Such a suture is also known as *schindylesis*,

and it is exemplified in the articulation between the rostrum of the sphenoid and the vomer.

The **peg-and-socket suture** or *gomphosis* is only represented by the sockets of the teeth.

Ligaments.—These are composed of white fibrous tissue, and, as their name implies, they bind the bones together. At a synovial joint their chief use is to control movement, the bones being maintained in position by the muscles and atmospheric pressure. At their attachments they are intimately associated with the periosteum. When the fibrous tissue is arranged continuously round the joint the ligament is called a *capsular ligament.* In other cases the tissue is disposed as round cords, and in a third variety it forms flattened bands.

Synovial Membranes.—These membranes are associated with movable structures, such as joints, gliding tendons, and the skin covering bony projections. Accordingly there are three kinds of synovial membrane—namely, articular, tendon or vaginal, and bursal.

The **articular synovial membranes** line the interior of synovial joints, except where there is articular cartilage, and they stop at the margin of this cartilage. In some joints they give rise to folds, some of which contain adipose tissue. Such folds are known as synovial fringes.

It is usually taught that everything inside the capsule, except articular hyaline cartilage, is lined by synovial membrane, but there seems reason to doubt whether this really persists over the menisci.

The **tendon** or **vaginal synovial membranes,** also known as *synovial sheaths,* invest those tendons which glide freely within fibrous sheaths. They are met with around the ankle, particularly behind the lateral and medial malleoli, and upon the palmar aspect of the fingers.

The **bursal synovial membranes,** commonly called **synovial bursæ,** are synovial sacs which are situated between the integument or a muscle and some bony projection. They may be deep-seated or subcutaneous. The *deep-seated bursæ* are situated between a muscle, or its tendon, and the contiguous bone—*e.g.,* the tendon of the biceps brachii and the anterior part of the tuberosity of the radius. The *subcutaneous bursæ* are placed beneath the integument, which they separate from some bony projection—*e.g.,* the prepatellar bursa.

Movements.—The different kinds of movement at synovial joints are angular, circumduction, rotation, and gliding.

Angular Movement.—This increases or diminishes the angle between two or more bones. When it takes place in a forward and backward direction, so as to bend or straighten a joint, it is spoken of as *flexion* and *extension.* When it takes place laterally, away from or towards the median plane of the body, it is called *abduction* and *adduction.* In the case of the hand the median line from or towards which abduction and adduction take place is a line passing through the centre of the *middle finger,* and in the case of the foot, through the centre of the *second toe.*

Circumduction.—This consists of the four forms of angular movement, occurring successively in such sequence as flexion, abduction,

extension, and adduction. It occurs at ball-and-socket and condyloid joints, and during the movement a part of the limb describes a cone, the apex of which is formed by the proximal end at the moving joint, whilst the base is described by the distal end.

Rotation.—This is movement of a bone round its axis without much disturbance of its position. It occurs at ball-and-socket and pivot joints, and also at the knee, which is a hinge-joint.

Gliding Movement.—This consists of a simple to-and-fro or sliding movement of two articular surfaces, as between the articular surfaces of vertebræ, and at the carpal and tarsal joints. When the gliding is combined with a certain amount of turning or rolling, so as to bring different parts of the articular surfaces successively into contact in different positions of the joint, the movement is known as *coaptation*, as at the femoro-patellar joint.

A description of the different articulations will be found with that of the regions to which they belong.

CHAPTER IX

THE UPPER LIMB

The Back.

Landmarks.—The middle line of the neck presents a median furrow, called the **nuchal groove,** the presence of which is due to the shortness of most of the cervical spinous processes and the prominence on either side of the muscle masses at the back of the neck. At the upper end of this groove the strong bifid spine of the axis may be felt on deep pressure with the finger, but the spines of the third, fourth, and fifth cervical vertebræ cannot be detected, as these, falling short of the surface, permit dorsal flexion of the neck. At the lower end of the groove the spine of the seventh cervical or vertebra prominens is a well-marked and easily recognized prominence; above it the spine of the sixth cervical can usually be detected on deep pressure; below it the spines of all the thoracic and lumbar vertebræ can be recognized, especially if the back is bent forwards.

The vertebra causing the most conspicuous prominence, or the vertebra prominens, is inconstant; although it is usually the seventh cervical, it may be the first or even the second thoracic.

On either side of the middle line in the thoracic and lumbar regions there is an elongated furrow, called the **spinal groove,** produced by the prominence of the sacro-spinalis muscle. This groove is best marked in the lower thoracic and upper lumbar regions, and subsides about the level of the third sacral spine. If the subject is not too muscular, the outline of the scapula may be defined, and will be found to extend from the second to the seventh rib. The scapular spine and acromion process are usually readily felt. The root of the spine is on a level with the third thoracic spine, the inferior angle with the seventh rib. The crest of the ilium can be felt at the lower part of the back, its greatest prominence being on a level with the fourth lumbar spine.

Fascia.—The **superficial fascia** is thick and fatty, and contains the cutaneous nerves and vessels. The **deep fascia** is thin, membranous, and resistant. It contains no fat, and provides sheaths for the muscles.

Cutaneous Nerves (Fig. 250).—These are most readily found at the level of the deep part of the superficial fascia, the cutaneous vessels serving as a guide to them. They are derived from the posterior primary divisions of the spinal nerves, each of which, with a few exceptions, divides into a *lateral* and *medial branch.* In the *thoracic region* the medial branches of the upper six nerves become cutaneous

near the spines of the vertebræ, and extend outwards. The branch of the second is especially long, and can be traced outwards over the scapula. The lateral branches of the upper six thoracic nerves end in the muscles of the back. The medial branches of the lower six thoracic nerves are distributed to muscles only, lateral branches becoming superficial along a line following the angles of the ribs. In the *lumbar region* the medial branches end in the muscles. The lateral branches of the first three nerves furnish cutaneous offsets which descend over

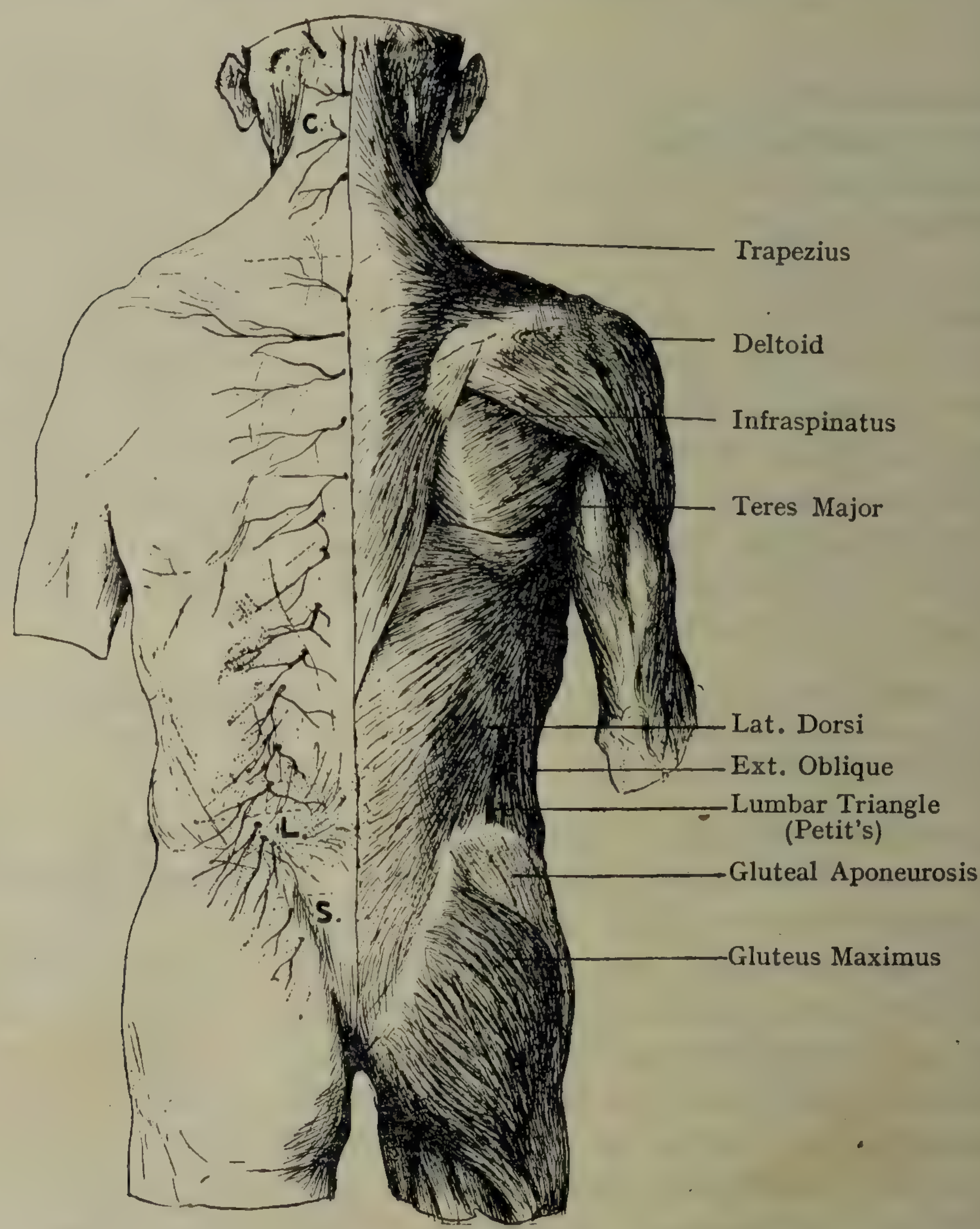


FIG. 250.—THE CUTANEOUS NERVES AND THE SUPERFICIAL MUSCLES OF THE BACK.

the iliac crest in front of the outer border of the sacro-spinalis to the skin in the gluteal region, supplying in their course the skin of the lumbar region. The lateral branches of the lower two nerves end in the deep muscles.

The **cutaneous arteries** accompanying the cutaneous nerves of the thoracic and lumbar regions are derived from the posterior branches of the intercostal and lumbar arteries.

Muscles—The Trapezius (Fig. 250).—This muscle is so named because, together with its fellow, it presents a four-sided appearance. (The

two muscles have also been likened to a monk's hood or cowl; hence the name *cucullaris*.)

Origin.—The inner third of the superior nuchal line of the occipital bone, and the external occipital protuberance; the ligamentum nuchæ; and the spinous processes and supraspinous ligaments of the last cervical, and, as a rule, of all the thoracic vertebræ. The origins of the two muscles are markedly tendinous between the second cervical and third thoracic spines, where they give rise to an elliptical area, *the speculum rhomboideum*, widest opposite the sixth cervical spine.

Insertion.—The posterior border of the outer third of the clavicle; the inner border of the acromion process, and upper lip of the posterior border of the spine of the scapula; and the tubercle marking the inner end of the spine. To this tubercle is attached a tendon in which all the fibres of the lower part of the muscle end; it forms the apex of a smooth triangular surface upon which the tendon glides, a bursa intervening between them.

Nerve-supply.—The accessory and a nerve derived from the third and fourth cervical spinal nerves. The two nerves are to be found at the anterior edge of the muscle some little distance above the clavicle. They pass on to its deep surface, where they both branch, the branches joining one another to form a network, the *subtrapezial plexus*, from which terminal twigs pass into the substance of the muscle.

The upper fibres of the muscle are directed downwards, outwards, and, twisting upon themselves, gain the front of the neck, where they are attached to the clavicle; the middle fibres pass more or less horizontally outwards to the scapular spine; and the lower fibres pass upwards and outwards, ending in the tendon attached to the tubercle of the spine.

Action.—The upper fibres elevate the outer end of the clavicle and the point of the shoulder. If the shoulder be fixed they draw the head downwards, and rotate it to the opposite side. The middle fibres approximate the scapula to the spine. The lower fibres are largely concerned in rotating the scapula in such a way that when they pull the inner end of the spine downwards the glenoid cavity at the outer extremity of the bone is elevated.

Ligamentum Nuchæ is a fibrous band, or intermuscular septum, occupying the median line of the neck. It is attached above to the external occipital protuberance, and to the external occipital crest below to the spine of the seventh cervical vertebra. Deeply it is attached to the spines of the cervical vertebræ from the second to the sixth. Between the spines it is continuous with the interspinous ligaments.

Latissimus Dorsi (Fig. 250)—*Origin.*—The spinous processes and supraspinous ligaments of the lower six thoracic vertebræ; the posterior lamina of the lumbar fascia by means of which it is attached to the lumbar and sacral spines and the posterior fourth of the outer lip of the iliac crest; by muscular fibres from the outer lip of the iliac crest

for about 2 inches; the outer surfaces of the last three or four rib lateral to their angles by fleshy slips, which interdigitate with slip of the obliquus externus abdominis; and inconstantly from the bacl of the inferior angle of the scapula.

Insertion.—The floor of the bicipital groove of the humerus abou its middle third for about $1\frac{1}{2}$ inches.

Nerve-supply.—The nerve to latissimus dorsi (long subscapular from the posterior cord of the brachial plexus, its fibres being derivec chiefly from the seventh cervical nerve. The nerve enters the muscl on its deep aspect.

The upper fibres of the muscle pass horizontally outwards, anc cross the inferior angle of the scapula, which they strap to the ches wall; the succeeding fibres pass obliquely upwards and outwards and those from the iliac crest and lower ribs pass almost verticall upwards.

Action.—The arm being raised, the muscle draws it downward and backwards, rotating it inwards at the same time. When the arm is fixed it can raise the trunk, as in the act of climbing a pole It also elevates the last three or four ribs, as in forced inspiration.

At the inferior angle of the scapula the muscle lies behind the teres major; as it passes outwards and forwards it winds round the lower border of this muscle, and eventually lies in front of it. Intervening between the tendons of the two muscles, close to their insertions, is a synovial bursa. Between the upper border of the latissimus dorsi, the lower border of the trapezius, and the base of the scapula, is a triangular area, the *auscultation triangle*, in which are exposed a portion of the rhomboideus major, the sixth rib, and the sixth intercostal space. The anterior border of the latissimus dorsi, between the iliac crest and last rib, may overlap the posterior border of the obliquus externus abdominis. Should this not be the case, there is a small triangular area, the *lumbar triangle* (*Petit*), between the two muscles. It is bounded in front by the posterior border of the obliquus externus abdominis, behind by the anterior border of the latissimus dorsi, and below by the iliac crest near its centre. It is covered by skin and fascia only; its floor is formed by a part of the obliquus internus abdominis. In this situation a lumbar hernia may occur, or a lumbar abscess may find its way to the surface.

Levator Scapulæ (Fig. 251)—*Origin.*—By four tendinous slips from the posterior tubercles of the transverse processes of the first four cervical vertebræ.

Insertion.—To the medial border of the scapula from the superior angle to the triangular surface at the root of the spine.

Nerve-supply.—Branches of the third, fourth, and fifth cervical nerves, the last of which is given off in common with the nerve to the rhomboids.

The muscle is directed downwards, backwards, and slightly outwards.

Action.—Acting from its origin, the muscle raises the superior

ngle of the scapula, and rotates the bone in such a way as to depress ne point of the shoulder. When the scapula is fixed it is a lateral exor of the neck.

The levator scapulæ may have three or even fewer slips of attachment to ne vertebræ. Between it and the serratus anterior is a strong fascial layer epresenting the intermediate part of a primitively continuous muscle sheet ound in many animals.

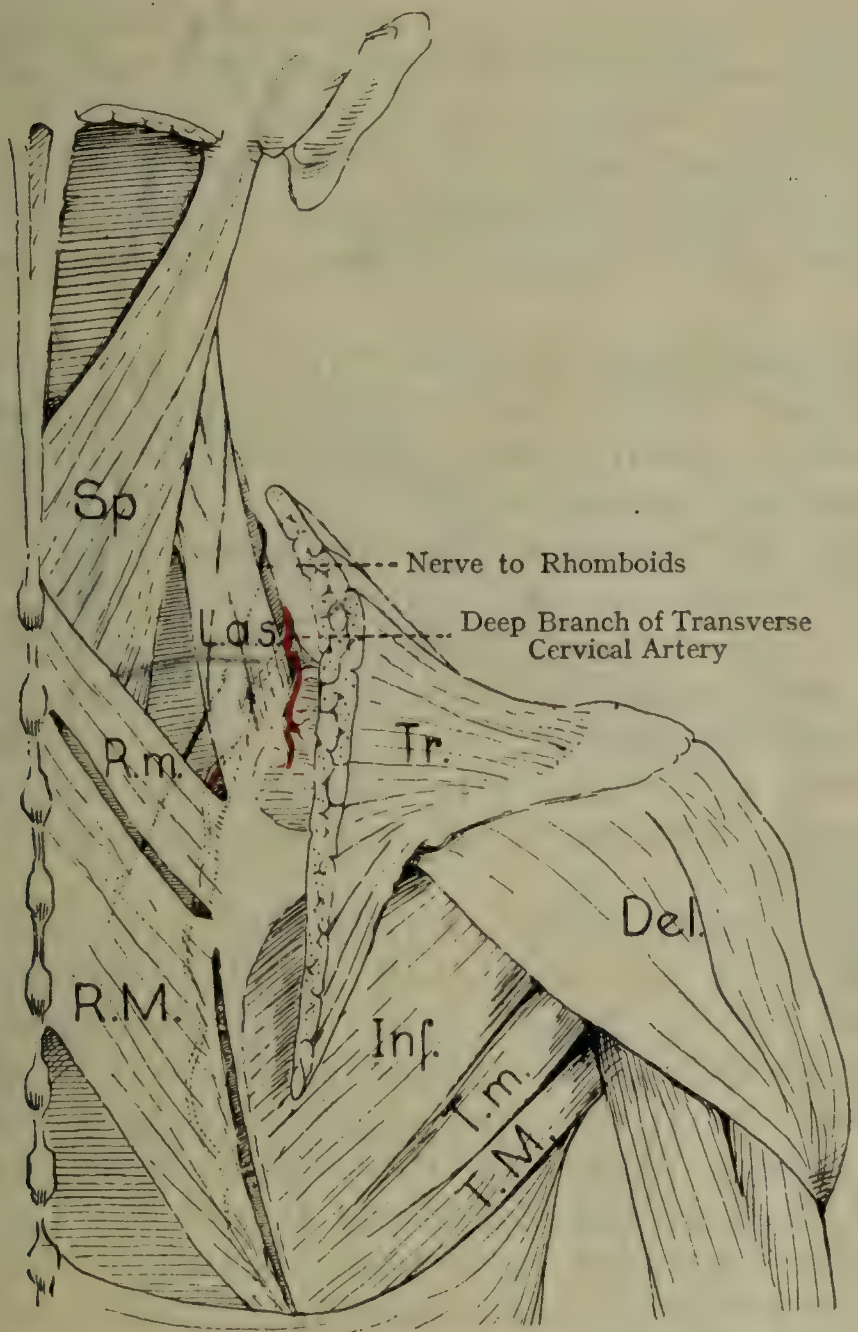


FIG. 251.—THE STRUCTURES LYING DEEPLY TO THE TRAPEZIUS.

Del., deltoid; inf., infraspinatus; L.a.s., levator scapulæ; R.M., rhomboideus major; R.m., rhomboideus minor; Sp., splenius; T.M., teres major; T.m., teres minor; Tr., trapezius.

Rhomboideus Minor (Fig. 251)—*Origin.*—The lower part of the ligamentum nuchæ, and the spines of, and the supraspinous ligament between, the seventh cervical and first thoracic vertebræ.

Insertion.—The medial border of the scapula opposite the triangular surface at the root of the spine.

Rhomboideus Major (Fig. 251)—*Origin.*—The spines and supraspinous ligaments of the thoracic vertebræ from the second to the fifth inclusive.

Insertion.—The medial border of the scapula from the triangula surface at the root of the spine to the inferior angle. The insertio takes place by means of a tendinous arcade, which is firmly attache near the inferior angle. This arcade is attached by connective tissu to the greater part of the medial border, from which the muscle ca be detached to a large extent without injury.

Nerve-supply of the Rhomboids.—The nerve to the rhomboids is branch of the fifth cervical. This nerve passes through the scalenu medius, gives a branch to the levator scapulæ, and passes downward on the back midway between the middle line and the medial borde of the scapula. It lies deeply to the two rhomboid muscles, into th deep surfaces of which its branches pass.

The direction of the rhomboid muscles is downwards and out wards.

Action.—The muscles draw the scapula backwards and upward and the lower part of the rhomboideus major, by pulling the lowe angle of the bone upwards and inwards, slightly rotates it, and de presses the point of the shoulder.

Deep Branch of Transverse Cervical Artery (Fig. 251).—Althoug this vessel, as its name implies, is usually a branch of the transvers cervical, it may arise from the third part of the subclavian. It passe backwards deeply to the levator scapulæ, and then downwards unde cover of the rhomboid muscles, lying close to the medial border of th scapula. It gives off branches to the adjacent muscles, and severa offsets to the front and back of the scapula taking part in the scapula anastomosis.

At the upper border of the scapula a limited view is obtained c the inferior belly of the omo-hyoid muscle, and the suprascapula vessels and nerve. The former arises from the upper border of th bone to the inner side of the suprascapular notch, as well as fror the suprascapular or transverse ligament bridging the notch. Th suprascapular artery passes to the supraspinous fossa above th ligament, and the suprascapular nerve below it. The artery in thi part of its course furnishes an acromial branch to the upper surfac of the acromion process. The transverse cervical artery is seen, a a higher level than the suprascapular, dividing into superficial an deep branches. The former passes upwards superficially to the levato scapulæ, the latter downwards and backwards deeply to it. Lyin deeply to the muscles associated with the scapula are the followin structures:

Serratus Posterior Superior (Fig. 253)—*Origin.*—The lower part o the ligamentum nuchæ, and the spines and supraspinous ligament of the last cervical and first two thoracic vertebræ.

Insertion.—By fleshy and tendinous slips into the upper border and outer surfaces of the second, third, fourth, and fifth ribs, latera to their angles.

Nerve-supply.—The second, third, and fourth intercostal nerves The origin of the muscle is by a very thin aponeurosis which occupie

bout half its length. The direction of the fibres is downwards and ıtwards.

Action.—The muscle elevates the ribs into which it is inserted, ıd is therefore a muscle of inspiration.

Serratus Posterior Inferior (Fig. 253)—*Origin.*—The posterior mina of the lumbar fascia, by means of which the muscle is attached the spines and supraspinous ligaments of the lower two thoracic and pper two or three lumbar vertebræ.

Insertion.—By four fleshy slips unto the lower borders of the last ur ribs.

Nerve-supply.—The ninth, tenth, and eleventh intercostal nerves.

The serrations of insertion overlap each other from above down- ards; the second is the broadest, and the third to a large extent

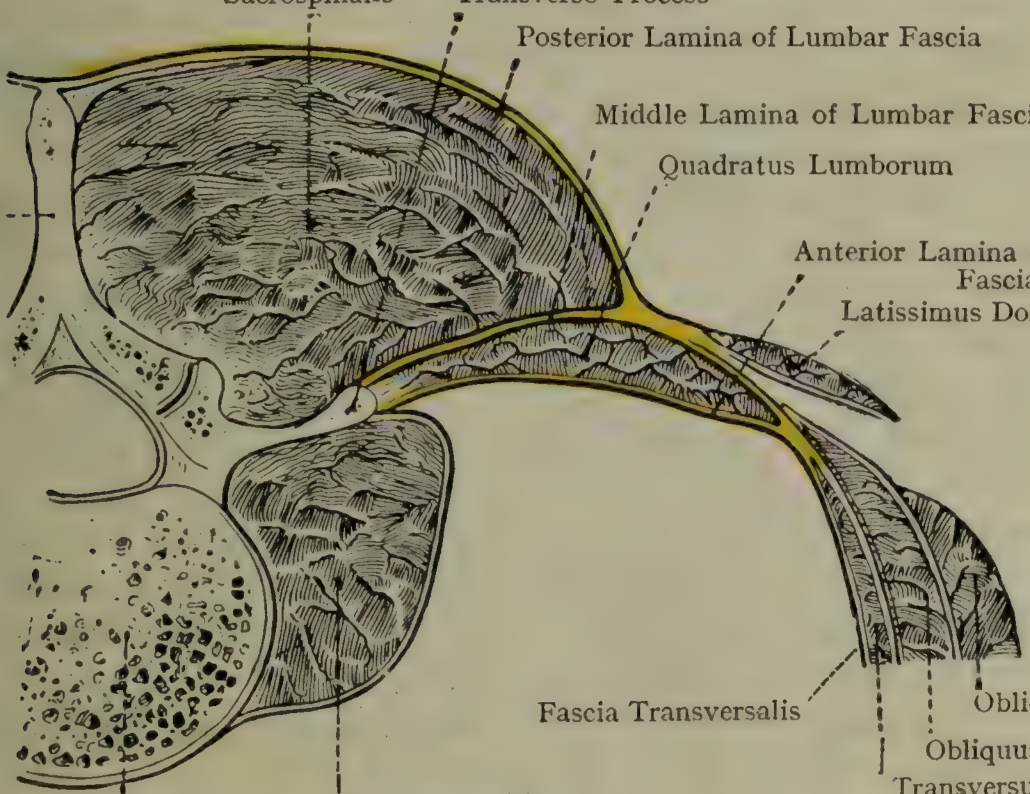


FIG. 252.—DIAGRAM OF THE LUMBAR FASCIA.

onceals the fourth. The direction of the fibres is upwards and utwards.

Action.—Draws backwards and slightly depresses the lower four bs, the effect of which is to increase the capacity of the lower part f the thoracic cavity; it fixes the lower four ribs, and thus acts as an uxiliary to the diaphragm. In either case it acts as a muscle of ıspiration.

Posterior Lamina of the Lumbar Fascia (Fig. 252).—The lumbar ıscia is composed of three laminæ—*anterior, middle,* and *posterior,* he latter of which alone is fully exposed in this region. It is of con- iderable strength, and is attached to the spines of the lumbar and acral vertebræ, and the posterior fourth of the outer lip of the iliac rest. It affords origin to a portion of the latissimus dorsi and to the erratus posterior inferior, and lies behind the sacro-spinalis, forming

the posterior wall of its sheath. At the outer border of the sacr spinalis it blends with the middle lamina, which may be partial seen by raising this border. Superiorly it is joined by the thorac part.

The Thoracic Part of the Lumbar Fascia.—This is a thin aponeurot sheet which covers the sacro-spinalis in the thoracic region. Its fibr are chiefly arranged transversely, being attached medially to the spin of the vertebræ, and laterally to the angles of the ribs. Super-adde to the transverse fibres there are a few which are longitudina Superiorly the aponeurosis passes deeply to the serratus posteri superior, and becomes continuous with the deep cervical fascia ensheatl ing the splenius. Inferiorly it blends with the posterior lamina of th lumbar fascia.

Splenius (Fig. 253).—This muscle is so named because it stra or binds down the muscles beneath it. It has a continuous origi but subdivides into two parts—**splenius capitis** and **splenius cervicis.**

Origin.—The lower two-thirds of the ligamentum nuchæ, and th spines of the last cervical and first six thoracic vertebræ.

Insertion—**Splenius Capitis.**—The hinder and lower part of th outer surface of the mastoid process, and the outer third of the superic nuchal line of the occipital bone, below the attachment of the sterno mastoid, deeply to which it lies. **Splenius Cervicis.**—The posteric tubercles of the transverse processes of the first two or three cervica vertebræ, behind the levator scapulæ, and in line with the costo cervicalis.

Nerve-supply.—The posterior primary divisions of the cervica nerves below the third, and of the upper five thoracic nerves.

The muscle is a thin, finely fasciculated sheet, the direction o whose fibres is upwards and outwards.

Action.—The muscle extends the head, is a lateral flexor of the neck and rotates the head to the same side.

Sacro-spinalis (Erector Spinæ) (*vide* Fig. 253).—This composit muscle is single below in the region between the last rib and iliac crest where it is tendinous medially and fleshy laterally. Extending up wards, it subdivides into three longitudinal columns—outer, middle and inner; there are three muscles in each of the outer and middl columns, and one in the inner column, making seven muscles in all.

Origin.—The spines of the last two thoracic, all the lumbar, an the upper four sacral vertebræ; the back of the fourth sacral vertebra the posterior sacro-iliac ligament; and the posterior fifth of the ilia crest. The *insertion* of the muscle is represented by the columns int which it divides. Near the last rib it presents a surface groove, in dicating its subdivision at this level into an outer and inner column the latter subdividing into the middle and inner columns.

The Lateral Column (the Ilio-costo-cervicalis) is composed of thre muscles—the ilio-costalis, the costalis, and the costo-cervicalis i succession from below upwards.

The Ilio-costalis is the direct continuation of the outer part o

e sacro-spinalis, and is *inserted* into the lower border of the twelfth), and by fleshy and tendinous bundles into the angles of ribs from e seventh to the eleventh.

The Costalis (Musculus Accessorius) (*vide* Fig. 253) prolongs the o-costalis from the lower six to the upper six ribs. It *arises* by ndons, medial to the slips of insertion of the ilio-costalis, from the

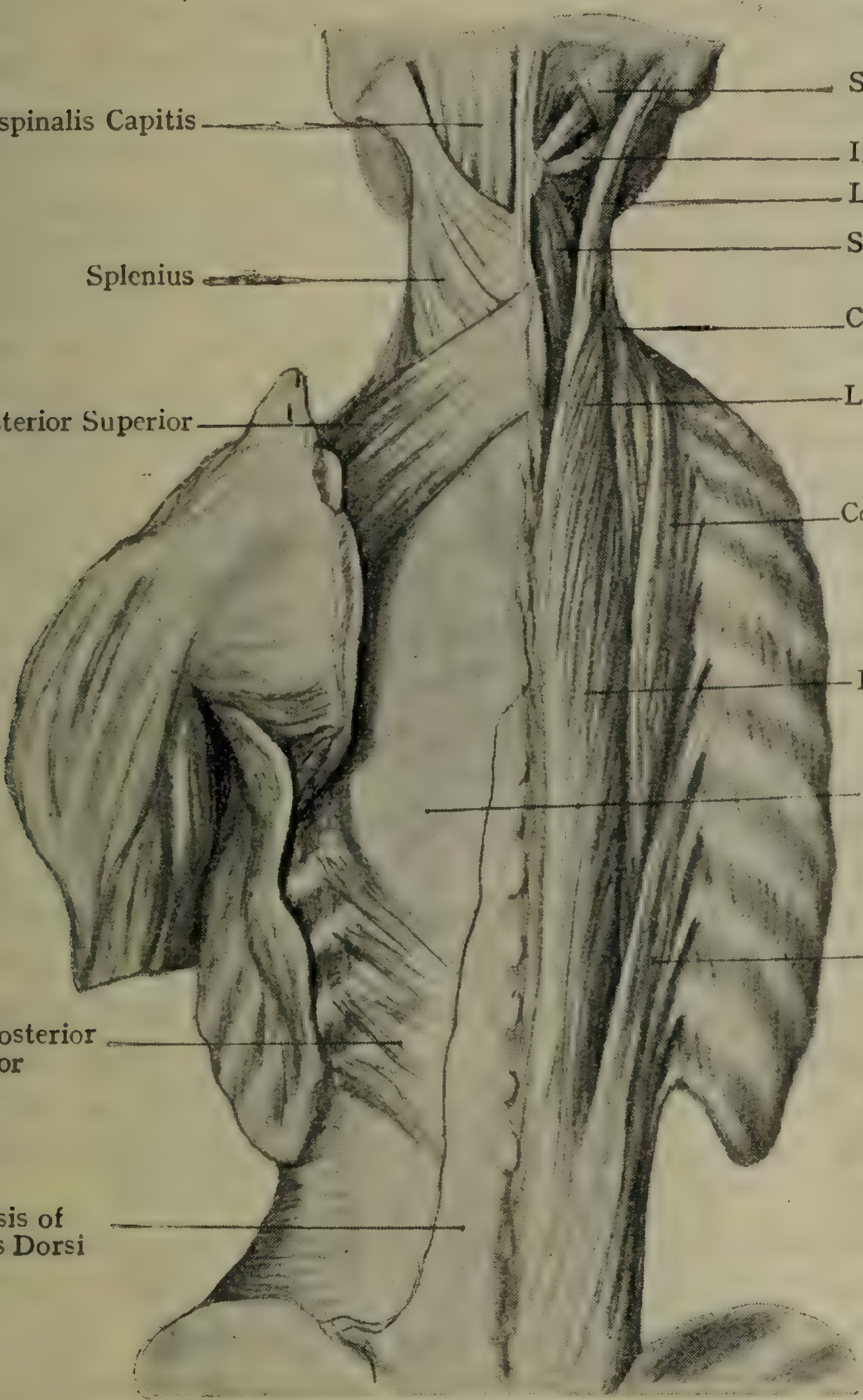


FIG. 253.—THE POST-VERTEBRAL MUSCULATURE.

n the left not dissected, but on the right dissected to some extent, splenius and semispinalis capitis having been removed to expose suboccipital structures.

ngles of the ribs from the seventh to the eleventh, and from the outer ırface of the twelfth rib; it is *inserted* by tendons into the angles of ıe upper ribs from the second to the sixth, and into the outer border f the first rib lateral to the tubercle.

The Costo-cervicalis (Cervicalis Ascendens) (*vide* Fig. 253) is the ontinuation of the costalis upwards into the neck. It *arises* by tendin-

ous slips from the third, fourth, fifth, and sixth ribs, medial to th tendons of insertion of the costalis; it is *inserted* into the posteric tubercles of the transverse processes of the fourth, fifth, and sixt cervical vertebræ, where it is in line with the splenius cervicis.

Action.—The muscles of the outer column are extensors and latera flexors of the vertebral column; they also depress the ribs and aid i expiration.

The Intermediate Column (the Longissimus) consists of three muscle —the longissimus thoracis, the longissimus cervicis, and the longis simus capitis, in order from below upwards.

The Longissimus Thoracis is the direct continuation of the inne part of the sacro-spinalis, and is inserted in a twofold manner. Th *inner insertions* are by round, tapering tendons attached to the ac cessory processes of the lumbar vertebræ and the extremities of th transverse processes of the thoracic vertebræ. The *outer insertion* are fleshy, and are attached to the backs of the transverse processe of the lumbar vertebræ, and to the outer surfaces of the lower ten rib lateral to the tubercles.

The Longissimus Cervicis (Transversalis Cervicis) is the continuatio of the longissimus thoracis into the neck. It *arises* from the transvers processes of the upper five or six thoracic vertebræ, and is *inserte* into the posterior tubercles of the transverse processes of cervica vertebræ from the second to the sixth inclusive, where it is media to the splenius cervicis and costo-cervicalis.

The Longissimus Capitis (Trachelo-mastoid) (*vide* Fig. 253) is th continuation of the longissimus thoracis to the head. It *arises* fror the transverse processes of the upper five or six thoracic vertebræ i close connection with the longissimus cervicis, and from the articula processes and capsular ligaments of the lower three cervical vertebra It is *inserted* into the lower and hinder aspect of the mastoid proces under cover of the splenius capitis. The muscle is very narrow an ribbon-like, and near its insertion is crossed by a tendinous inte section.

Action.—The muscles of the middle column are extensors and latera flexors of the vertebral column. They also extend the head, flex th neck to one side, and rotate the head to the same side.

The Medial Column (the Spinalis) consists chiefly of the **spinali thoracis,** which is intimately associated with the inner part of th longissimus dorsi. It *arises* from the lower two thoracic and uppe two lumbar spines, and is *inserted* by tendinous slips into the uppe thoracic spines—sometimes the upper four, sometimes as many as th upper eight.

Action.—Extends the thoracic portion of the vertebral column.

Nerve-supply.—The sacro-spinalis and its component muscles ar supplied by the posterior primary divisions of the spinal nerves.

Between the iliac crest and the last rib the sacro-spinalis is enclosec in a sheath, the posterior wall of which is formed by the posterio lamina of the lumbar fascia, the anterior wall by the middle lamin

this fascia. On the back of the sacrum its tendon gives origin
eeply to fibres of multifidus.

Semispinalis Capitis (Complexus)—*Origin.*—The extremities of the
ansverse processes of the upper six thoracic and last cervical vertebræ,
nd the backs of the articular processes and capsular ligaments of
ree or four cervical vertebræ above the seventh. The muscle may
ceive a fleshy slip from the spine of the seventh cervical.

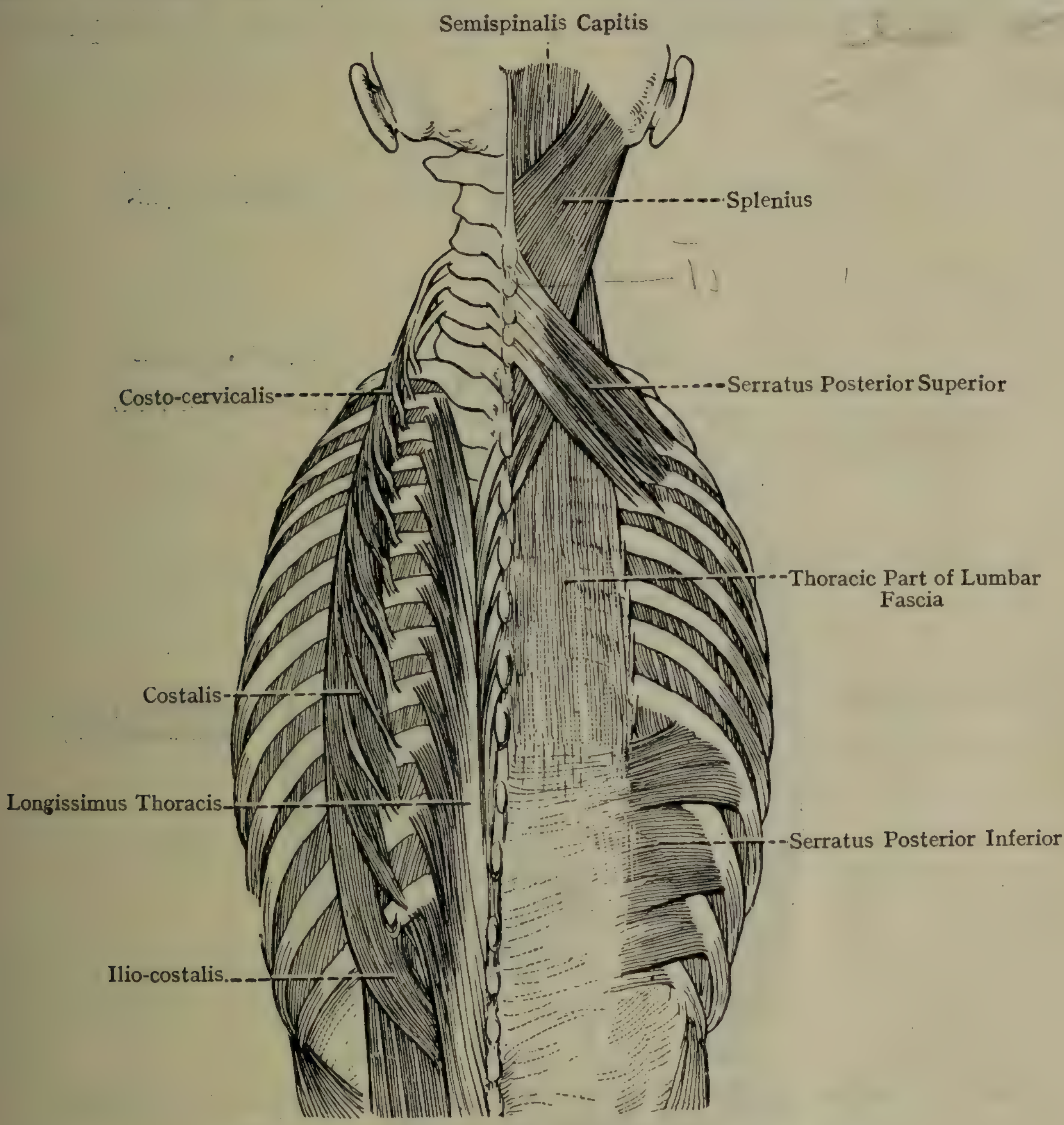


FIG. 254.—THE DEEP MUSCLES OF THE BACK.

Insertion.—The occipital bone between the superior and inferior
uchal lines, extending outwards for about 2 inches from the occipital
rest. About the level of the sixth cervical vertebra the inner part
of the muscle is interrupted by a tendinous intersection, and from this
circumstance is known as the **biventer cervicis.**

Nerve-supply.—The posterior primary division of the first cervical
or suboccipital nerve; the greater occipital; and the posterior primary
divisions of cervical nerves below the second.

The innermost and longest fibres pass almost vertically upwards; the outer and upper fibres are short and pass upwards and inwards.

Action.—Both muscles extend the head; one muscle inclines it to one side and rotates it to the opposite side.

A small part of the semispinalis capitis may appear superficially in the upper part of the posterior triangle of the neck. The greater occipital nerve passes through the upper part of the muscle. Immediately below the occipital bone it covers the rectus capitis posterior

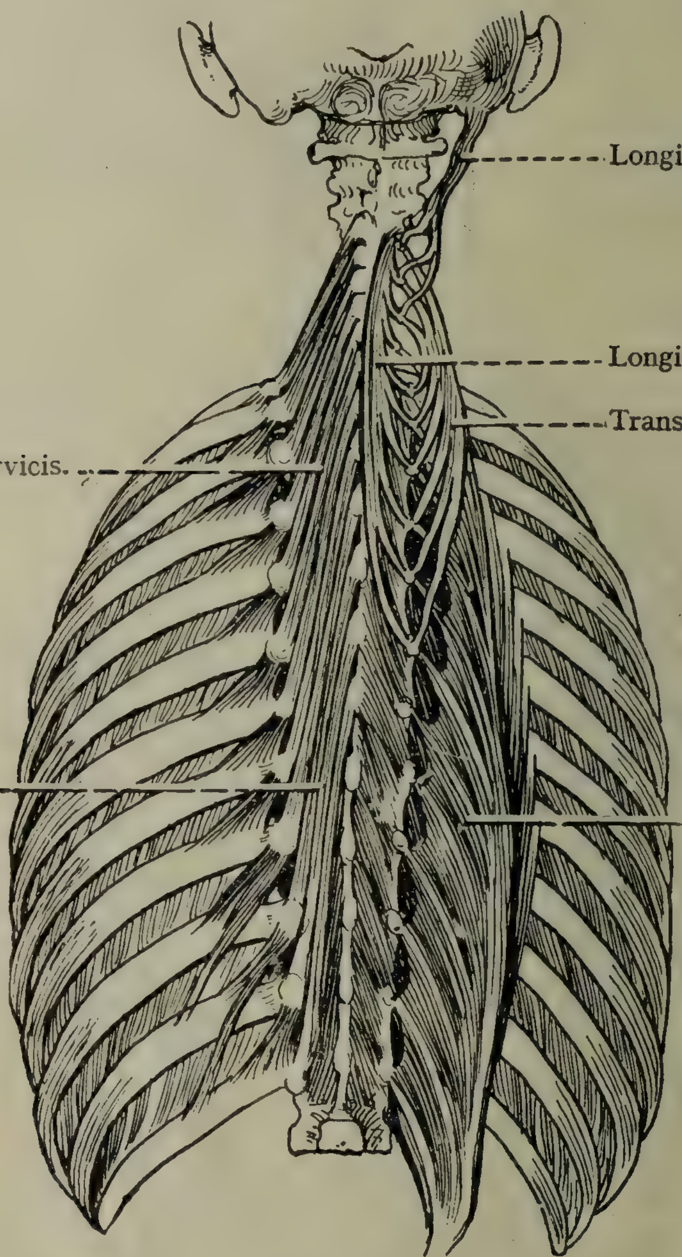


Fig. 255.—The Middle Column of the Sacro-spinalis and the Semispinales Muscles.

major and minor and the superior and inferior oblique muscles superficially, and forms the roof of the suboccipital triangle.

Semispinalis Thoracis (Fig. 255)—*Origin.*—The extremities of the transverse processes of the thoracic vertebræ from the sixth to the tenth inclusive.

Insertion.—The spines of the last two cervical and upper four thoracic vertebræ.

Semispinalis Cervicis (Fig. 255)—*Origin.*—The extremities of the transverse processes of the upper five thoracic vertebræ.

Insertion.—The spines of the cervical vertebræ from the second ɔ the fifth inclusive.

The bundle of fibres inserted into the spine of the axis is the largest, nd the bundles overlap one another from above downwards.

Nerve-supply of the Semispinales.—The posterior primary divisions f the cervical and upper thoracic nerves.

The fibres of the two muscles are directed upwards and inwards.

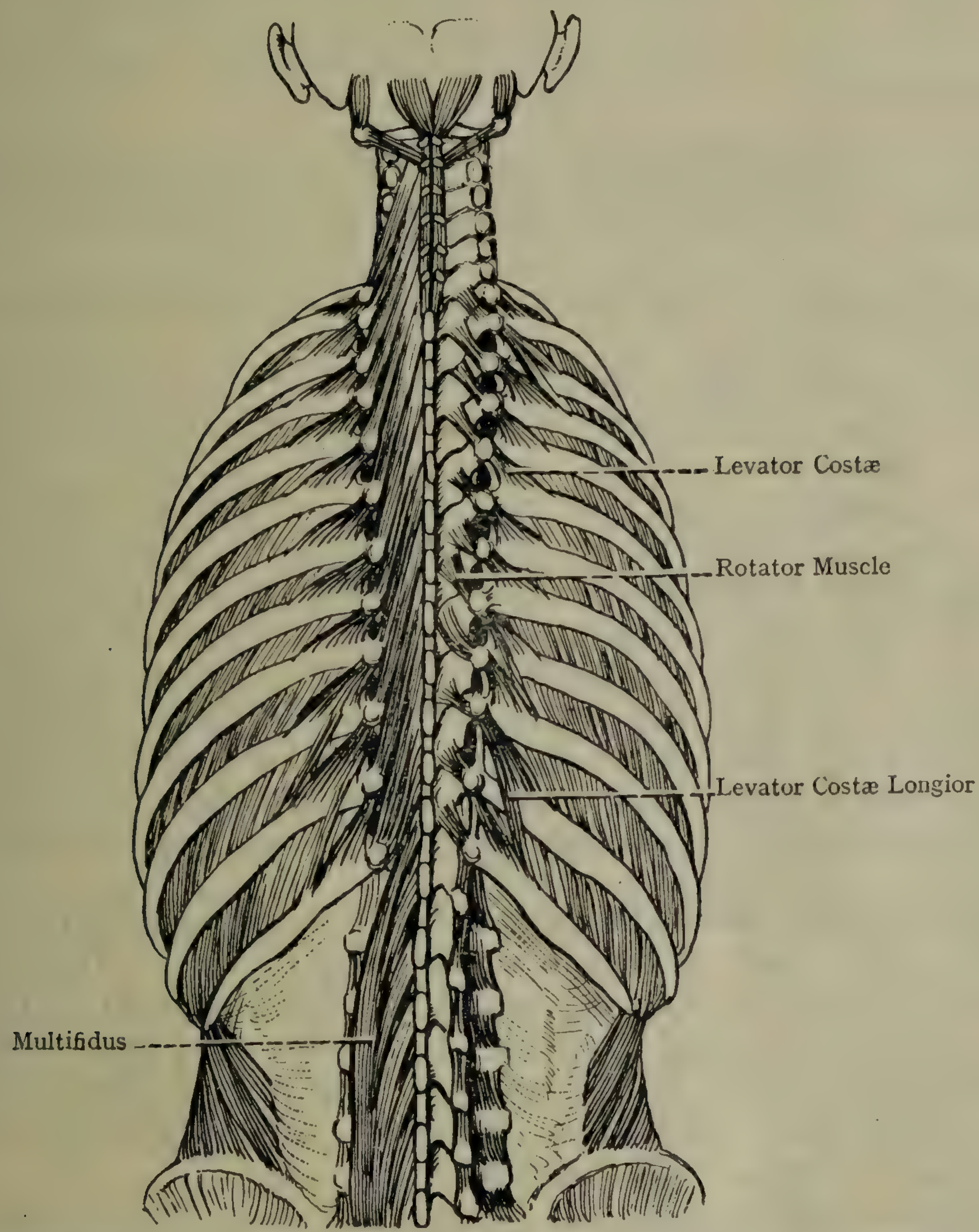


FIG. 256.—THE MULTIFIDUS SPINÆ AND LEVATORES COSTARUM MUSCLES.

Action.—The muscles are extensors and lateral flexors of the ertebral column. The semispinalis cervicis and the cervical portion of the semispinalis thoracis also rotate the cervical vertebræ towards he opposite side.

Multifidus (Fig. 256) lies deeply in the groove by the sides of the pines of the vertebræ.

Origin.—The sacral groove and the deep surface of the tendon of he sacro-spinalis; the posterior sacro-iliac ligament and the hinder part

of the inner lip of the iliac crest; the mammillary tubercles of th lumbar vertebræ; the transverse processes of the thoracic vertebræ and the articular processes of the lower four cervical vertebræ.

Insertion.—The spines of the vertebræ from root to tip.

The superficial fibres from any given origin pass over three or fou vertebræ before obtaining insertion, the succeeding fibres pass ove two or three vertebræ, and the deeper fibres pass over one.

Nerve-supply.—The posterior primary divisions of the spinal nerves

Action.—An extensor and lateral flexor of the spinal column, a the same time rotating the cervical and thoracic regions towards th opposite side.

The fibres of multifidus, semispinalis thoracis, and semispinalis cervicis al pass obliquely upwards and medially from the transverse processes to the spinou processes; they together form the semispinalis group of muscles.

The Rotatores (Fig. 256) are confined to the thoracic region, and ar eleven in number.

Origin.—The upper and back part of a transverse process.

Insertion.—The lower border of the lamina of the vertebra imme diately above.

Nerve-supply.—The posterior primary divisions of the spinal nerves

Action.—Rotate the vertebræ towards the opposite side.

The Interspinales are usually confined to the cervical and lumbar regions, but may be found at either end of the thoracic region. They are arranged in pairs between the successive spines, the two slips being disposed one on either side of the interspinous ligament. In the neck they are limited to the region of the apices of the spines, but in the lumbar region they extend for nearly their whole length.

Nerve-supply.—Posterior primary divisions of the spinal nerves.

Action.—Extend the vertebræ.

The Intertransversales occur chiefly in the cervical, but also occur in the lower thoracic region and lumbar regions. They are arranged in pairs in each interspace, one muscle lying in front of the other. In the neck they extend between the anterior and posterior tubercles of adjacent vertebræ. In the lumbar region the muscles may be arranged in pairs, but are, as a rule, undivided. In this region they may be absent and replaced by membrane.

Nerve-supply.—Posterior primary divisions of the spinal nerves.

Action.—The muscles are lateral flexors of the successive vertebræ.

The Levatores Costarum (Fig. 256) are twelve in number on either side.

Origin.—The highest muscle arises from the tip of the transverse process of the seventh cervical vertebra, and the succeeding eleven arise from the tips of the transverse processes of the thoracic vertebræ from the first to the eleventh inclusively.

Insertion.—Each muscle is inserted into the outer surface of the rib below, extending from the tubercle to the angle. In the case of the lower two or three muscles the more superficial fibres passing over

one rib are inserted into the rib next below it, these fibres constituting the **levatores costarum longiores.**

Nerve-supply.—The intercostal nerves.

The muscles are directed downwards and outwards.

Action.—Elevate the ribs, and are therefore muscles of inspiration.

Each muscle is somewhat fan-shaped, and contains an admixture of aponeurotic fibres. The direction of the muscle fibres coincides with that of the external intercostals, with which their outer borders are closely associated.

Posterior Primary Divisions of the Spinal Nerves.—In the thoracic region these nerves pass backwards through a four-sided space bounded below by the neck of a rib, above by the transverse process of the upper vertebra, externally by the superior costo-transverse ligament, and medially by the body of a vertebra. Between the transverse processes each nerve divides into a medial and lateral branch. The **medial branches** incline inwards on the superficial surface of multifidus, and the upper six become cutaneous near the spines of the vertebræ, whilst the lower six end in the deep muscles. The **lateral branches** pass outwards beneath the middle column of the sacro-spinalis, and, on reaching the interval between the middle and outer columns of that muscle, end differently in the upper and lower parts of the back. The upper six end in the deep muscles, but the lower six become cutaneous along the line of the angles of the ribs. In the lumbar region the posterior primary divisions pass backwards, each through a space bounded laterally by the quadratus lumborum muscle, medially by the intertransversalis muscle, and above and below by a transverse process, the medial branch occupying a groove between the mammillary and accessory processes of the vertebra. Their further disposition is similar to that in the lower thoracic region, but the lateral branches of the first three only furnish cutaneous nerves, and these are mainly distributed to the skin of the gluteal region.

The **arteries** of the thoracic region are the posterior branches of the intercostal arteries. Each **posterior branch** passes backwards in company with the corresponding posterior primary division of a spinal nerve. Before passing through the quadrangular space it gives off a *lateral spinal branch*, which enters the spinal canal through the intervertebral foramen. Passing backwards, the trunk of the artery divides into medial and lateral branches, which have a distribution similar to that of the corresponding branches of the nerve.

The **veins** of the thoracic region terminate in the intercostal veins.

The **arteries** of the lumbar region are the **posterior** branches of the lumbar arteries. Each accompanies the corresponding posterior primary division of a spinal nerve, and its distribution is comparable to that in the thoracic region.

The **veins** of the lumbar region terminate in the inferior vena cava.

The Pectoral Region and Axillary Space.

Landmarks.—The outline of the clavicle and acromion process of the scapula are readily defined. The acromial epiphysis may remain permanently detached from the spine and simulate a fracture. The roundness of the shoulder is largely due to the deltoid muscle, but also in part to the head of the humerus. Below the middle of the clavicle is a depression, the **infraclavicular fossa,** corresponding to an interval between the deltoid and pectoralis major. In this region it is possible to compress the axillary artery against the second rib, but very firm pressure is required. Below the outer part of the clavicle the tip of the coracoid process, which is here covered in front by the deltoid, may be felt as a somewhat obscure rounded knob. If the arm is raised from the side, at right angles to the trunk, the coraco-brachialis muscle is rendered prominent. In this position the course of the axillary artery is indicated by a line drawn from the middle of the clavicle to the inner edge of the muscle. The hollow of the armpit, indicating the position of the axillary space, is bounded in front and behind by the axillary folds. The anterior axillary fold is usually at the level of the fifth rib, and is caused by the prominent lower edge of the pectoralis major; the posterior fold is at a lower level, and corresponds to the lower edge of the latissimus dorsi. In the female the mammary gland causes a more or less well-marked rounded prominence on the front of the chest. A little below and medial to the centre of the mammary prominence is the nipple, which is surrounded by a pigmented circular area—the areola. The exact position of the nipple is subject to variation. As a rule it corresponds to the fourth intercostal space about 4 inches from the mid-sternal line, but in corpulent persons, and in females with pendulous mammæ, it is lower in position. In the middle line the sternum can readily be made out, and about 2 inches below its upper border a transverse ridge, or sternal angle, may be felt. This ridge serves as a guide to the position of the second costal cartilage on either side. Above the upper border of the sternum is the suprasternal depression. Below the lower border of the body of the sternum is an infrasternal depression, situated between the seventh pair of costal cartilages, and marking the position of the xiphoid process.

The Cutaneous Nerves are arranged in three groups—supraclavicular, anterior, and lateral branches of intercostal nerves.

The supraclavicular nerves are branches of the cervical plexus, and are derived from the third and fourth cervical nerves. They are three in number—medial, intermediate, and lateral branches. As they descend from the neck they lie deeply to the platysma myoides. The **medial branch** crosses the sterno-clavicular joint, and is distributed to the skin covering the upper part of the sternum. The **intermediate branch,** consisting usually of two or more nerves, crosses the middle part of the clavicle, and is distributed to the skin covering the front of the chest. The **lateral branch** crosses the acromion pro-

cess, and is distributed to the skin covering the upper part of the deltoid.

The anterior cutaneous nerves are the terminal branches of the upper six intercostal nerves, and become superficial by passing through the pectoralis major close to the sternum. Small medial twigs supply the skin covering the sternum; larger lateral branches supply the

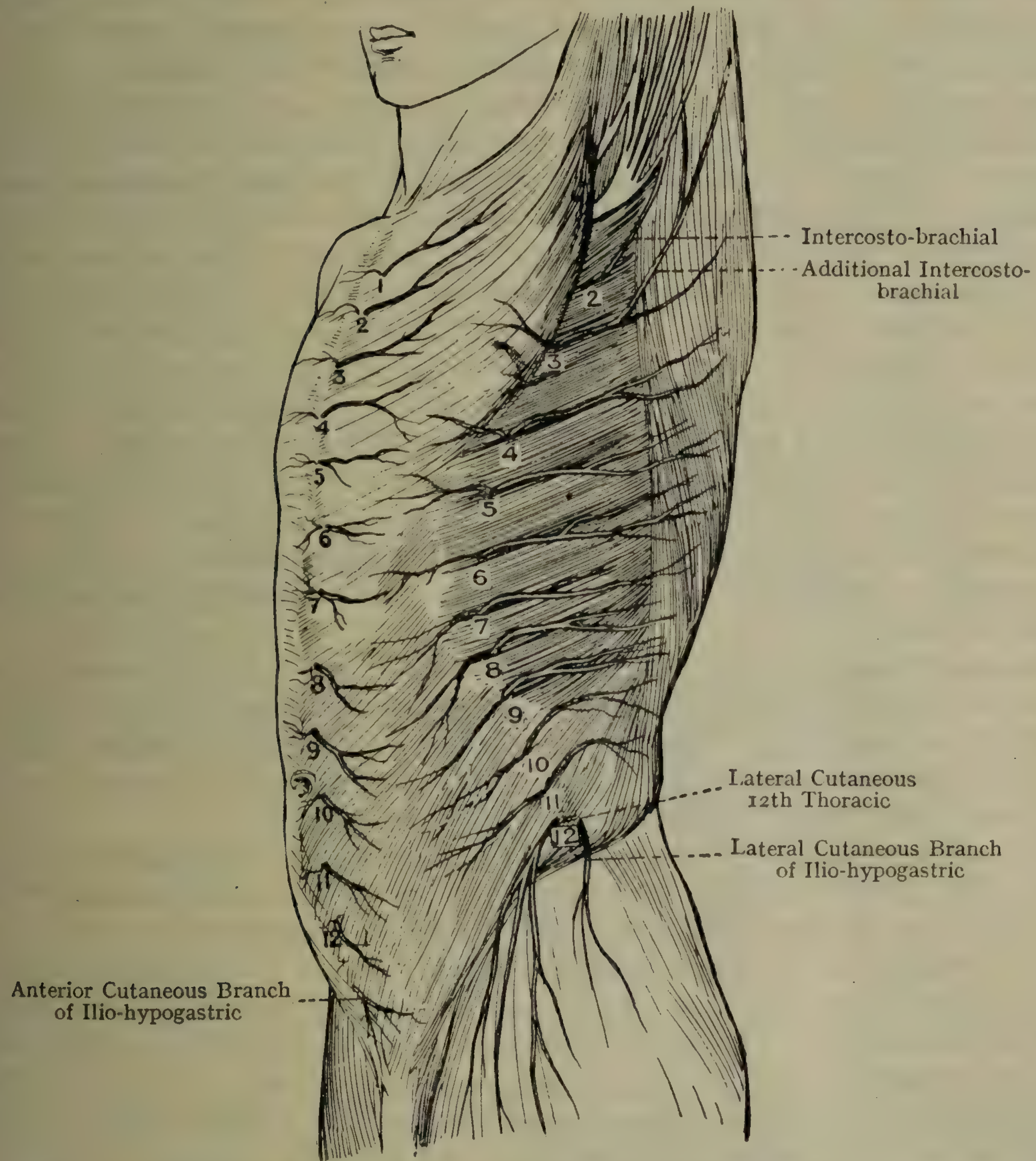


FIG. 257.—CUTANEOUS NERVES OF THE TRUNK (ANTERO-LATERAL VIEW) (AFTER HENLE).

1-12, anterior cutaneous; 2-12, lateral cutaneous.

skin covering the pectoralis major. The branch of the first intercostal nerve is sometimes absent.

The lateral cutaneous nerves are branches of the intercostal nerves from the third to the sixth inclusively. The first intercostal nerve has no lateral cutaneous branch. The lateral cutaneous of the second intercostal nerve is the intercosto-brachial nerve, which crosses the

axillary space to the arm. The succeeding lateral cutaneous nerves escape from their respective intercostal spaces by passing through the external intercostal muscles not far from the lower border of the pectoralis major. Each divides into anterior and posterior branches, which pass out between the digitations of the serratus anterior, the two being separated, each from the other, by a slight interval. The *anterior branches* wind round the lower border of the pectoralis major, and supply skin in the pectoral region; the *posterior branches* pass backwards, and supply the skin on the side wall of the chest.

The anterior and lateral cutaneous nerves are accompanied by arteries, the anterior being the perforating branches of the internal mammary, and the lateral being branches of the intercostal arteries.

Fascia.—The **superficial fascia** is continuous over the clavicle with the superficial fascia of the neck, and is noteworthy in two respects. In the first place, just below the clavicle it has a faintly reddish colour, due to the fact that over the clavicular portions of the pectoralis major and deltoid it contains fibres of the platysma, which can be seen on incising it. In the second place, in the region of the mammary gland it divides into two laminæ, which ensheathe that gland. From these laminæ processes pass into the substance of the gland supporting its lobes. From the anterior lamina fibrous bands pass to the skin, these being known as the **ligamenta suspensoria of Cooper.** Inferiorly the superficial fascia is continuous with that covering the anterior abdominal wall.

The **deep fascia** is thin and membranous, and closely invests the pectoralis major. Superiorly it is attached to the front of the clavicle, medially it is fixed to the front of the sternum, laterally it is continuous with the deep fascia over the deltoid, and inferiorly at the lower border of the pectoralis major it joins the axillary fascia.

The **axillary fascia** stretches from the anterior to the posterior fold of the axilla, and forms the floor of the space. It is continuous in front with the deep pectoral fascia, and behind it blends with the deep fascia covering the latissimus dorsi. Laterally it is continuous with the deep fascia of the arm, and medially with the fascia covering the serratus anterior. It domes upwards into the axilla, its convexity being maintained by the deep pectoral fascia (*vide* p. 420). The axillary fascia is not a continuous membrane, but exhibits deficiencies through which the superficial fascia of the pectoral region is directly continuous with the fatty tissue filling the axillary space.

The Mammary Gland (Fig. 258) is situated on the surface of the pectoralis major. It is somewhat hemispherical, and extends vertically from the second to the sixth rib, and transversely from the side of the sternum to the anterior fold of the axilla, except below and laterally, where it extends beyond that fold and rests upon the serratus anterior and external oblique muscles. There is no fat beneath the nipple and areola, the skin of these parts being provided with plain muscular tissue disposed circularly. The contraction of the muscle fibres compresses the veins, and erection of the nipple is the result. The summit

of the nipple is perforated by the openings of the lactiferous ducts. The skin of the areola presents a number of small projections due to sebaceous glands, known as the **glands of Montgomery.** The mamma is a compound racemose gland, which is composed of about twenty lobes, these in turn consisting of lobules all being embedded in a fibrous stroma. The entire gland is ensheathed by the splitting of the superficial pectoral fascia into two laminæ, which send processes into its interior supporting its component lobes. The posterior layer of the sheath is loosely connected to the deep pectoral fascia covering the pectoralis major, and occasionally deep processes of the gland penetrate into the substance of the muscle. The lobes are pyramidal, and their apices converge toward the nipple. Each lobe is distinct, and has its own duct. A lobe is composed of lobules, each lobule consisting

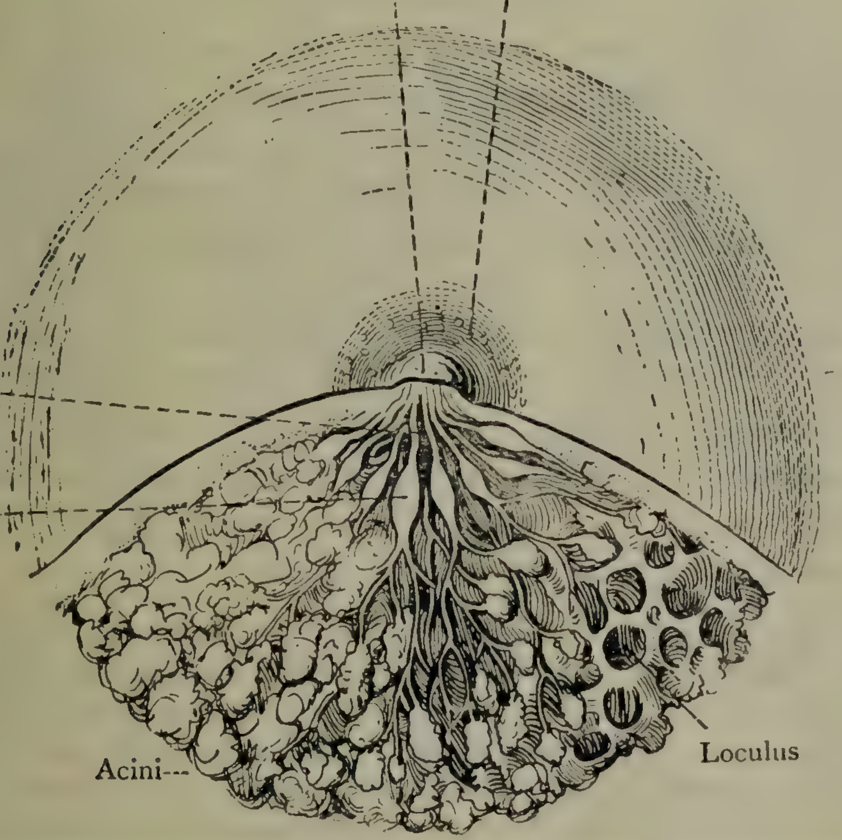


FIG. 258.—THE FEMALE MAMMA DURING LACTATION (AFTER LUSCHKA).

of a cluster of tubes, called **alveoli** or **acini,** which represent the secreting parts of the gland, and are lodged in spaces known as *loculi.* The alveolar tubes are lined with cubical epithelium, the cells of which contain fat globules during the period of the functional activity of the organ. The ducts of the lobes are about twenty in number, and are called the **lactiferous** or **galactophorous ducts.** They are lined with columnar epithelium, and as they approach the nipple each presents a dilatation, called the **sinus** or **ampulla.** Terminally each duct becomes narrow, and enters the nipple to open by a minute pore on its summit. The mammary glands are present in both sexes, but in the male their development is, as a rule, arrested, and they are in a rudimentary condition.

Bloodvessels of the Mamma.—The **arteries** are the external mammary

branches of the lateral thoracic artery from the second part of t axillary; the anterior cutaneous or perforating branches of the intern mammary; and branches from the intercostal arteries.

The **veins** join the axillary and internal mammary veins.

Lymphatics.—The **principal lymphatic vessels** of the mamma gland arise in the fibrous stroma, lie between the galactophoro ducts, and converge towards the nipple. In the region around t nipple they terminate beneath the areola in a network, the **subareol plexus.** This plexus also receives the cutaneous lymphatics of t nipple and areola. The *efferent* vessels from this plexus pass to t *pectoral group* of **axillary glands,** more particularly to those on a lev with the *third rib.*

There are, however, other paths by which lymph is conveyed aw from the mammary gland. Some lymphatic vessels emerge from *abo the outer two-thirds* of the gland, and pass to the *pectoral group* of **axilla glands,** either directly, or after having joined the principal lymphatic Other vessels (one or more) draining the *deep* and *upper part* of t gland terminate in the **infraclavicular glands.** A third set of lymphati emerging from *about the inner third* of the gland pass backwards wi the perforating branches of the internal mammary artery through t intercostal spaces close to the edge of the sternum, and join the **med astinal glands.**

The Nerves are derived from the supraclavicular branch of t cervical plexus, and the anterior and lateral cutaneous branches the upper intercostal nerves.

Accessory mammæ are sometimes met with on the upper, lowe and inner outskirts of the main gland, more rarely in the axilla, o the anterior abdominal wall, or in the groin.

Structure of the Mamma.—The mammary gland belongs to the class acino-tubular or compound racemose glands. It consists of glandular tiss and a fibrous connective-tissue stroma, which together constitute a firm, ligh red mass, known as the *corpus mammæ.*

The **glandular element** is composed of large lobes, varying in number fro fifteen to twenty. There is no firm fibrous capsule, such as that possessed b the parotid salivary gland, but from the superficial pectoral fascia, within whic the mammary gland is embedded, fatty processes project between the lobe the fibrous tissue of these processes being continuous with the sustentacul tissue of the gland. Each lobe is tapering in outline, and is provided with i own duct, the various lobes being disposed in a radiating manner from th nipple.

A **mammary lobe** is composed of smaller lobes, each small lobe consisting a group of lobules, the structure of which furnishes the key to the structure the entire gland.

A **mammary lobule** consists of from one to three *acini,* provided with common duct. This duct is one of the radicles of the main duct of a give mammary lobe. The radicle duct breaks up into two or three somewhat dilate excretory passages, the walls of each of which are convoluted. This convolute character is due to the fact that the walls are distended into a series of pouche called *alveoli,* which beset all parts of the wall of the acinus, including its cæca end, thus giving it somewhat of the appearance of a grape—hence the nam *acinus.* The wall of each alveolus consists of a delicate basement membrane which is invested by capillary bloodvessels, and lined with cubical or shor

olumnar epithelium. From one to three acini constitute a lobule, and they are onsequently appendages of a lobular duct. Contiguous lobular ducts unite nd form the duct of a small lobe, and the contiguous ducts of small lobes unite nd form the duct of a large lobe. The number of main ducts corresponds to he number of main lobes—namely, from fifteen to twenty. They are referred o as the **lactiferous** or **galactophorous ducts.** The main lactiferous ducts *con-erge towards* the nipple. As they lie beneath the areola, each duct expands ıto a somewhat spindle-shaped dilatation, called the **ampulla** or **lactiferous inus,** which serves as a reservoir for the milk during lactation. Terminally, he duct becomes narrow, and having traversed the nipple, opens upon its summit t the bottom of a small depression or *foveola*. The orifice of the duct is of maller size than the excretory tube leading to it. The arrangement of orifices t the summit of the nipple may be compared to the arrangement of the orifices f the excretory tubes of the kidney at the apex of a Malpighian pyramid.

The walls of the ducts consist of areolar and elastic tissue, and they are lined ith columnar epithelium. The elastic tissue is disposed both longitudinally nd in a circular manner.

FIG. 259.—SECTIONS ACROSS MAMMARY RIDGES AT 8 AND 12 MM.
Other two sections show slow enlargement during second and third months.

Development of the Mammary Glands.—The mammary glands are of *ecto-ermic origin*. In the course of the second month of intra-uterine life a **circular hickening of the epidermis** (ectoderm) makes its appearance in the region of he future gland. This thickening projects into the subjacent mesoderm, and he superficial central cells of the thickening being shed the thickened area is ow depressed. From the deep surface of the thickened ectodermic area solid olumns of cells grow into the subjacent mesoderm and give off lateral branches. hese cell columns become hollow, and form the **lactiferous** or **galactophorous ucts,** which open upon the area corresponding to the circular thickening of pidermis. The lateral offshoots of the cell columns give rise to the **lobes, obules,** and **alveoli** or **acini** of the gland, each lateral offshoot thus giving rise o a mammary gland in miniature.

The **nipple** and **areola** are developed from the glandular area—that is to ay, the area of the original thickening of epidermis. The depression of this rea disappears, and its central portion becomes elevated to form the **nipple.** his contains the terminal parts of the lactiferous ducts, bloodvessels, and onnective tissue. The remainder of the glandular area forms the **areola.** he corium corresponding to the nipple and areola is provided with unstriped ıuscular tissue.

The **connective-tissue stroma** of the gland is developed from *mesoderm* into hich the outgrowths penetrate.

Pectoralis Major (Fig. 260)—*Origin.*—The anterior surface of th inner part of the clavicle, and the anterior sterno-clavicular ligament the anterior surface of the sternum as low as the xiphoid process the anterior surfaces of the upper six costal cartilages, and slightl from the bony part of the sixth rib; and the upper portion of th aponeurosis of the external oblique.

Insertion.—The lateral lip of bicipital groove of the humerus.

The muscle is subdivided by a more or less definite interval int two parts, an upper or *clavicular* and a lower or *sterno-costal.*

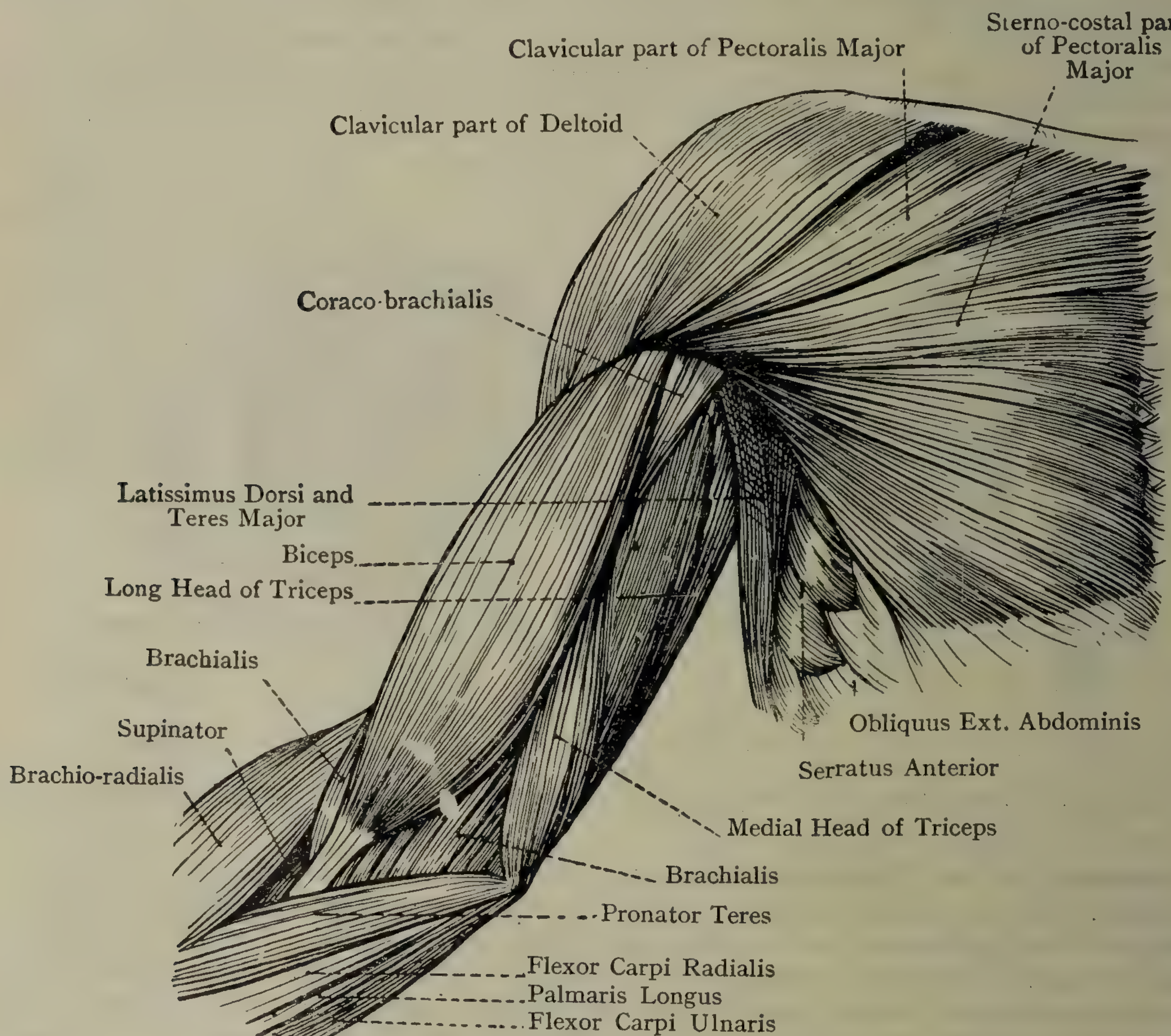
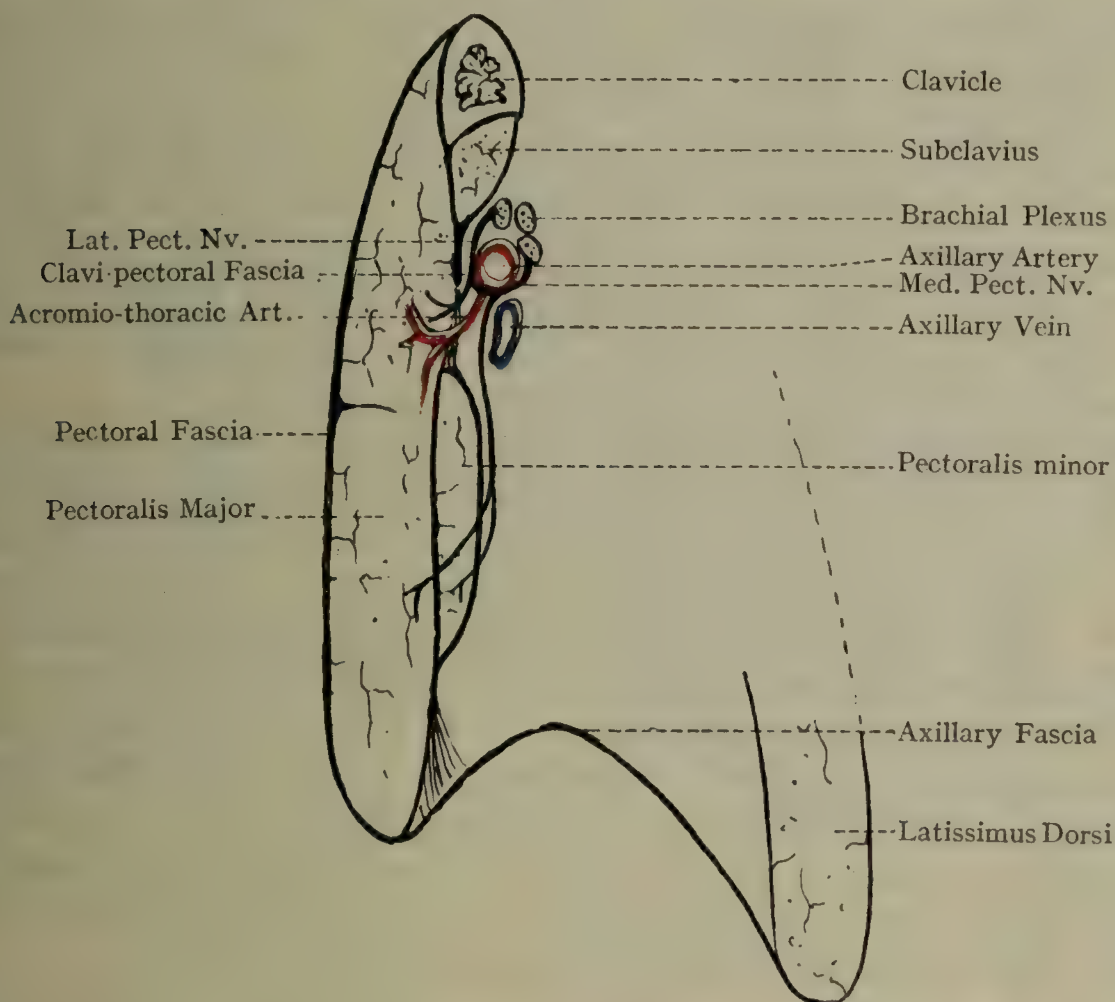


Fig. 260.—The Superficial Muscles of the Front and Inner Side of the Pectoral and Brachial Regions.

The tendon of insertion is so folded upon itself as to present in section the appearance of an inverted V, and is therefore composed of two layers, anterior and posterior, the former of which is vertically the shorter, the two being continuous with one another below. The *anterior layer* receives the sterno-costal fibres above the third costal cartilage, and superficially the clavicular fibres, which, descending to a lower level than the other fibres of the muscle, are intimately connected at their insertion with the tendon of the deltoid. The *posterior layer* receives all the fibres from the third costal cartilage downwards;

ese fibres, as they pass outwards and upwards, twist upon themselves, nd round the lower border of the muscle, and gain its deep aspect, here they ascend to the posterior layer of the tendon, the lowest res being continuous with its upper end, the highest fibres with its wer end. The posterior layer ascends on the outer bicipital lip to higher level than the anterior, and from its upper border a tendinous pansion spreads across the upper end of the bicipital groove, and tends upwards to the capsular ligament of the shoulder-joint. om the lower border of the tendon an expansion extends downwards the deep fascia of the arm.



G. 261.—A Diagrammatic Sagittal Section through the Anterior Wall of the Axilla to illustrate the Dispositions of the Deep Pectoral Fascia, the Clavi-pectoral Fascia, and the Structures traversing the Latter.

Nerve-supply.—The lateral pectoral from the lateral cord of the achial plexus (its fibres coming from the fifth, sixth, and seventh rvical nerves)—the branches of this nerve enter the deep surface of e clavicular and upper sterno-costal portions; and the medial pectoral, e branches of which enter the deep surface of the sterno-costal portion, ter having passed though the pectoralis minor.

The upper fibres pass downwards and outwards, the middle trans-rsely outwards, and the lower upwards and outwards.

Action.—Adducts the arm and rotates it inwards. The clavicular rtion pulls the arm forwards, or flexes the shoulder-joint. If the n is fixed, it can raise the trunk, this action coming into play when

climbing a pole; it can also elevate the upper ribs, and is one of th muscles concerned in forced inspiration.

The upper border of the muscle is related to the deltoid, from whicl it is separated by a triangular interval for a short distance below th clavicle, the cephalic vein, the deltoid branch of the acromio-thoraci artery, and the infraclavicular glands intervening between the two.

A small variable muscle, the **sternalis,** is sometimes present on one or bot sides. It is more or less vertically disposed, lying in front of the pectorali major, close to the sternum. Its disposition and attachments are very in constant.

The Deep Pectoral Fascia (Fig. 261) is situated on the deep aspec of the pectoralis major, taking part in the formation of the deep laye of its sheath. Above it consists of two layers ensheathing the sub clavius, and attached to the anterior and posterior lips of the sub clavian groove on the inferior surface of the clavicle. A single laye between the subclavius above and the pectoralis minor below it en sheathes the latter muscle, and is thence prolonged downwards fron its lower border to the axillary fascia, with which it blends. The lowe part is known as the *suspensory ligament* of the axilla.

The Clavi-pectoral Fascia is that part of the deep pectoral fasci which occupies a triangular interval (Fig. 264), bounded above by th subclavius, below by the upper edge of the pectoralis minor, and a the apex of which is the coracoid process. The upper part of th membrane is thick and resistant, and presents, when artificially de fined, a well-marked curved lower edge arching from the sternal en of the first rib to the coracoid process. This arched band is know as the *costo-coracoid ligament.* Below the costo-coracoid ligamen the membrane is loose and fatty; here the cephalic vein, the acromio thoracic artery, the lateral pectoral nerve, and lymphatic vessels pas through it. The clavi-pectoral fascia lies in front of the axillar vessels, with the sheath of which it is continuous.

The **costo-coracoid ligament** may represent the ventral end of the coracoi bar, the dorsal end of which persists as the coracoid process.

Pectoralis Minor (Fig. 262)—*Origin.*—The upper borders and oute surfaces of the third, fourth, and fifth ribs near their anterior ex tremities, as well as from the fascia covering the adjacent externa intercostal muscles.

Insertion.—The antero-medial border of the coracoid process o the scapula and the adjacent portion of its upper surface.

Nerve-supply.—The medial pectoral nerve, a branch of the media cord of the brachial plexus, its fibres being derived from the eightl cervical and first thoracic nerves. The branches of the nerve ente the muscle on its deep surface, and a few of them pass through it t enter the deep surface of the pectoralis major.

It is a triangular muscle, the direction of which is upwards an outwards.

Action.—Draws the scapula downwards and forwards, depressin

the point of the shoulder. If the shoulder is fixed it raises the ribs, and is thus concerned in forced inspiration.

Subclavius—*Origin.*—By a rounded, tapering tendon from the upper surface of the first rib at its junction with its cartilage.

Insertion.—The subclavian groove on the under surface of the

FIG. 262.—THE GREATER PART OF PECTORALIS MAJOR HAS BEEN REMOVED, AND THE CUT TENDON TURNED FORWARD, TO EXPOSE PECTORALIS MINOR IN POSITION IN THE FRONT WALL OF THE AXILLARY SPACE.

Only muscles are shown.

clavicle, extending from the rhomboid impression medially to an interval between the conoid tubercle and trapezoid line laterally.

Nerve-supply.—The nerve to the subclavius, which arises from the front of the upper trunk of the brachial plexus, its fibres being derived from the fifth cervical. The nerve descends from the neck behind the clavicle, and enters the deep surface of the muscle.

It is a prismatic muscle directed obliquely upwards and outwards.

Action.—Depresses the clavicle.

The Axillary Space is situated between the upper part of the arı and upper part of the thoracic wall. In form it is a four-sided pyrami and presents an apex, a base or floor, and four walls—anterior, posterio inner, and outer. It is of much greater extent towards the thorac wall than towards the arm, as the anterior and posterior walls converg from the former to the latter. The **apex** is the narrowest part of th space, is truncated, and is directed upwards towards the root of the necl It is a small triangular space lying between the clavicle, the first ri and the upper border of the scapula. The **base** or **floor** is of coı siderable extent, and is formed by the axillary fascia, superficial fasci and skin. The **anterior wall** is formed by the pectoralis major, togethe with the fascia ensheathing the subclavius and pectoralis minor. Tl **posterior wall** is formed from above downwards by the subscapulari teres major, and latissimus dorsi. The posterior wall in vertical exter

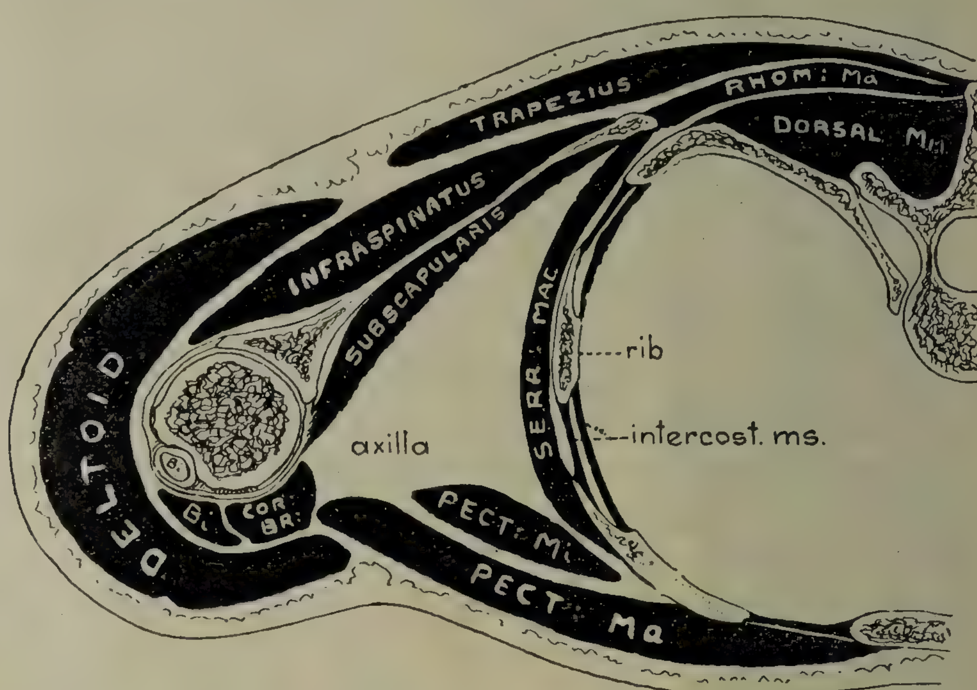


FIG. 263.—SCHEME OF A HORIZONTAL SECTION THROUGH THE AXILLA TO ILLUSTRATE THE CHIEF STRUCTURES CONSTITUTING ITS FOUR WALLS.

is longer than the anterior. The **inner wall** is formed by the uppe four or five ribs, with their intercostal muscles between them, thes structures being covered on their axillary aspect by the serratus anteric muscle. The **outer wall** is very narrow, and is formed by the uppe part of the shaft of the humerus, clothed by the coraco-brachialis an short head of the biceps.

Contents.—The axillary vessels and the main nerve trunks gain th axilla by passing through the triangular interval representing it truncated apex. In the upper part of the space these structures li immediately behind the anterior wall. As they extend downwarc to the arm they cling to the outer wall, but, relatively to the spac incline backwards, and in its lower part are in contact with the posteric wall. The acromio-thoracic and the lateral thoracic arteries are i close relation with the anterior wall, the former above the pectoral minor, the latter follows the lower border of the muscle. The sul

scapular artery lies on the posterior wall, and follows the lower border of the subscapularis. The anterior and posterior circumflex arteries are in relation with the posterior wall, but soon leave the space, the latter passing backwards between the subscapularis and teres major, the former passing outwards in front of the humerus.

The lateral pectoral nerve passes through the clavi-pectoral fascia, and enters the deep surface of the pectoralis major. The medial pectoral nerve enters the deep surface of the pectoralis minor, some of its branches passing through it to the pectoralis major. The nerve to serratus anterior descends on the inner wall, lying on the serratus anterior. The intercosto-brachial nerve, escaping from the second

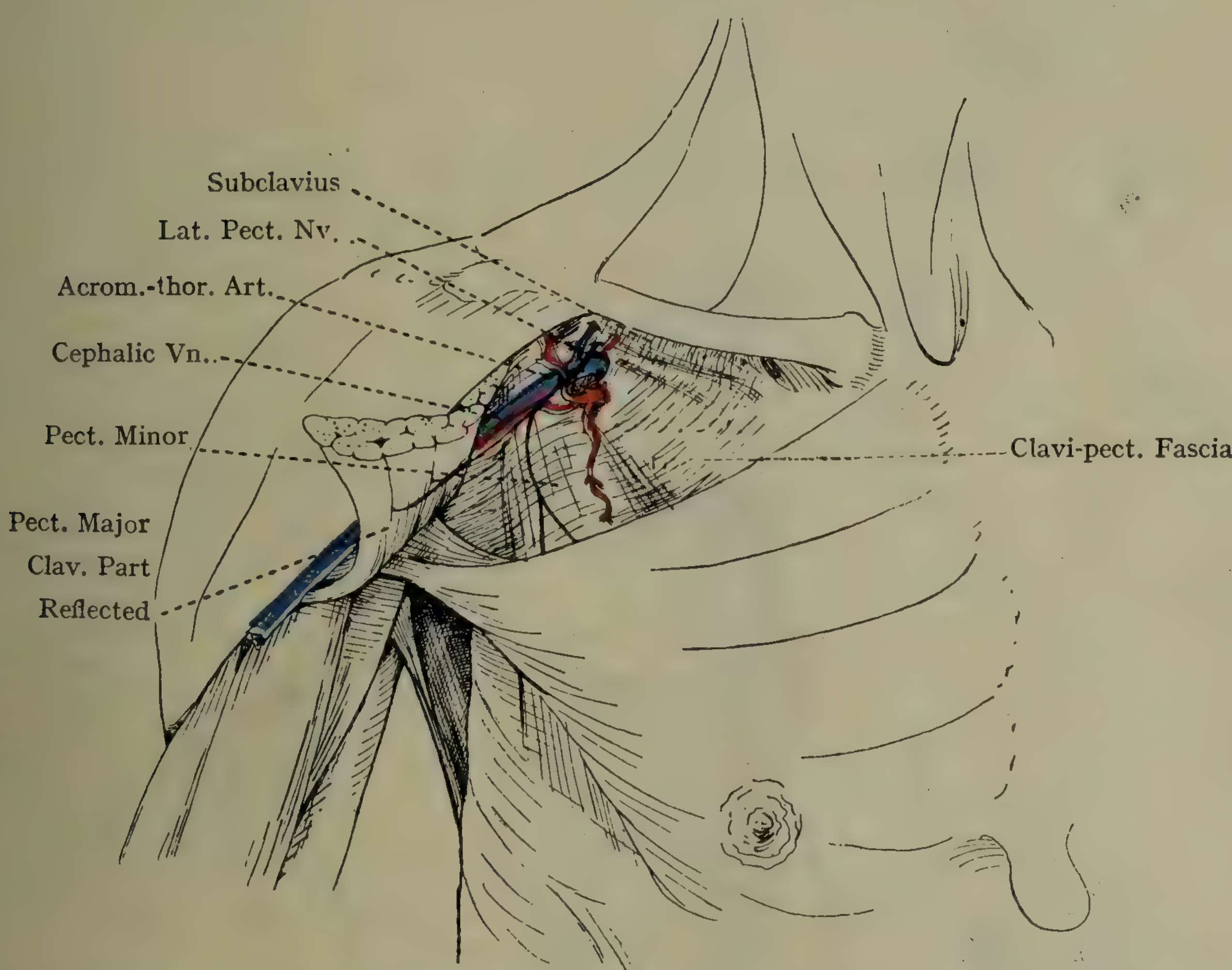


Fig. 264.—The Structures exposed to View on reflecting the Clavicular Part of the Pectoralis Major.

intercostal space, crosses the axilla to the inner side of the arm. At a lower level a branch of the lateral cutaneous of the third intercostal may also cross the axilla to the inner side of the arm. The two subscapular nerves and the nerve to latissimus dorsi lie upon the posterior wall, and supply the three muscles of which it is formed. The circumflex nerve accompanies the posterior humeral circumflex artery. The radial nerve descends behind the axillary artery. The median nerve is on the outer side of the main artery, and the ulnar nerve is medial to it, between it and the vein. The medial cutaneous nerve of arm is on the inner side of the vein, and the medial cutaneous nerve of forearm is usually in front of the main artery.

The **axillary lymphatic glands** are disposed in *four groups.* Th **lateral** or **humeral glands** are on the *outer wall,* in close relation wit the axillary vein. The **pectoral glands** follow the lateral thoraci

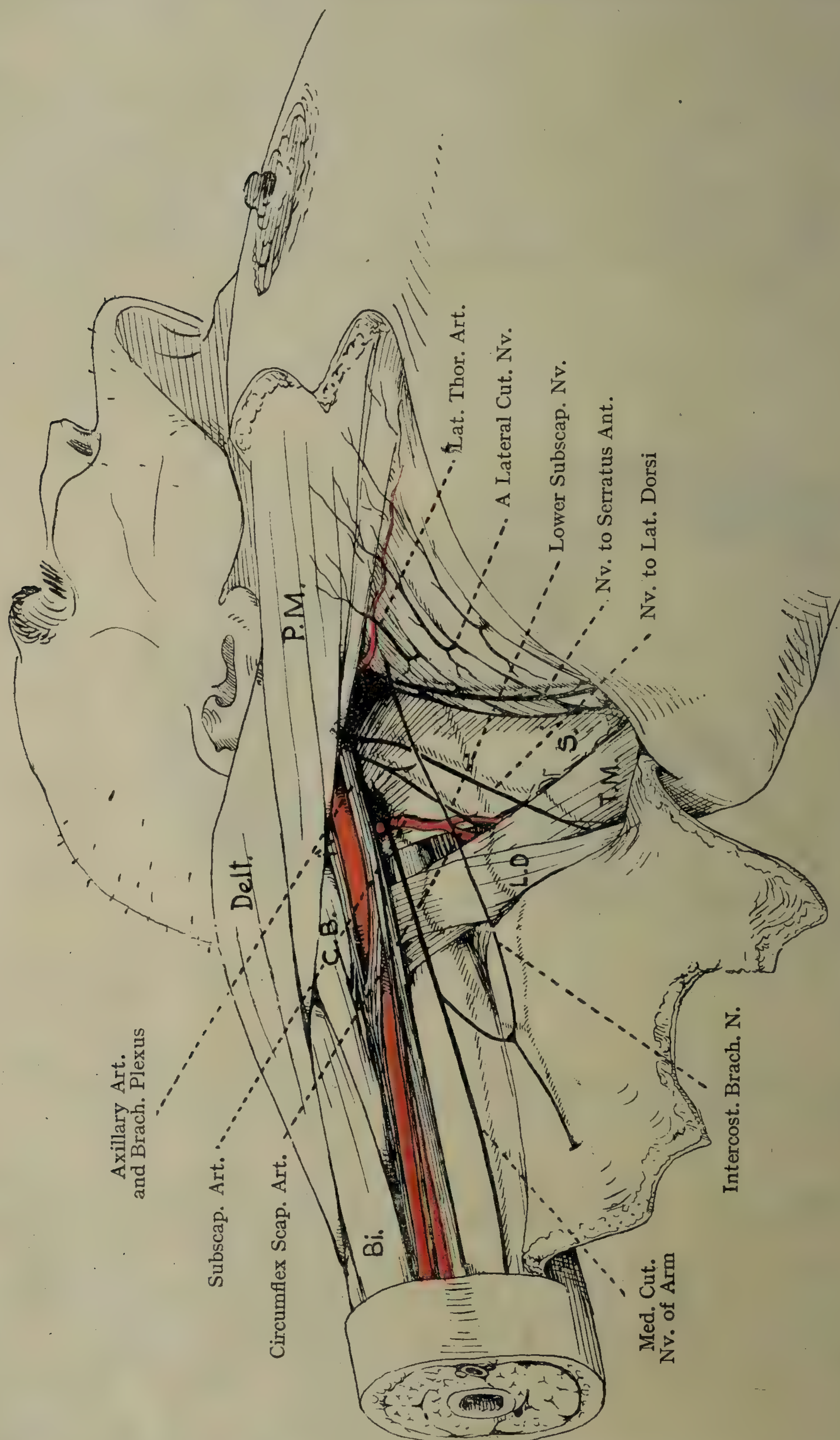


FIG. 265.—THE AXILLARY SPACE VIEWED FROM BELOW.

Bi., biceps; C.B., coraco-brachialis; Delt., deltoid; L.D., latissimus dorsi; P.M., pectoralis major; S., subscapularis; T.M. teres major.

artery at the *lower border of the pectoralis minor.* The **subscapular glands** are on the *posterior wall,* disposed about the subscapular artery. The **apical glands** are near *the apex* of the space.

The Axillary Artery is the continuation of the subclavian, and extends from the outer border of the first rib to the lower border of the teres major, where it becomes continuous with the brachial. When the arm is by the side of the trunk, the vessel describes a curve with the convexity upwards, but when the limb is abducted and is at right angles to the trunk, its course is almost straight. The artery is crossed in front by the pectoralis minor, and is thus conveniently divided into three parts.

The First Part extends from the outer border of the first rib to the upper border of the pectoralis minor.

Relations.—*Anteriorly* it is covered by the subclavius, the clavicular part of the pectoralis major, and the clavi-pectoral fascia. The

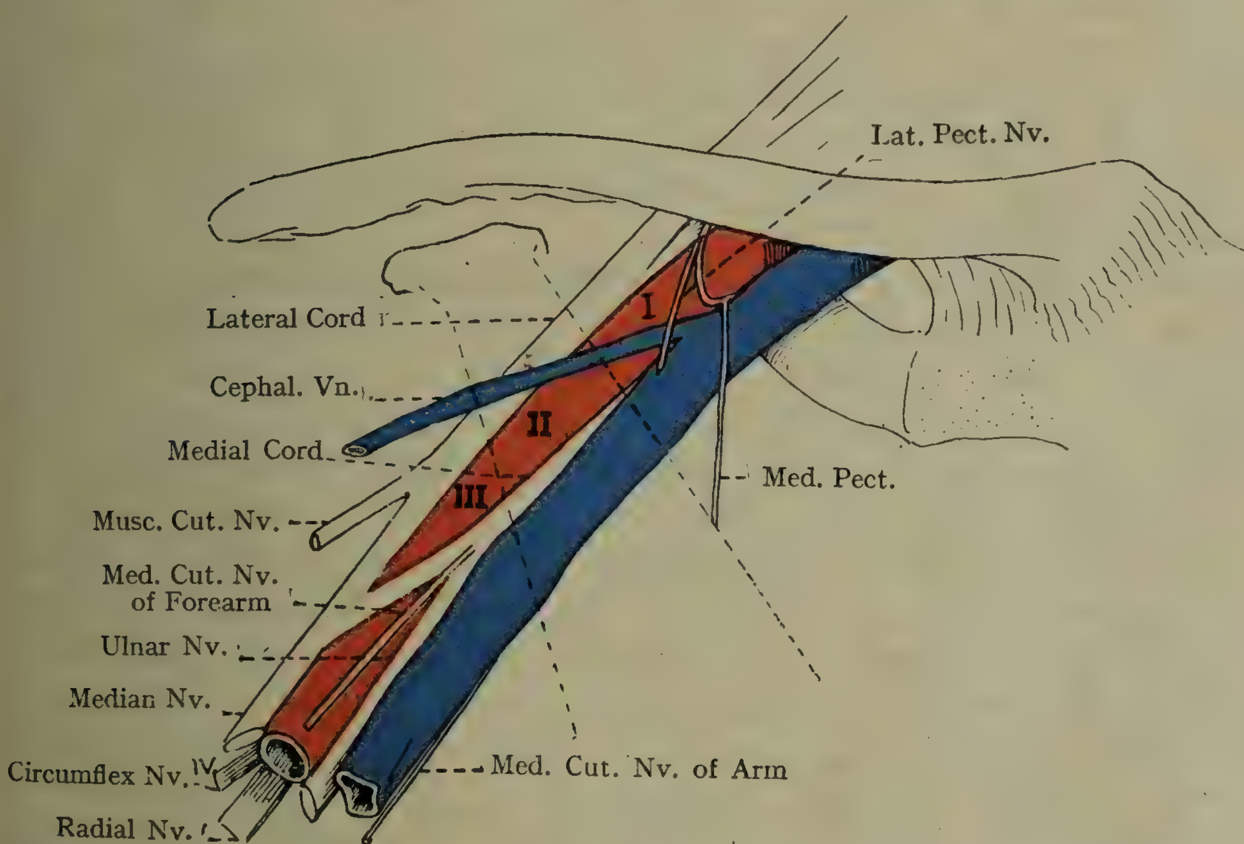


FIG. 266.—TO ILLUSTRATE THE RELATIONS OF VEINS AND NERVES TO THE AXILLARY ARTERY.

The two oblique dotted lines indicate the position of the pectoralis minor. I., II., and III. are placed on the three parts of the artery.

cephalic vein, some of the tributaries of the acromio-thoracic vein, and the communicating loop between the lateral and medial pectoral nerves, also lie in front of it. *Posteriorly* are the first intercostal space, the first digitation of the serratus anterior, the upper portion of the second rib, the nerve to serratus anterior and the medial pectoral nerve. *Laterally*, and above it, are the cords of the brachial plexus. *Below*, and slightly overlapping it, is the axillary vein.

The Second Part lies behind the pectoralis minor.

Relations.—*Anteriorly* are the pectoralis major and minor muscles. *Posteriorly* is the posterior cord of the brachial plexus, behind which is a quantity of fat separating the vessel from the subscapularis. *Laterally* is the outer cord of the brachial plexus. *Medially* are the

inner cord of the brachial plexus, medial pectoral nerve, and the axillary vein.

The Third Part is the longest part, and extends from the lower border of the pectoralis minor to the lower border of the teres major.

Relations.—*Anteriorly*, but at some little distance from it, is the pectoralis major. As the posterior wall of the axilla is longer than the anterior, its lower end escapes from under cover of the lower edge of the pectoralis major and is superficial, being covered in front by skin and fascial layers only. The medial root of the median nerve at a higher level and the medial cutaneous nerve of forearm at a lower level are in front of it. *Posteriorly* are the subscapularis, tendon of the latissimus dorsi, the teres major, the circumflex and radial nerves. *Laterally* are the coraco-brachialis muscle, the outer root of the median nerve, and the musculo-cutaneous nerve. *Medially* is the axillary vein. Between the axillary vein and the artery are the medial root of the median nerve, the ulnar nerve, and for a short distance the medial cutaneous nerve of forearm; medial to the vein is the medial cutaneous nerve of arm.

Branches of the First Part.—The **superior thoracic artery** is a small and somewhat variable branch, arising from the deep aspect of the axillary artery, and passing backwards to supply the structures occupying the first intercostal space; it may send branches to the second intercostal space. The **acromio-thoracic artery** is a short large trunk arising from the front of the axillary artery above the upper border of the pectoralis minor. It passes forwards through the clavi-pectoral fascia, and divides into *pectoral branches*, descending between and supplying the two pectoral muscles; *acromial branches* passing outwards deeply to the deltoid—some of them pass through the muscle and ramify on the upper surface of the acromion process, where they anastomose with branches of the suprascapular and posterior circumflex; *deltoid* (*descending humeral*) *branch* passes downwards and outwards with the cephalic vein between the pectoralis major and deltoid, to which muscles it is distributed; *clavicular branch* passes upwards to end in the subclavius.

The acromio-thoracic artery is sometimes described as arising deeply to the pectoralis minor, and consequently as a branch of the second part of the axillary artery. This misconception has arisen from the fact that when the arm is abducted and is at right angles to the trunk, the position in which the axillary space is studied in the dissecting room, the pectoralis minor is shifted upwards to a considerable extent and overlaps the origin of the vessels. In the anatomical position, however, with the arm hanging by the side of the trunk, the origin is some little way above the upper edge of the muscle.

Branches of the Second Part.—The **lateral thoracic artery** is directed downwards and inwards, following the lower border of the pectoralis minor to the thoracic wall. It is distributed to the pectoral muscles, serratus anterior, and intercostal muscles, and sends *external mammary branches* which wind round the lower border of the pectoralis major and supply the mammary gland. It supplies the pectoral group of

axillary glands, and anastomoses with branches of the aortic intercostals and internal mammary. The **alar thoracic artery** is distributed to the axillary glands. It is seldom an independent branch, and is usually represented by branches of the lateral thoracic and subscapular.

Branches of the Third Part.—The **subscapular artery,** the largest of all the branches, arises close to the lower border of the subscapularis, and, following this border to the lower angle of the scapula, anastomoses there with the deep branch of the transverse cervical artery. In the upper part of its course it is accompanied by the nerve to latissimus dorsi. In addition to branches to the muscles on the posterior wall, to the serratus anterior, and to the posterior group of axillary glands, it gives off close to its origin a large branch, the *circumflex scapular.* The **circumflex scapular** passes backwards through a triangular space bounded *above* by the subscapularis, *below* by the teres major, and *laterally* by the long head of the triceps. It winds round the lateral border of the scapula, grooving the bone, and after passing through the origin of the teres minor, reaches the infraspinous fossa, where it breaks up into numerous branches, which supply the infraspinatus muscle, and which anastomose with branches of the suprascapular and deep branch of transverse cervical. As it passes through the triangular space it furnishes an *infrascapular branch,* which ramifies in the venter of the scapula deeply to the subscapularis, and anastomoses with the ventral branches of the suprascapular and deep branch of transverse cervical. Before passing through the teres minor it gives off a *teres branch,* which, passing downwards between the teres major and minor to the lower angle of the scapula, anastomoses there with the deep branch of transverse cervical and subscapular arteries. The circumflex scapular sometimes arises directly from the axillary.

The **anterior humeral circumflex artery** is small, and arises from the outer side of the axillary artery a little below the subscapular artery, and opposite the posterior circumflex. It passes outwards in front of the surgical neck of the humerus deeply to the coraco-brachialis and short head of the biceps. On reaching the bicipital groove it gives off an *ascending* or *bicipital branch,* passing upwards in the groove lodging the long head of the biceps, and distributed to the shoulder-joint. Crossing the bicipital groove, it winds round the outer side of the bone, where it anastomoses with the posterior circumflex.

The **posterior humeral circumflex artery** is large, and arises from the back of the axillary a little below the subscapular. It passes backwards with the circumflex nerve through the quadrilateral space, bounded *above* by the teres minor (with the subscapularis in front), *below* by the teres major, *medially* by the long head of the triceps, and *laterally* by the surgical neck of the humerus. It winds round the surgical neck, and has many branches, some of which enter the deep surface of the deltoid. An *acromial branch* ascending deeply to the deltoid traverses the muscle, and reaches the upper surface of the acromion process, where it anastomoses with the suprascapular and

acromial branches of the acromio-thoracic. Other branches becom superficial at the hinder edge of the deltoid and supply the skin It anastomoses with the anterior circumflex on the outer side of th humerus, completing an arterial circle embracing the surgical neck A branch passes downwards between the long and outer heads of th triceps, and anastomoses with the profunda branch of brachial artery

The posterior humeral circumflex artery is subject to certain variations. I may arise in common with the subscapular or with the profunda; in the latte

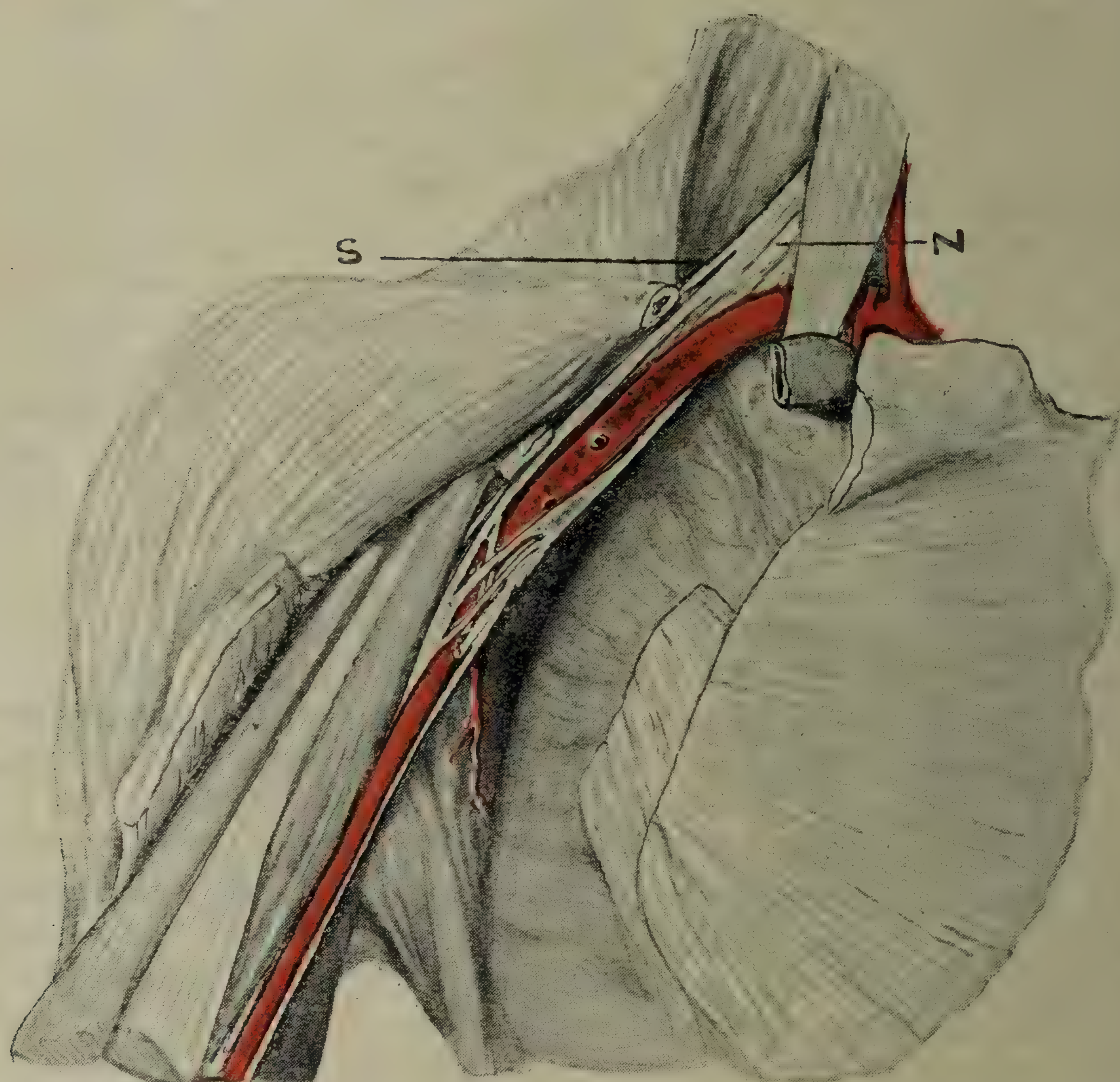


FIG. 267.—AXILLA VIEWED FROM THE FRONT AFTER REMOVAL OF FRONT WALL. Axillary vein and most branches of the artery cut away. To show relations of nerves to artery and of both to the axillary walls.

case it ascends behind the teres major. It may give off the anterior circumflex, profunda, or circumflex scapular.

Varieties of the Axillary Artery.—The subscapular, circumflex, and profunda of the brachial may arise by a common trunk. The artery may give origin to a large branch, which, extending down to the forearm, may be continuous with the radial, the ulnar, or the common interosseous artery.

The Axillary Vein is mainly the continuation upwards of the basilic vein, but results from the somewhat variable junctions of this vein and the two venæ comites of the brachial artery. As a rule the basilic vein is joined by the medial vena comes at the lower border of the teres

major. As the common trunk resulting therefrom is joined at a higher level by the lateral vena comes the axillary vein is somewhat shorter than its companion artery. Its tributaries correspond with the branches of the axillary artery, with the exception of the acromio-thoracic vein, which joins its upper end in common with the cephalic vein.

Axillary Sheath.—The axillary vessels and the brachial plexus of nerves are enclosed in a sheath of loose connective tissue, which is continuous above with the deep cervical fascia, and blends with the deep aspect of the clavi-pectoral fascia.

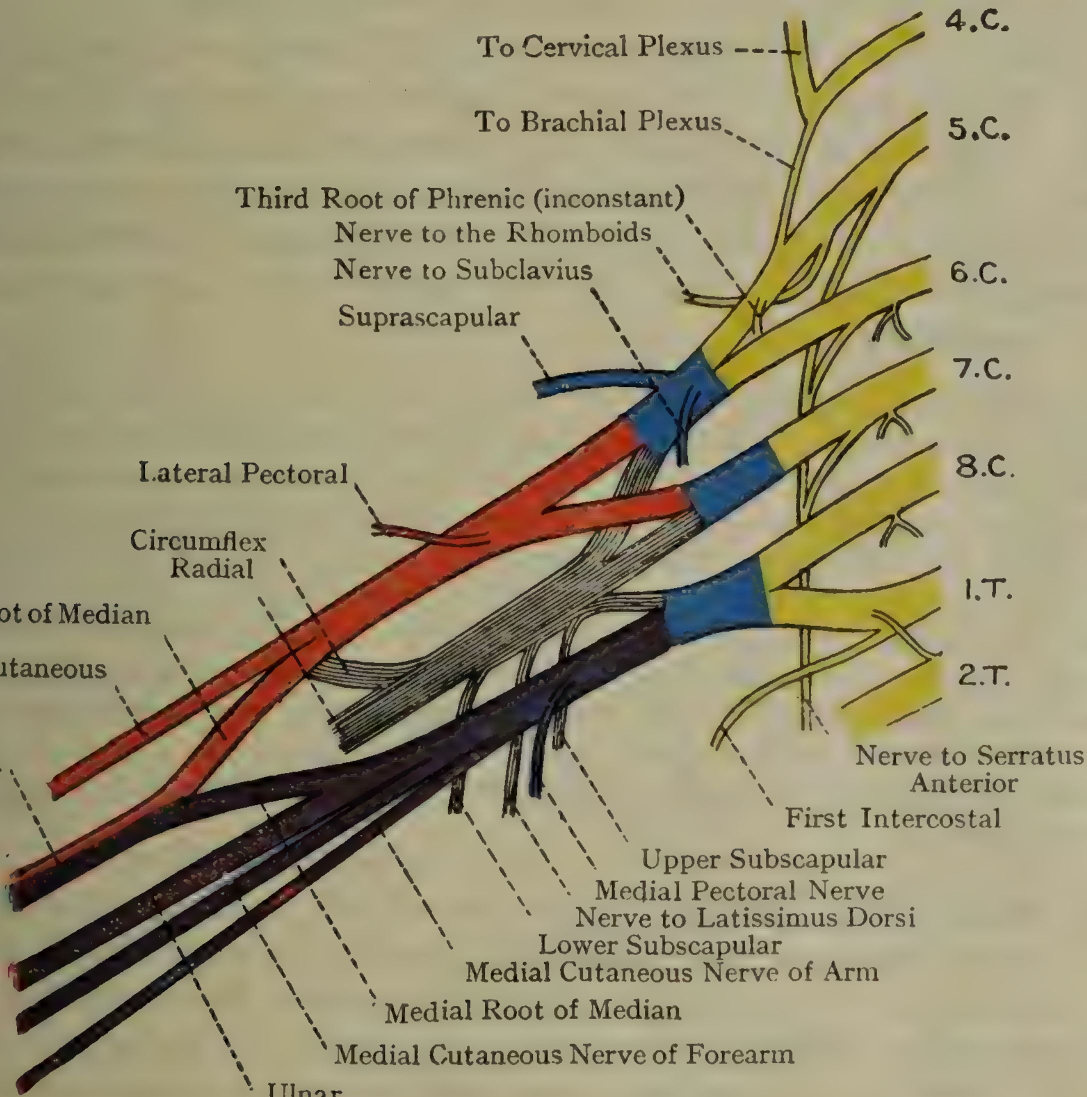


FIG. 268.—THE BRACHIAL PLEXUS.

Yellow=spinal nerves and their branches; blue=trunks; red=lateral cord; purple=medial cord; grey=posterior cord.

Brachial Plexus (Fig. 268).—The brachial plexus is situated in the lower part of the posterior triangle of the neck, and extends downwards behind the clavicle into the upper part of the axilla. It is a complicated network of nerves, the arrangement of which may be described in four stages—namely: (1) nerve roots, (2) nerve trunks, (3) divisions of the nerve trunks, and (4) nerve cords.

First Stage.—The plexus is derived from the anterior primary divisions of the fifth, sixth, seventh, and eighth cervical, and the first thoracic spinal nerves. Superiorly the plexus is reinforced by a small descending branch from the fourth cervical, joining the fifth, and inferiorly is occasionally reinforced by a branch from the second

thoracic, joining the first. The continuation of the anterior primary division of the first thoracic nerve, after giving off the lowermost root of the plexus, is the first intercostal nerve. The roots of the plexus lie between the scalenus anterior muscle in front and the scalenus medius behind.

Second Stage.—The fifth and sixth cervical nerves join at the outer border of the scalenus anterior to form the **upper trunk**; the seventh cervical is prolonged independently as the **middle trunk**; and the eighth cervical, together with the contribution from the first thoracic, unite between the scalene muscles to form the **lower trunk.**

Third Stage.—A little above the clavicle each of the three trunks subdivides into an anterior or ventral and a posterior or dorsal division.

Fourth Stage.—The anterior divisions of the upper and middle trunks unite to form the **lateral cord** of the plexus; the anterior division of the lower trunk is relatively large, and forms the **medial cord**; all three posterior divisions (that of the lower trunk being small) unite to form the **posterior cord.**

As a variety, the anterior division of the middle trunk may subdivide into two branches, one entering the outer cord and the other the inner. The fusions between the nerve roots to form the three trunks may be interpreted as a concentration at the root of the limb of the successive contributions from the spinal nerves destined for the limb. The cleavage into divisions is a primary rearrangement of the nerve fibres into two sets, *posterior* and *anterior*, the posterior fibres being gathered together into the posterior cord, which is posterior in position, and whose branches are distributed to the muscles (extensor) and skin disposed on the *posterior* aspect of the limb, the anterior fibres being prolonged into the lateral and medial cords, which are anterior in position, and their ultimate branches distributed to the muscles (flexor) and skin on the *anterior* aspect of the limb.

Branches of the Plexus.—The branches may be conveniently classified into two groups: *Supraclavicular* branches of the nerve roots or of the nerve trunks arising above the level of the clavicle; *collateral* branches arising from the three nerve cords before their final subdivision; *terminal* branches, into which the nerve cords ultimately subdivide.

Supraclavicular Branches.—The **lowermost root** of the **phrenic nerve** (inconstant) is a branch of the fifth cervical.

The Nerve to the Rhomboids (**Posterior Scapular Nerve**) (Fig. 269) arises from the back of the fifth cervical close to, or in common with, the highest root of the nerve to serratus anterior; it passes backwards and outwards through the scalenus medius.

The Nerve to Serratus Anterior (**Nerve of Bell**) arises by three roots from the back of the fifth, sixth, and seventh cervical nerves. The upper two roots pass through the scalenus medius, and appear at its outer edge below the nerve to the rhomboids; the lowest root passes in front of the scalenus medius, and joins the trunk formed by the others near the first rib. The nerve passing downwards behind the first part of the axillary artery descends into the axilla, where it lies upon the axillary surface of the serratus anterior, which it supplies.

The Nerve to the Subclavius is a small branch arising from the ront of the upper trunk, its fibres being derived from the fifth cervical. [t descends in front of the third part of the subclavian artery, and, passing behind the clavicle, enters the deep aspect of the subclavius nuscle. This nerve sometimes communicates with the phrenic nerve.

The Suprascapular Nerve is a large nerve arising from the back of the upper trunk, its fibres being derived from the fifth and sixth cervical. It is directed downwards, outwards, and backwards, ying deeply to the trapezius and nferior belly of the omo-hyoid, to he upper border of the scapula, where it comes into relation with he suprascapular artery. It is listributed to the supraspinatus, ntraspinatus, and shoulder-joint.

Infraclavicular Branches.—The **ateral pectoral,** a branch of the ateral cord, derives its fibres from he fifth, sixth, and seventh cervical nerves. It descends in front of the first part of the axillary artery, communicates with the nedial pectoral, and, traversing he clavi-pectoral fascia, is finally listributed to the upper part of he pectoralis major.

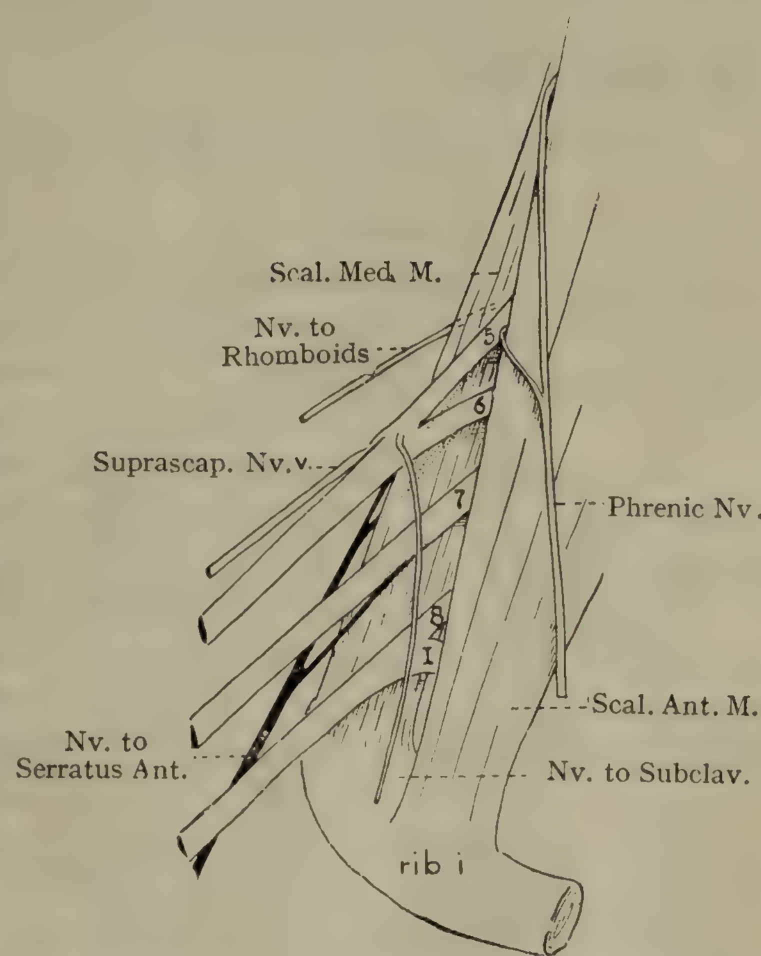


FIG. 269.—THE SUPRACLAVICULAR BRANCHES OF THE BRACHIAL PLEXUS.

The **medial pectoral nerve,** a branch of the medial cord, derives its fibres from the eighth cervical and first thoracic. It descends behind the first part of the axillary artery, and then passes forwards between the artery and the axillary vein. It receives a branch rom the lateral pectoral nerve, with which it forms a loop disposed in ront of the first part of the artery. Its terminal branches enter the deep surface of the pectoralis minor; a few of them pierce that muscle and enter the deep surface of the pectoralis major.

The three **subscapular nerves** are branches of the posterior cord. The **upper** subscapular is a small nerve which derives its fibres from he fifth and sixth cervical. It is situated high up on the posterior wall of the axilla, and enters the upper part of the subscapularis. The **middle, the nerve, to latissimus dorsi** derives its fibres chiefly from he seventh cervical, but also from the sixth and eighth. It descends along with the subscapular artery to the latissimus dorsi, which it supplies. The **lower** subscapular nerve derives its fibres from the ifth and sixth cervical. Near the lower border of the subscapularis t breaks up into branches, some of which enter the lower part of that nuscle; others end in the teres major.

Terminal Branches of the Lateral Cord.—The **musculo-cutaneous nerve** derives its fibres from the fifth, sixth, and seventh cervical, and arises about the level of the pectoralis minor. It lies for a short distance on the outer side of the axillary artery, but passing downwards and outwards it leaves the vessel, and traverses the coraco-brachialis, giving a branch to the muscle before reaching it. The fibres of this branch are derived from the seventh cervical nerve.

This is the usual arrangement in the adult, but in the young subject the nerve to the coraco-brachialis is frequently an independent branch of the lateral cord of the plexus.

The **lateral root of the median** lies on the outer side of the axillary artery, and is there joined by the inner root.

Terminal Branches of the Medial Cord.—The **medial cutaneous of arm** (**lesser internal cutaneous**) derives its fibres from the first thoracic. It first lies behind the axillary vein, but descends to its inner side. It communicates with the intercosto-brachial nerve, and is sometimes absent.

The **medial cutaneous of forearm** (**internal cutaneous**) derives its fibres from the eighth cervical and first thoracic, and descends partly in front of the axillary artery and partly to its inner side.

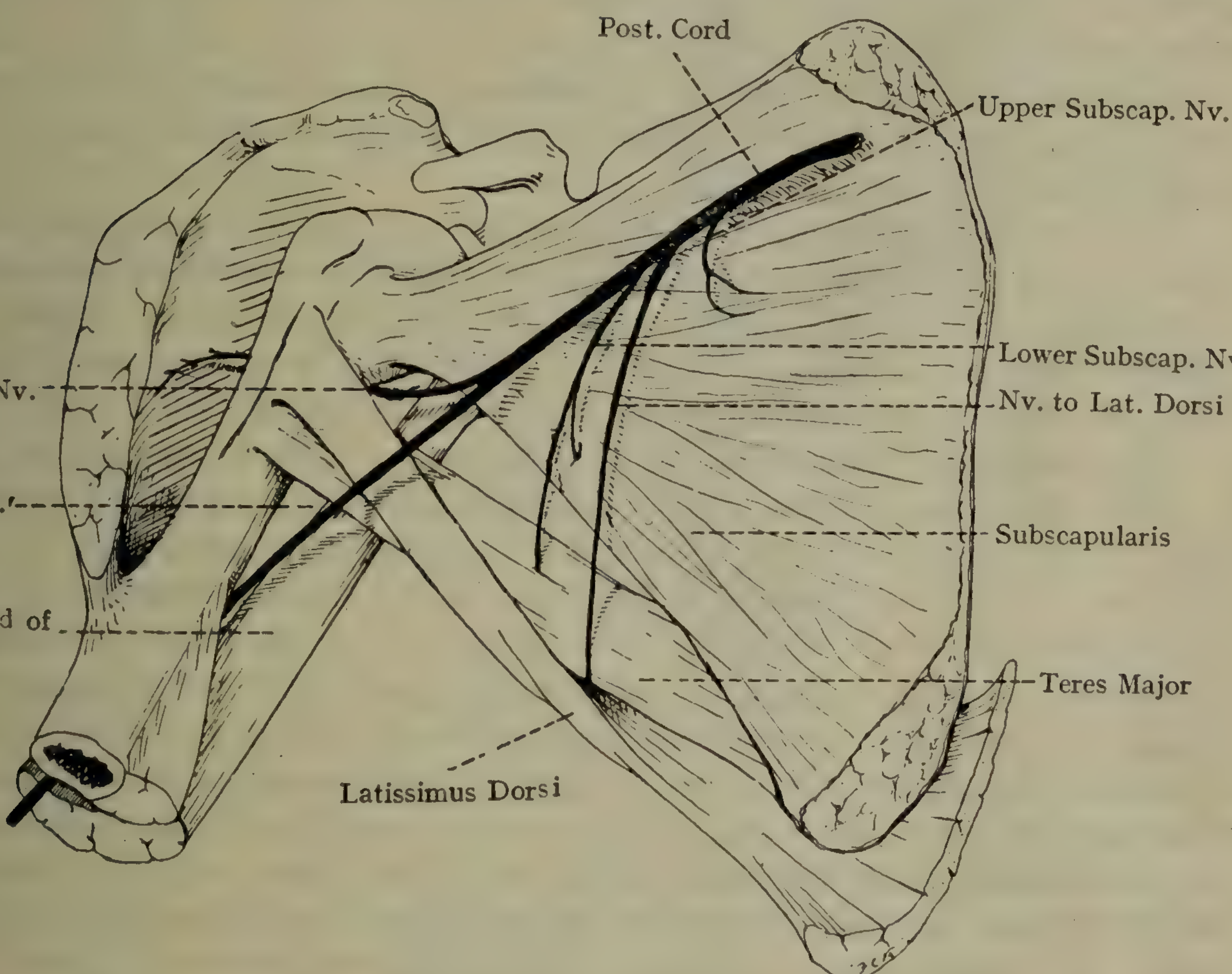
The **medial root of the median** is smaller than the outer, and passes obliquely across in front of the axillary artery to join the outer root a little below the lower border of the pectoralis minor. The trunk of the nerve, which derives its fibres from all the nerves of the plexus, descends on the outer side of the third part of the artery.

The **ulnar nerve** derives its fibres from the eighth cervical and first thoracic, and is the largest branch of the inner cord, of which it is the continuation. It appears at the lower border of the pectoralis minor, and descends, lying deeply to the inner side of the third part of the axillary artery, between it and the vein.

Terminal Branches of the Posterior Cord.—The **circumflex nerve** (Fig. 264) derives its fibres from the fifth and sixth cervical nerves. It lies at first behind the axillary artery, resting on the subscapularis, but at the lower border of that muscle it passes backwards through the quadrilateral space in company with the posterior humeral circumflex artery. In this situation (Fig. 273) it supplies an *articular branch* to the shoulder-joint, and divides into anterior and posterior divisions. The *anterior division* accompanies the posterior humeral circumflex artery, and divides into a number of branches which enter the deep surface of the anterior part of the deltoid. Some of the branches traverse the muscle and supply the skin over its anterior part. The *posterior division* gives branches to the posterior part of the deltoid, a branch to the teres minor, and the upper lateral cutaneous nerve of arm, which, winding round the posterior border of the deltoid, are distributed to the skin covering the hinder part of the muscle and the back of the arm. The nerve to the teres minor presents a small swelling, having the appearance of a ganglion, but which is really a fibrous thickening.

In connection with the distribution of the circumflex nerve, **Hilton's law,** although not universally applicable, may be here stated: *a nerve trunk supplying a given joint also supplies the muscles moving that joint, and the skin covering their insertions.* For example, the circumflex nerve supplies the shoulder-joint, the deltoid, and the skin covering its insertion.

The **radial (musculo-spiral) nerve** (Fig. 270), the largest of all the branches of the plexus, is the continuation of the posterior cord. It derives its fibres from the last four cervical nerves, and sometimes from the first thoracic as well. It descends behind the third part of the axillary artery, resting upon the subscapularis, latissimus dorsi, and teres major. In the axillary space it gives off muscular and cutaneous branches.



IG. 270.—SCHEME TO ILLUSTRATE THE NERVES IN RELATION WITH THE POSTERIOR WALL OF THE AXILLA, ALSO THE QUADRILATERAL AND TRIANGULAR SPACES AS VIEWED FROM IN FRONT.

he **muscular branches** supply the long and medial heads of the triceps, hose for the long head being short, and enter the upper part of the uscle; that for the medial head is a long nerve descending in company ith the ulnar nerve, and enters the lower part of the muscle; it is nown as the *ulnar collateral nerve* (Krause). The **posterior cutaneous ranch** often arises in common with one of the muscular branches, and asses backwards deeply to the intercosto-brachial nerve to be distributed to the skin of the back of the arm, extending downwards early as low as the elbow.

In addition to the branches of the brachial plexus, the skin of the rm is supplied by the **intercosto-brachial nerve** (Fig. 265), the lateral

cutaneous branch of the *second* intercostal nerve. It escapes fro the second intercostal space between two digitations of the serrat anterior and crosses the axillary space. It usually communicates wit a branch of the lateral cutaneous of the third intercostal nerve, an also communicates with the medial cutaneous of arm and the posteri cutaneous nerve of arm from the radial. It is distributed to the ski covering the inner and back part of the upper part of the arm. A secon intercosto-brachial nerve, derived from a lateral cutaneous branc of the first intercostal nerve, is sometimes present, and when this the case the medial cutaneous of arm is absent. In some cases th lateral cutaneous of the third intercostal nerve provides an intercost brachial nerve, which communicates with that from the second, an may largely replace it.

The Axillary Lymphatic Glands are very numerous; they lie em bedded in the loose fatty tissue of the axillary space and are dispose in *five groups.*

The **lateral glands** lie upon the outer wall of the space, forming chain along the axillary vein. Their *afferent* vessels are nearly all th superficial and deep lymphatics of the upper limb. Most of the *efferent* vessels join the central glands, but some ascend to join th infraclavicular glands or the supraclavicular glands.

The **pectoral glands** follow the lateral thoracic artery at the lowe border of the pectoralis minor muscle, and under cover of the anterio fold of the axilla. They lie upon the serratus anterior, in the angl between it and the pectoral muscles, and extend from the level of th second to the level of the fifth intercostal space. They receive *affere* vessels from the anterior and lateral parts of the thoracic wall, th upper part of the anterior abdominal wall, and the greater part of th mammary gland, especially its lower and outer parts. Their *efferen* vessels join the central glands, but a few join the infraclavicular glands

The **subscapular glands,** situated upon the posterior wall of th axilla, follow the lower border of the subscapularis muscle and accom pany the subscapular artery. Their *afferent* vessels drain the lowe and back part of the neck and the posterior part of the trunk, a fe being derived from the lateral abdominal wall. Their *efferent* lym phatics join the central glands.

The **central glands** occupy the base of the axilla, and may be re garded as the meeting place of the three preceding groups whos vessels they receive. Their *efferent* vessels join the infraclavicula glands.

The **infraclavicular glands,** which are joined by the efferent vessel of the central glands, are situated in close relation to the upper par of the axillary vein near the upper border of the pectoralis minor.

Serratus Anterior (Fig. 271)—*Origin.*—The outer surfaces of th first eight or nine ribs about midway between the angles and costa cartilages by means of fleshy slips or digitations. The first slip arise from both the first and second ribs, and from a fibrous arch betwee them.

Insertion.—The medial margin, and the ventral surfaces of the ıpper and lower angles of the scapular.

Nerve-supply.—The nerve to serratus anterior. The nerve descends ɔn the axillary surface of the muscle.

The muscle is arranged in three parts. The *upper part*, consisting ɔf the first digitation, is short, thick, and quadrilateral; it is inserted nto the triangular area ɔn the ventral aspect of he upper angle of the scapula. The *middle part* s a thin, expanded sheet, consisting of the second ınd the third digitations. The fibres diverge as they ıpproach the scapula, and ıre inserted into a linear ırea extending for nearly he whole length of the nedial margin of the scapula. The *lower part*, consisting of the lower five ɔr six digitations, is fan-shaped, the fibres converging from the ribs to he scapula, where it is nserted into an expanded ırea on the ventral aspect ɔf the lower angle. The ower four or five digitations interdigitate with those of the obliquus externus abdominis.

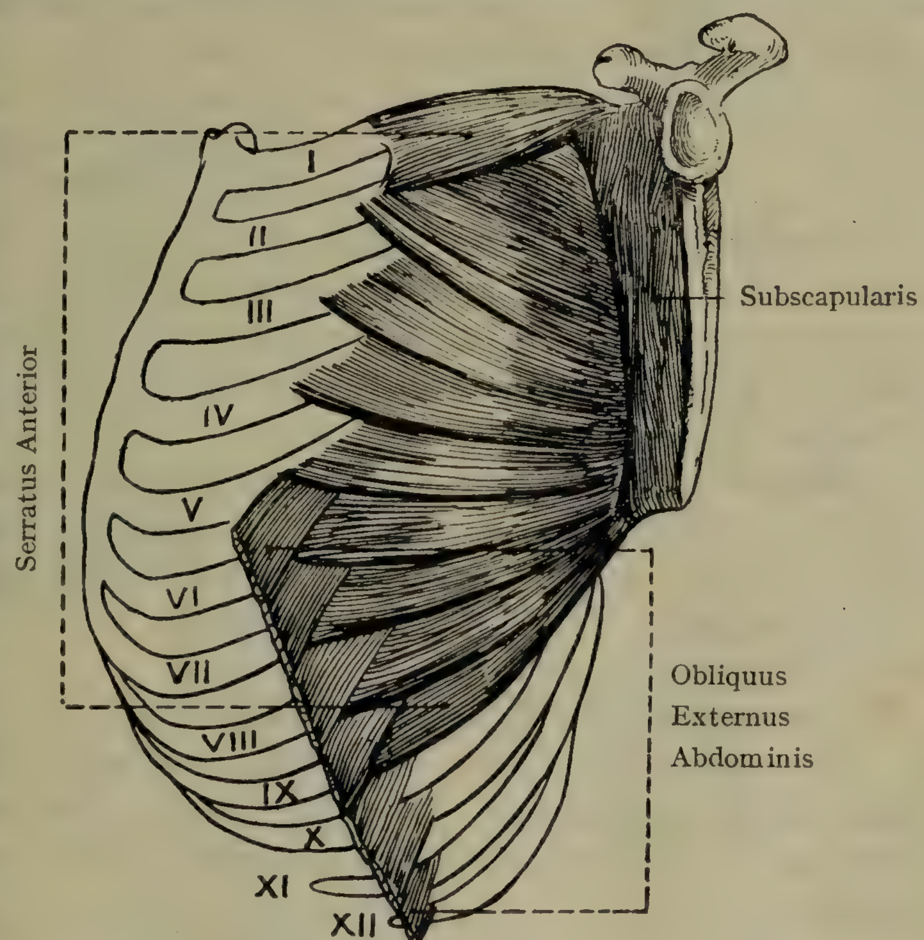


FIG. 271.—THE SERRATUS ANTERIOR MUSCLE.

The muscle is a curved sheet which, extending backwards from ts origin to its insertion, clings closely to the chest wall, intervening ɔetween it and the subscapularis (Fig. 263).

Action.—The muscle draws the scapula forwards. The strong ower part, acting upon the lower angle, rotates the bone and elevates he point of the shoulder. In this movement it acts together with he trapezius (p. 399). An important use of the muscle is to fix the capula, this condition being necessary before the deltoid can elevate he humerus. The muscle serves to keep the lower angle of the capula in contact with the chest wall. When the shoulder is fixed ɔy other muscles, the lower part of the muscle can raise the ribs, and ıct as a muscle of inspiration.

When the serratus anterior muscle is paralyzed (in association with the homboid muscles), the condition known as *winged scapula* is produced. The ɔwer angle and medial border of the scapula are displaced *backwards* when an ffort is made to abduct the arm or to thrust it forwards.

The Scapular Region.

The Cutaneous Nerves of the shoulder are derived from the lateral branches of the **supra-clavicular** nerves and the **circumflex.** The **lateral supra-clavicular branches** descend over the acromion process and divide into numerous branches, supplying the skin over the upper part of the deltoid. Some of the branches of the **circumflex nerve** traversing the deltoid supply the skin over its anterior part; the upper lateral cutaneous nerve of arm, derived from the posterior division, appears at its hinder edge and supplies the skin covering the lower and hinder parts of the muscle.

Deep Fascia.—As it covers the infraspinatus the deep fascia is thick and strong. It is continuous with septa between that muscle and the teres muscles, and between the two teres muscles. At the posterior border of the deltoid it is continuous with the two layers which ensheathe that muscle.

Deltoid (Fig. 272)—*Origin.*—The anterior border of the outer third of the clavicle; the outer border of the acromion process; and the lower lip of the posterior border of the spine of the scapula.

Insertion.—The deltoid tuberosity on the outer aspect of the shaft of the humerus.

Nerve-supply.—The circumflex nerve (p. 432).

The muscle is very coarsely fasciculated, and is triangular, the base being upwards. The clavicular portion passes downwards and outwards, the acromial downwards, and the spinous downwards and forwards.

Action.—The acromial portion abducts the arm to the position of nearly a right angle with the trunk; the clavicular portion draws it forwards; and the spinous portion draws it backwards.

The fibres of the acromial part of the muscle are short and obliquely disposed. Attached on either side of four tendinous planes, extending downwards from its origin into the substance of the muscle, the fibres are so disposed as to form a series of feather-like arrangements lying side by side. The fibres are attached below on either side of three tendinous planes of insertion, alternating in position with the tendinous planes of origin, and attached below to the humerus.

The anterior border is related to the pectoralis major, which lies deeply to it below, but diverges from it above, the cephalic vein and the deltoid branch of the acromio-thoracic artery lying between the two. The posterior border is bound down to the deep fascia covering the infraspinatus. Deeply to the muscle are the shoulder-joint, subacromial bursa, coracoid process, coraco-brachialis, biceps, tendons of insertion of the supraspinatus, infraspinatus, and teres minor; parts of the long and lateral heads of the triceps, teres major, tendon of insertion of the pectoralis major, circumflex nerve, and posterior humeral circumflex artery.

The Subacromial Bursa is a large bursa intervening between the acromion process and deltoid above, and the upper part of the capsular

ligament with the tendons inserted into the greater tuberosity of the humerus below.

Supraspinatus—*Origin.*—The inner two-thirds of the supraspinous fossa of the scapula, and the deep fascia covering the muscle.

Insertion.—The upper impression on the greater tuberosity of the humerus, its tendon being closely connected with the upper part of the capsular ligament, and with that of the infraspinatus.

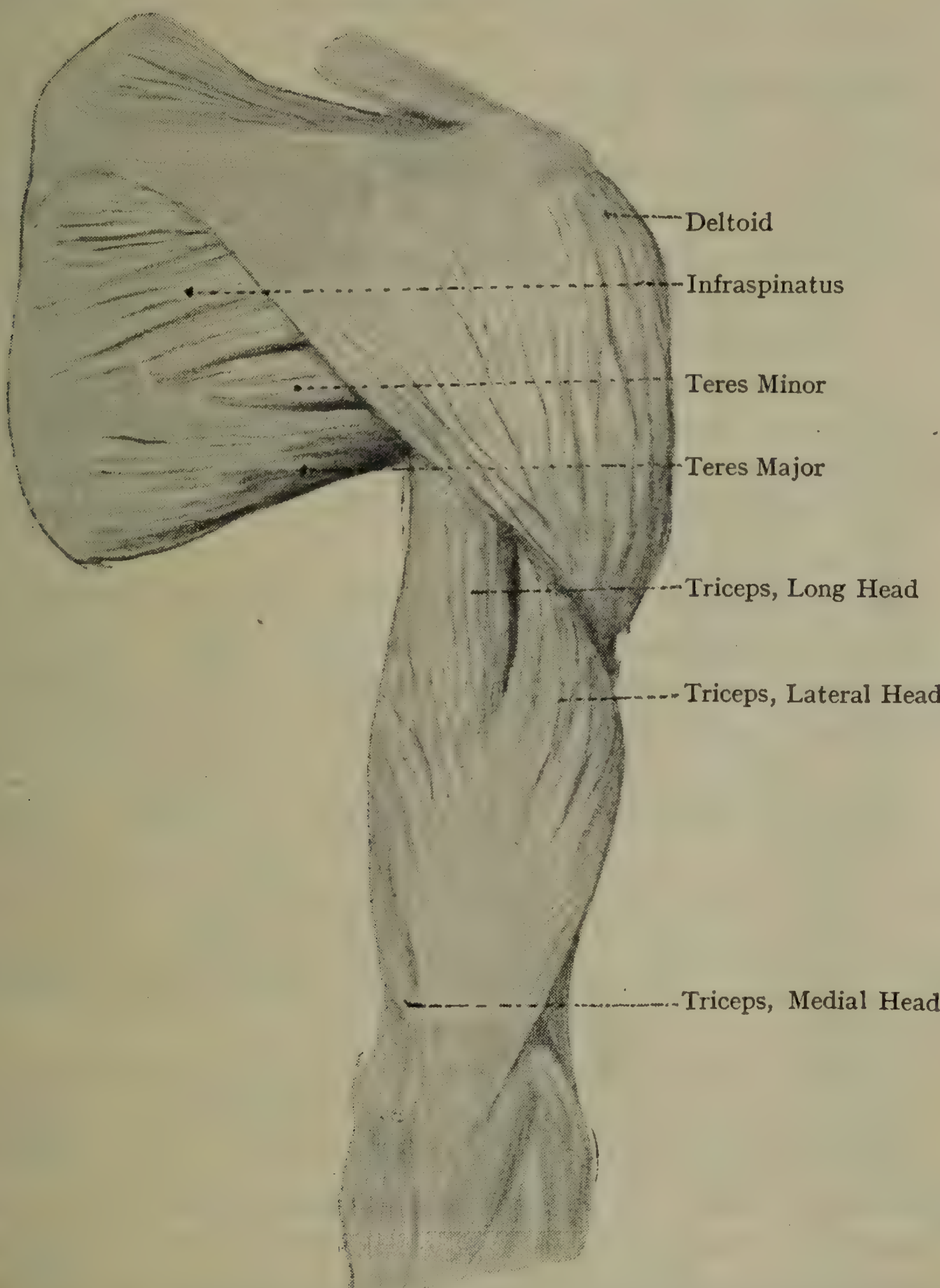


FIG. 272.—SURFACE VIEW OF MUSCLES OF BACK OF SCAPULA AND ARM.

Nerve-supply.—The suprascapular nerve (p. 431).

The direction of the muscle is outwards and forwards.

Action.—Abducts the arm in association with the deltoid.

Inferior Belly of the Omo-hyoid—*Origin.*—The upper border of the scapula medial to the suprascapular notch, and the adjacent part of the suprascapular ligament.

Infraspinatus—*Origin.*—The infraspinous fossa of the scapula for about its inner two-thirds, and the deep fascia covering the muscle.

Insertion.—The middle impression on the greater tuberosity c the humerus, its tendon being close by connected with the back par of the capsular ligament, from which it is sometimes separated by bursa. The fibres converge to a tendon which, at first conceale within the substance of the muscle, passes outwards to its insertion.

Nerve-supply.—The suprascapular nerve.

Action.—When the arm is hanging by the side of the trunk th muscle is a lateral rotator. When the arm is raised the muscle carrie it backwards in association with the deltoid.

The Suprascapular Artery (Fig. 276) is derived from the thyrc cervical trunk, a branch of the first part of the subclavian. It passe transversely outwards behind the clavicle, and reaches the upper borde of the scapula in company with the suprascapular nerve. Havin passed backwards above the suprascapular ligament, the nerve as rule lying below this ligament, it descends into the supraspinous foss deeply to the supraspinatus, to which it gives several branche Finally, it passes downwards behind the neck of the scapula throug the spino-glenoid notch, deeply to the spino-glenoid ligament, int the infraspinous fossa, where it supplies the infraspinatus, deeply t which it lies, and anastomoses with the circumflex scapular and dee branch of transverse cervical.

Branches.—*Muscular,* in the neck, to the sterno-mastoid an subclavius; *suprasternal,* passes downward in front of the sterno clavicular joint, and supplies the skin over the manubrium; *nutrien* to the clavicle; *acromial,* traverses the trapezius to reach the uppe surface of the acromion process, where it anastomoses with branche of the acromio-thoracic and posterior circumflex; *articular,* to th acromio-clavicular and shoulder-joints; *anterior,* given off as it passe backwards over the suprascapular ligament, and anastomosing in th subscapular fossa with the circumflex scapular and deep branch o transverse cervical; *supraspinous* and *infraspinous,* distributed to th muscles on the back of the scapula.

The Suprascapular Nerve passes backwards below the supra scapular ligament into the supraspinous fossa, where it gives branche to the supraspinatus and articular branches to the acromio-clavicula and shoulder-joints. It accompanies the artery through the spino glenoid notch, lying deeply to the spino-glenoid ligament, to th infraspinous fossa, where it ends in branches to the infraspinatus.

Teres Minor (Fig. 273)—*Origin.*—A long narrow area on the dorsun of the scapula close to the lateral border, and the septa between it an the infraspinatus and the teres major respectively.

Insertion.—The lower impression on the greater tuberosity of th humerus, and the surgical neck of the bone for a short distance below its tendon being closely connected with the back part of the capsula ligament.

Nerve-supply.—A branch of the circumflex nerve (p. 432).

The direction of the muscle is outwards and slightly upwards and forwards.

Action.—When the arm is abducted it is a lateral rotator; it also assists in depressing the arm.

Teres Major (Fig. 273)—*Origin.*—From an oval impression on the dorsum of the scapula near its lower angle, and from the lower third of the lateral border; also from the septa between it and the teres minor and infraspinatus respectively.

Insertion.—The medial lip of the bicipital groove of the humerus for about 2 inches.

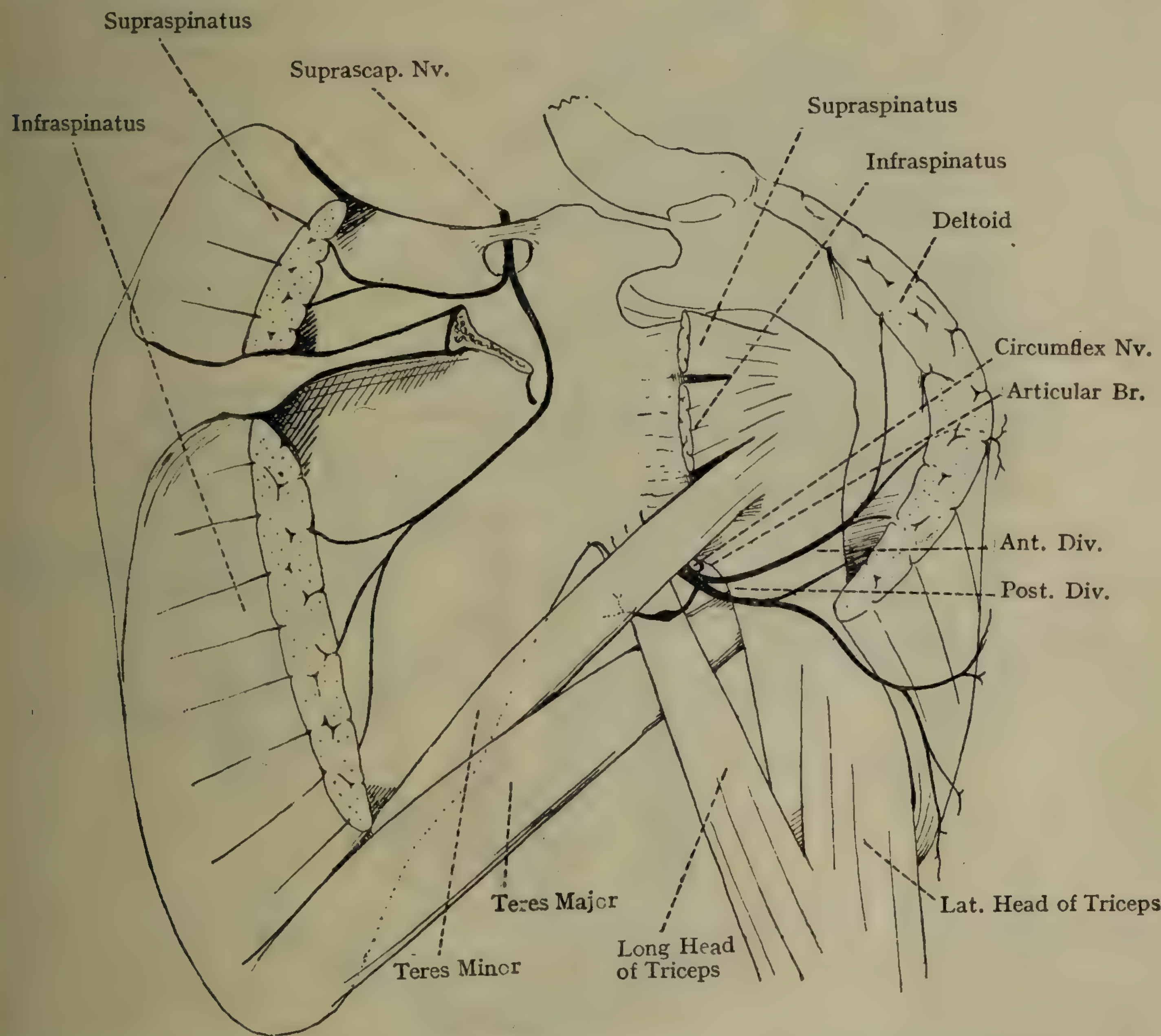


FIG. 273.—THE SUPRASCAPULAR AND CIRCUMFLEX NERVES FROM BEHIND.

The deltoid, supraspinatus, and infraspinatus muscles have been partially removed. The boundaries of the quadrilateral and two triangular spaces as they appear from behind.

Nerve-supply.—The lower subscapular nerve (p. 431).

The direction of the muscle is obliquely upwards, outwards, and forwards.

Action.—Adducts the arm, and when the arm is abducted acts as a medial rotator.

The latissimus dorsi winds round the lower border of the muscle, and is finally placed in front of it. The two tendons are at first closely connected by their lower borders, but close to their insertions are

separated by a bursa. A bursa between the teres major and the humerus is sometimes present.

Subscapularis (Fig. 270)—*Origin.*—The anterior surface of the scapula, with the exception of the neck, and the areas giving attachment to the serratus anterior. The origin of the muscle fibres is partly from a series of tendinous planes embedded in the substance of the muscle, and attached to the ridges on the anterior surface of the

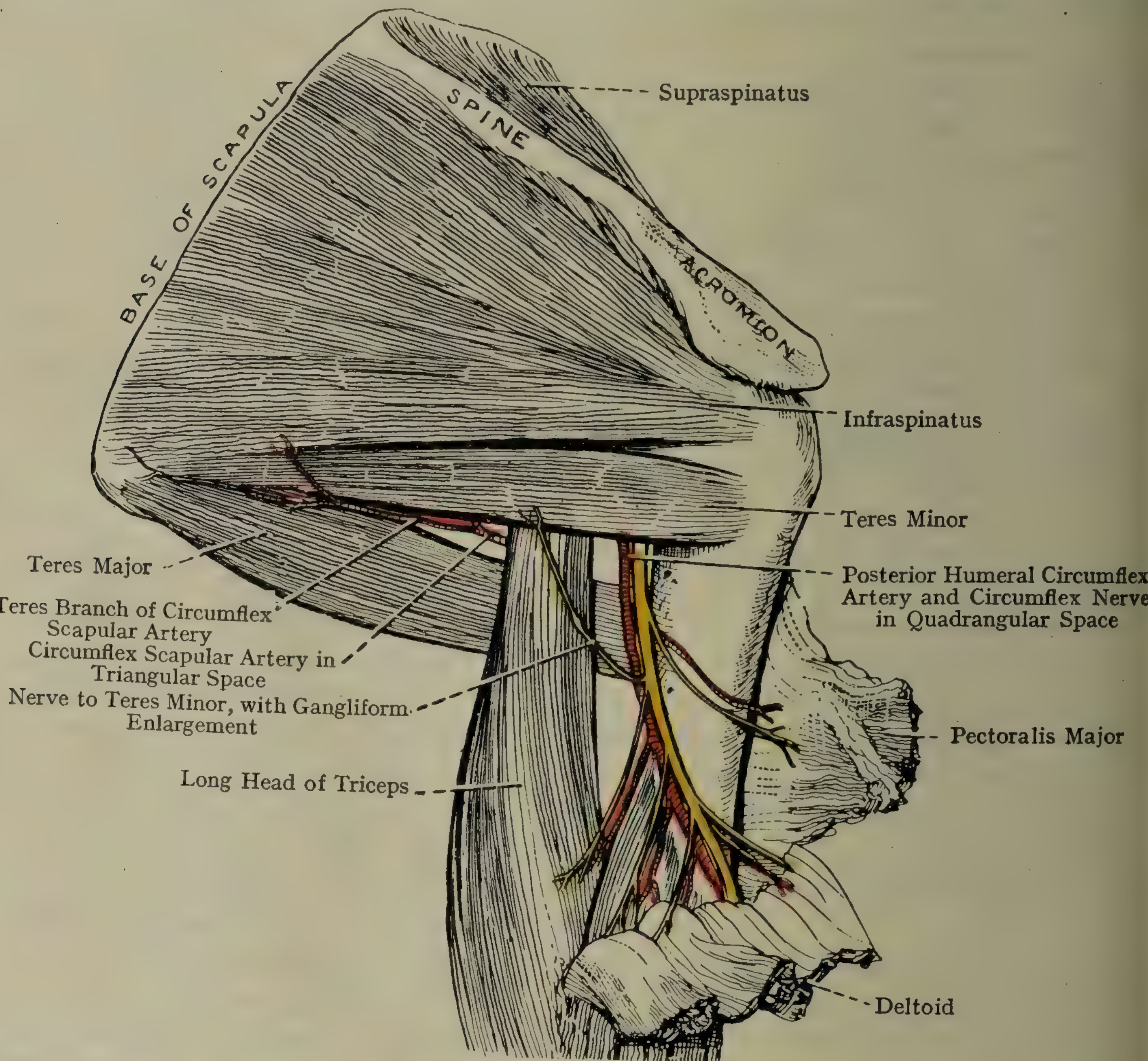


FIG. 274.—DISSECTION OF THE SCAPULAR AND UPPER BRACHIAL REGIONS FROM BEHIND.

The deltoid has been turned down, carrying the circumflex nerve and vessels with it, and the triangular and quadrangular muscular spaces, with their contents, are shown.

scapula; partly by means of muscle slips attached to the depressions between the ridges.

Insertion.—The lesser tuberosity of the humerus, from which it descends downwards for some little distance on to the neck of the bone.

Nerve-supply.—The upper, and partly by the lower, subscapular nerves (p. 431).

The direction of the muscle is mainly upwards and outwards.

Action.—Rotates the arm inwards, and when it is raised draws it forwards and downwards.

The tendon of the muscle is closely blended with the front of the capsular ligament. Between it and the neck of the scapula is a bursa, which is continuous with the synovial membrane of the shoulder-joint through a deficiency in the capsule.

Triangular and Quadrilateral Spaces (Fig. 275).—As the long head of the triceps descends obliquely downwards and outwards from the infraglenoid tubercle of the scapula to the back of the shaft of the humerus, it lies behind the teres major and in front of the teres minor, these two muscles diverging from one another as they pass outwards to the humerus. The long head of the triceps with the two teres muscles and the shaft of the humerus help to form the boundaries of a quadrilateral and two triangular spaces.

The **Quadrilateral Space** is bounded *above* by the teres minor, together with the subscapularis lying in front of it, the lower edges

FIG. 275.—DIAGRAMS TO SHOW FORMATION OF TRIANGULAR AND QUADRILATERAL SPACES.

of the two muscles being at the same level; *below* by the teres major, in front of which is the tendon of the latissimus dorsi; *laterally* by the neck of the humerus; and *medially* by the long head of the triceps. This space is occupied by the circumflex nerve and posterior humeral circumflex artery.

The **Upper Triangular Space,** bounded *above* by the teres minor and subscapularis, *below* by the teres major, and *laterally* by the long head of the triceps, contains the commencement of the circumflex scapular artery.

The **Lower Triangular Space,** bounded *above* by the teres major and the tendon of the latissimus dorsi, *medially* by the long head of the triceps, and *laterally* by the shaft of the humerus, transmits the radial nerve and the profunda artery to the back of the arm.

Scapular Anastomosis (Fig. 276).—The anastomoses of arteries about the scapula are divided into two sets—scapular proper and acromial.

Scapular Anastomoses Proper.—The arteries taking part in these anastomoses are the suprascapular and deep branch of transverse

cervical, deriving their blood from the subclavian; and the circumfle scapular branch of the subscapular, derived from the third part of th axillary. The suprascapular is a branch of the thyro-cervical trun from the first part of the subclavian; the transverse is also a branch o the thyro-cervical trunk. The suprascapular and deep branch o transverse cervical are distributed to the supraspinous and infra-

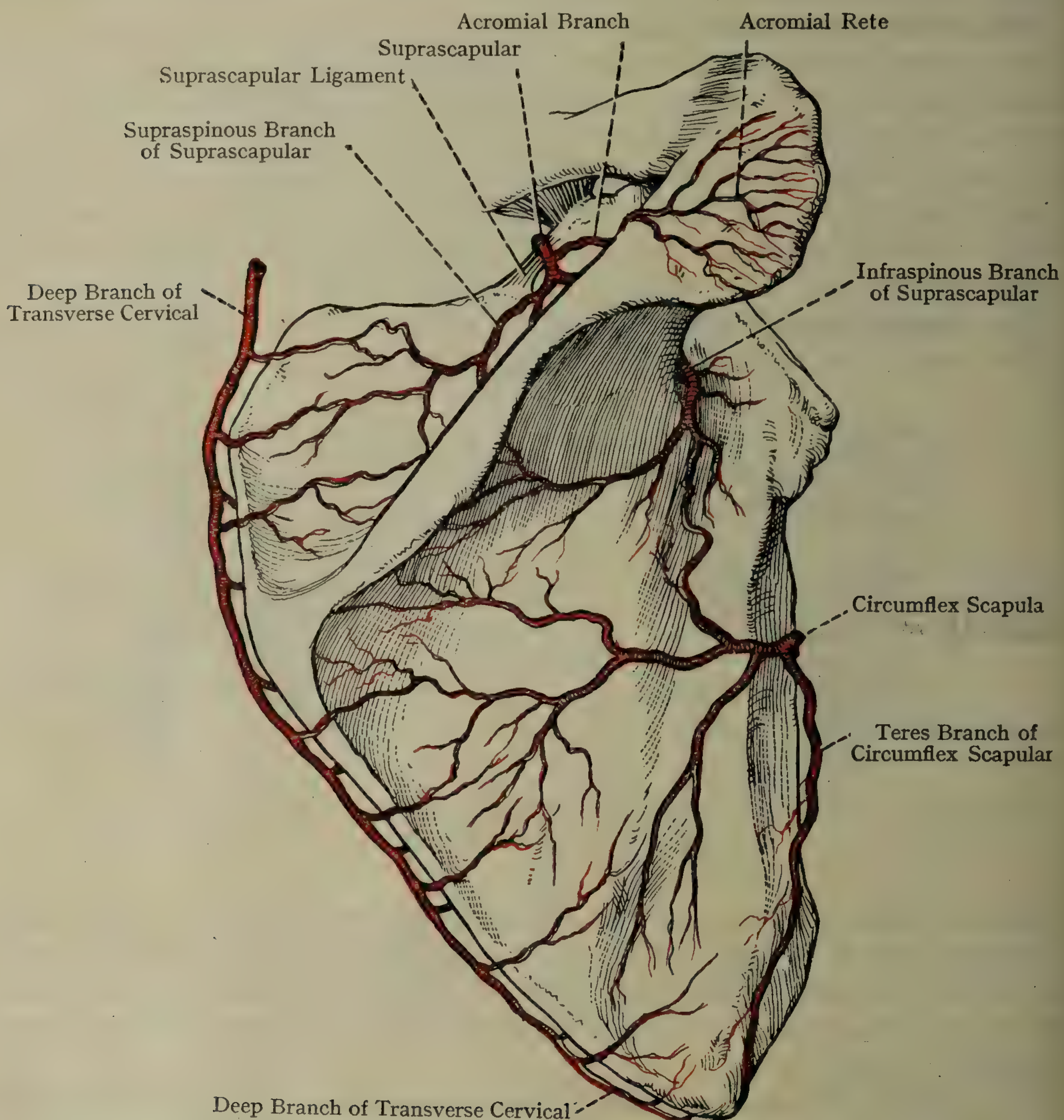


FIG. 276.—THE ANASTOMOSES OF ARTERIES ON THE POSTERIOR SURFACE AND ACROMION PROCESS OF THE SCAPULA.

spinous fossæ and anterior surface. The circumflex scapular ramifies in the infraspinous fossa and anterior surface. In the supraspinous fossa the suprascapular anastomoses with the deep branch of transverse cervical. In the infraspinous fossa the suprascapular, the circumflex scapular, and the deep branch of transverse cervical anastomose together. In the anterior surface of the scapular the ventral branches of the suprascapular and deep branch of transverse cervical anastomose

with the ventral branch of the circumflex scapular. At the lower angle of the bone the deep branch of transverse cervical anastomoses with the descending or teres branch of the circumflex scapular.

Acromial Anastomosis.—The arteries taking part in the acromial anastomosis or rete on the upper surface of the acromion process are the acromial branch of the suprascapular, branches of the acromio-thoracic artery, and twigs from deep branch of transverse cervical.

The scapular anastomoses are of importance in providing collateral channels for the blood after ligature of the third part of the subclavian artery.

The Articulations of the Clavicle.

Sterno-clavicular Joint (Fig. 277).—The articular surfaces are the inner end of the clavicle and the clavicular notch on the upper border of the manubrium sterni. The articular surface of the clavicle is larger than the sternal, and the two are separated by an interarticular disc.

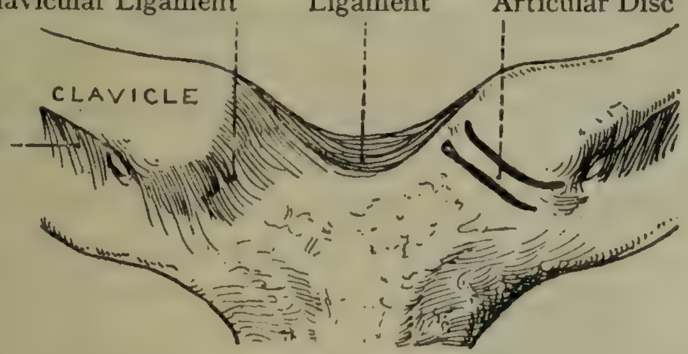


FIG. 277.—THE STERNO-CLAVICULAR JOINTS.
The left anterior sterno-clavicular ligament has been removed.

The joint is surrounded by a complete capsule, weak above and below, but strong in front and behind, where it provides the anterior and posterior sterno-clavicular ligaments. In addition, there are the inter-clavicular and costo-clavicular ligaments.

The **anterior sterno-clavicular ligament** is broad, and its fibres extend obliquely downwards and inwards from the front of the clavicle to the front of the manubrium. The sternal head of origin of the sterno-mastoid lies in front of it. The **posterior sterno-clavicular ligament** resembles the anterior, and is similarly disposed behind the joint. The sterno-hyoid muscle arises in part from it. The **interclavicular ligament** is a well-marked, curved bundle of fibres, attached at either side to the upper and back part of the inner end of the clavicle. As it extends between the two bones it curves downwards to be attached to the suprasternal notch on the upper border of the manubrium. The **costo-clavicular** or **rhomboid ligament** is a strong, quadrilateral band of fibres extending from the upper surface of the first costal cartilage to the rhomboid line on the under surface of the clavicle; its direction is upwards, backwards, and outwards.

The **articular disc** is a nearly circular, flattened plate, thinner at the centre and lower part than elsewhere. It is attached above to the upper and back part of the inner end of the clavicle, and below to the inner end of the first costal cartilage, where it inclines slightly outwards to form with the first costal cartilage a socket for the inferior aspect of the inner end of the clavicle. Circumferentially it is adherent to the capsular ligament. The plate sometimes presents a central deficiency.

The joint has two synovial cavities, one on either side of the articular disc. When the latter is perforated these are continuous with each other.

Nerve-supply.—The medial supraclavicular.

Movements.—These take place in upward, downward, forward, and backward directions. A combination of these movements or circumduction can also occur. In the upward and downward movements the clavicle moves on the articular disc, and the forward and backward movements take place between the articular disc and the manubrium. Upward displacement of the inner end of the clavicle is limited by the costo-clavicular ligament and the articular disc.

Acromio-clavicular Joint.—The articular surfaces are the outer end of the clavicle and the facet on the acromion process. These surfaces are occasionally partially separated by an incomplete articular disc. The joint is surrounded by a capsular ligament, thickened above and below, forming the superior and inferior ligaments.

The **acromio-clavicular ligament** extends between the corresponding margins of the bones, the former being strengthened by aponeurotic fibres from the trapezius and deltoid. The articular disc, when present, is limited to the upper part of the joint, where it is attached to the ligament. Occasionally it is complete, and subdivides the joint into two synovial compartments.

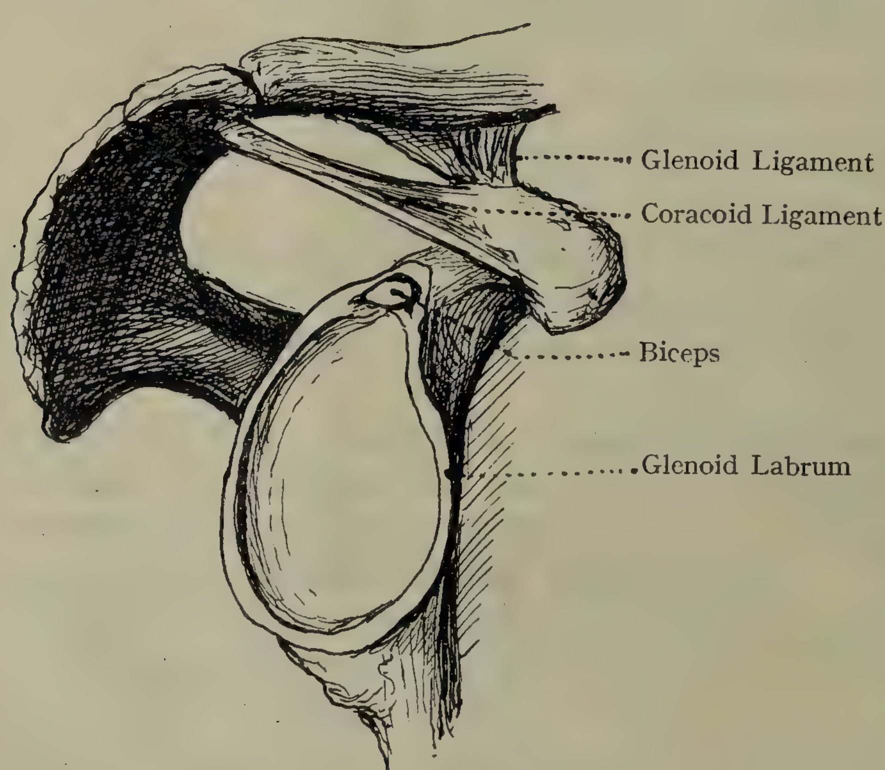


Fig. 278.—The Right Glenoid Cavity and the Adjacent Ligaments.

The **coraco-clavicular ligament,** an accessory ligament to the joint, connects the clavicle with the coracoid process, and is composed of two parts—conoid and trapezoid. The **conoid ligament,** medial and posterior in position, is attached below by its apex to an impression at the back part of the antero-medial border of the coracoid process, and above by its base to the conoid tubercle of the clavicle, its direction being upwards and backwards. The **trapezoid ligament,** lateral and

anterior in position, is somewhat quadrilateral. It is attached below to the trapezoid ridge on the back part of the upper surface of the coracoid process, and above to the trapezoid ridge on the under surface of the clavicle, its direction being upwards, backwards, and outwards. Between the two ligaments there is a slight interval, which may be occupied by a bursa.

Nerve-supply.—The lateral supraclavicular.

Movements.—The movements at this joint are very limited, and consist chiefly of gliding in upward and downward, and forward and backward directions.

The Ligaments of the Scapula.

The **suprascapular ligament** (Fig. 273) extends from the upper border of the scapula, medial to the suprascapular notch, to the root of the coracoid process. It is thin and flat, bridges across the notch, and converts it into a foramen. It gives origin to some fibres of the inferior belly of the omo-hyoid; the suprascapular nerve passes below it, the suprascapular artery above it. This ligament is sometimes replaced by bone.

The **coraco-acromial ligament** is triangular, and is attached by its apex to the tip of the acromion process, by its base to the postero-lateral border of the coracoid process. Its superior surface is covered by the deltoid, and the inferior surface overhangs the shoulder-joint, the subacromial bursa intervening. The acromion process, coraco-acromial ligament, and coracoid process form the coraco-acromial arch, which lodges the head of the humerus when the arm is abducted. The arch therefore forms an auxiliary socket for the head of the bone.

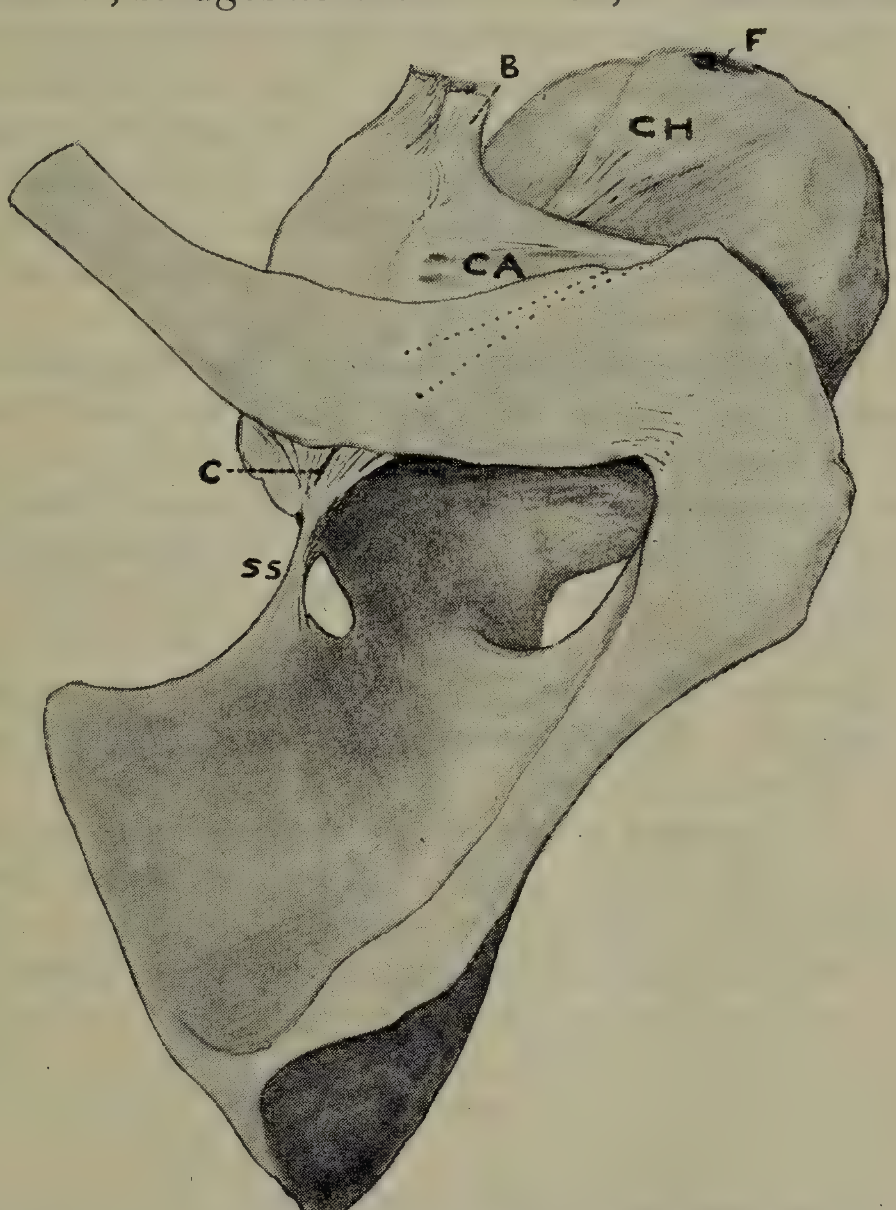


Fig. 279.—Coraco-acromial (CA) Ligament, Coraco-humeral (CH), and Capsule of Shoulder. C, conoid ligament; SS, suprascapular ligament; B, short head of biceps; F, foramen for long head of biceps.

The **spino-glenoid ligament** consists of a few fibres extending

from the outer border of the spine to the adjacent part of the margin of the glenoid cavity. It arches over the suprascapular artery and nerve as they pass through the spino-glenoid notch on their way to the infraspinous fossa.

Movements of the Scapula.—These movements take place at the acromio-clavicular joint, and are associated with movements of the clavicle. They are of two kinds—namely, gliding and rotation.

Gliding Movements.—These take place upwards, downwards, outwards or forwards, and inwards or backwards. As they occur the scapula moves over the dorsal wall of the thorax in such a manner as to describe the arc of a circle. The centre of this circle corresponds to the sterno-clavicular joint, and the clavicle represents a ray of the circle. In the **inward** or **backward movement** the medial border of the scapula approaches the vertebral column; in the **outward** or **forward movement** it retreats *from* the vertebral column.

Rotatory Movements.—Rotation takes place inwards and outwards. During **medial rotation** the acromion is *elevated*, the superior angle is *depressed*, and the inferior angle moves *slightly outwards*. In medial rotation the *conoid ligament* is tightened. During **lateral rotation** the superior angle is *elevated*, the acromion is *depressed*, and the inferior angle moves *slightly inwards*. In lateral rotation the *trapezoid ligament* is tightened.

Chief Muscles concerned in the Movements.—**Elevation of Entire Scapula:** *Cervical part* of the trapezius, and the levator scapulæ. **Depression of Entire Scapula:** The *lower fibres* of the trapezius, and the pectoralis minor. **Outward or Forward Movement of Entire Scapula:** The serratus anterior. **Inward or Backward Movement of the Entire Scapula:** The *middle* and *lower parts* of the trapezius, and the rhomboid muscles.

Special Movements.—**Elevation of Acromion:** *Cervical part* of the trapezius. **Elevation of Superior Angle:** Levator scapulæ, aided by the rhomboid muscles.

The **inferior angle** of the scapula is kept in contact with the dorsal wall of the thorax by the *upper horizontal fibres* of the latissimus dorsi muscle, which pass over its dorsal aspect.

The medial border of the scapula is kept in contact with the dorsal wall of the thorax by the serratus anterior and rhomboid muscles.

The Arm.

Landmarks.—The front of the arm presents a well-marked elongated prominence, which reaches from the anterior fold of the axilla to near the elbow, and is due to the biceps. Medial to it in the upper part of the arm is another smaller swelling caused by the coracobrachialis. On either side of the bicipital prominence is a groove, that on the outer side indicating the position of the cephalic vein, and that on the inner side the position of the basilic vein, brachial artery, and median nerve. Lateral to the bicipital prominence, for a short

listance above the elbow, is the prominence formed by the brachio-radialis and extensor carpi radialis longus. At the elbow the medial and lateral epicondyles of the humerus and the olecranon process of the ulna are to be noted. The medial epicondyle forms a very distinct projection, having an inclination backwards; behind it, close to the olecranon, is the ulnar nerve. The lateral epicondyle is not so well marked, but may be felt in semiflexion of the joint. The olecranon process can easily be felt at the back of the elbow. When the joint is extended, the summit of the olecranon and the two epicondyles are all in line with one another. When the arm and forearm are at right angles to one another, the summit of the olecranon is below a line connecting the epicondyles. In extreme flexion of the elbow the summit of the olecranon is in front of a line connecting the epicondyles. The posterior surface of the olecranon is covered by a subcutaneous bursa. When the joint is extended, the head of the radius can be felt at the bottom of a depression situated at the outer and back part, immediately below the lateral epicondyle. It is most readily felt when the forearm is alternately pronated and supinated. In front of the elbow there is a slight hollow indicating the position of the antecubital fossa, and in this region the median basilic and median cephalic veins may be visible through the skin. On the back of the forearm the posterior subcutaneous border of the ulna can readily be felt. It extends from the apex of the triangular surface on the back of the olecranon process downwards and inwards to the styloid process at the lower end of the ulna, occupying the back of the inner side of the waist. The styloid process of the radius projecting downwards to a lower level than that of the ulna can easily be felt on the outer side of the lower end of the bone. About the middle of the back of the lower end of the radius is the dorsal tubercle, which bounds laterally the groove for the tendon of the extensor pollicis longus.

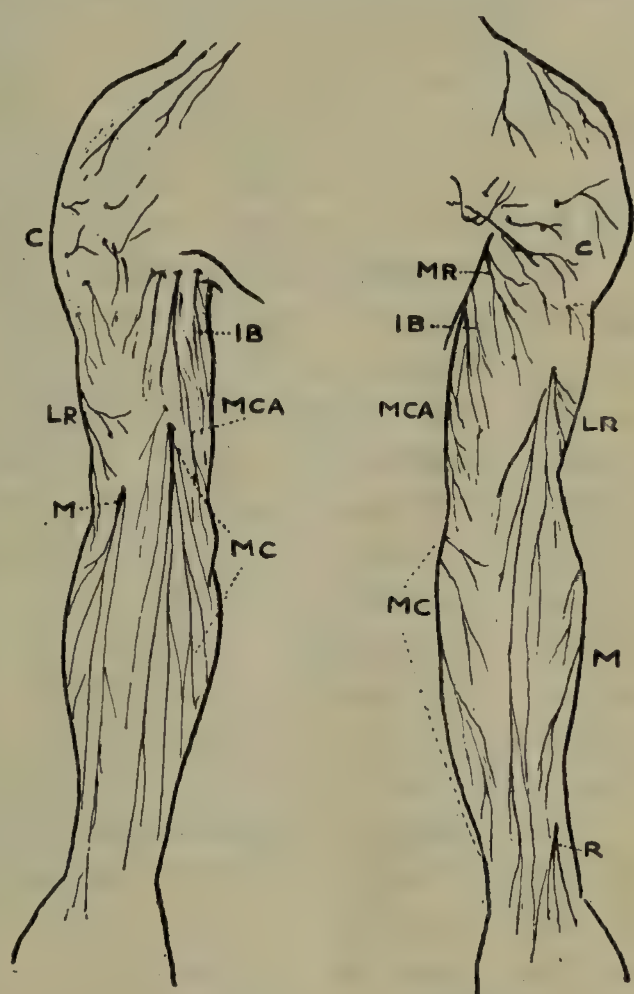


Fig. 280.—Diagrams of Cutaneous Nerves of Upper Limb, Front and Back.

The Olecranon Bursa is situated subcutaneously on the posterior triangular surface at the back of the olecranon process of the ulna.

Cutaneous Nerves.—The **intercosto-brachial nerve,** having crossed the axillary space, supplies the skin of the inner and back part of the

upper part of the arm. It may be accompanied by a twig from th lateral cutaneous branch of the third intercostal nerve.

The **medial cutaneous nerve of arm** (**lesser internal cutaneous**) i distributed to the skin of the inner side of the arm, as low as the interva between the medial epicondyle and olecranon.

The **medial cutaneous nerve of forearm** (**internal cutaneous**) sends on or more branches, which, traversing the deep fascia close to the axilla are distributed to the skin covering the biceps. The nerve itself passe through the deep fascia a little below the centre of the arm, and divide into anterior and posterior branches. The *anterior branch* descend behind, sometimes in front, of the median basilic vein, giving one o two twigs supplying the neighbouring skin, and finally descending int the forearm is distributed to the skin on the anterior aspect of its inne side. The *posterior branch* passes downwards and inwards on th inner side of the basilic vein. Extending downwards over the media epicondyle, it finally passes backwards to supply the skin over th back of the inner side of the forearm.

The **posterior cutaneous nerve of arm** (**internal cutaneous of musculo spiral**) is distributed to the skin on the back of the arm, usually as lov as the olecranon.

The **posterior cutaneous nerves of forearm** (**external cutaneous o musculo-spiral**) are two in number—upper and lower. They leav the main trunk towards the lower end of the spiral groove, just befor the nerve passes through the lateral intermuscular septum. The *uppe branch* is small, and descends with the cephalic vein to the front of the elbow; it supplies the skin on the outer side of the lower part of the arm. The *lower branch* is much larger and descends behind the latera epicondyle into the forearm, where it is distributed to the skin on the posterior aspect as low as the wrist.

The **lateral cutaneous nerve of forearm** (**external cutaneous**) pierces the deep fascia on the outer side of the biceps a little above the elbow. It descends behind the median cephalic vein, giving one or two twigs to the skin in the neighbourhood, and divides into two branches. One supplies the skin on the outer side of the front of the forearm, and the other gives branches to the skin on the back of the forearm.

The **cutaneous branch** of the **ulnar,** an inconstant branch, arises about the middle of the forearm, pierces the deep fascia, and has a limited distribution to the skin on the front of the lower part of the forearm.

Superficial Veins (Fig. 281).—There are four principal superficial veins in the forearm: the median, radial, anterior ulnar, and posterior ulnar.

The **median vein** is formed by the union of a few radicles which originate in the venous plexus in front of the wrist, and its course is upwards in front of the forearm. As it ascends it is joined by several veins, and often receives a large tributary from the back of the limb. It is in free communication with the radial and anterior ulnar veins. On arriving at the hollow in front of the elbow it re-

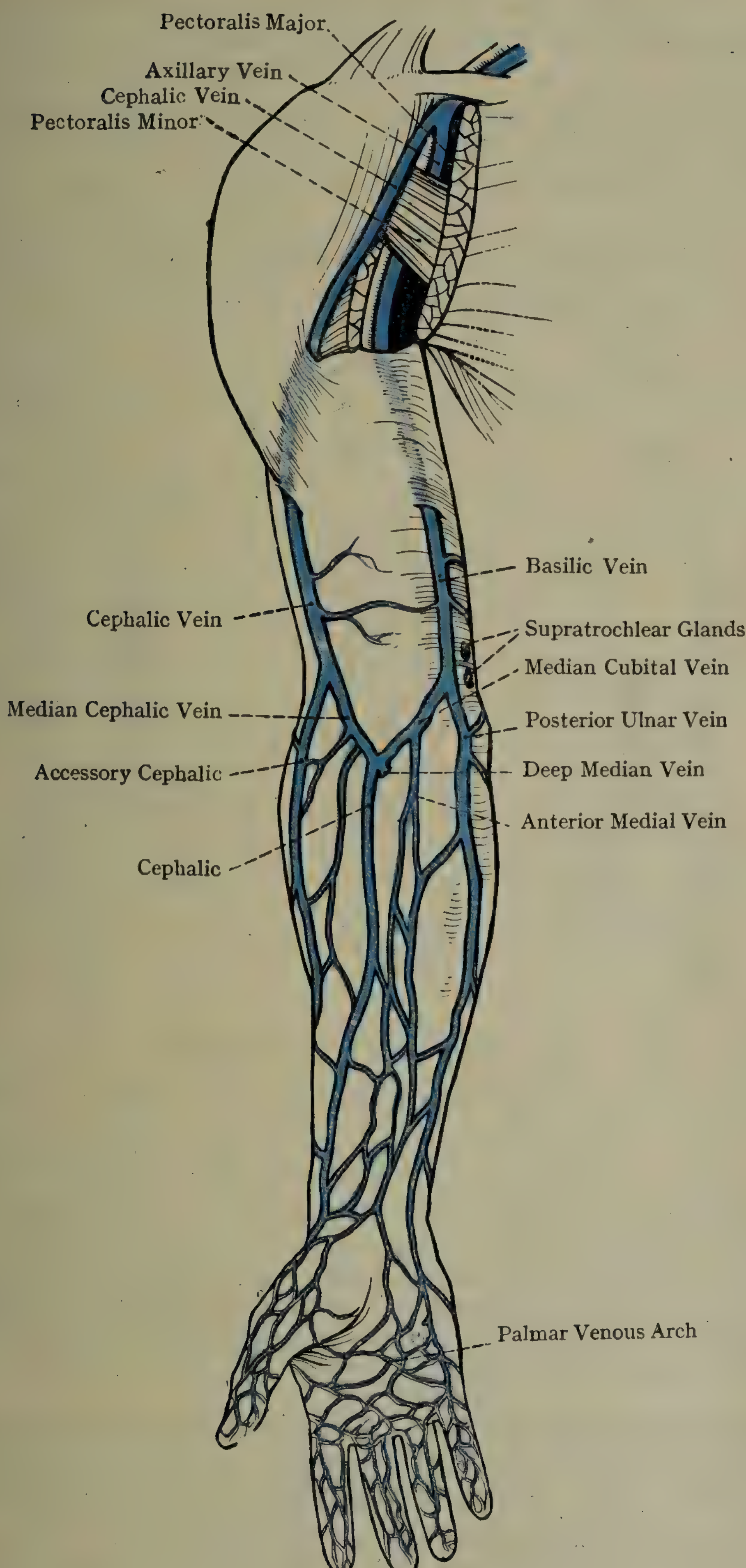


FIG. 281.—THE SUPERFICIAL VEINS OF THE UPPER LIMB (ANTERIOR VIEW).

ceives a short but large tributary, the **deep median vein,** which esta lishes a communication between it and the deep veins. It divid into the median cephalic and median basilic veins, which diver from each other as they ascend like the capital letter V. The **medi cephalic vein,** the smaller of the two, passes upwards and outwar in the interval between the biceps and brachio-radialis; the muscul cutaneous nerve lies deeply to it, but a few twigs of the nerve are supe ficial to it. A little above the lateral epicondyle it is joined by t radial vein, the resulting trunk being the **cephalic vein.** The **medi**

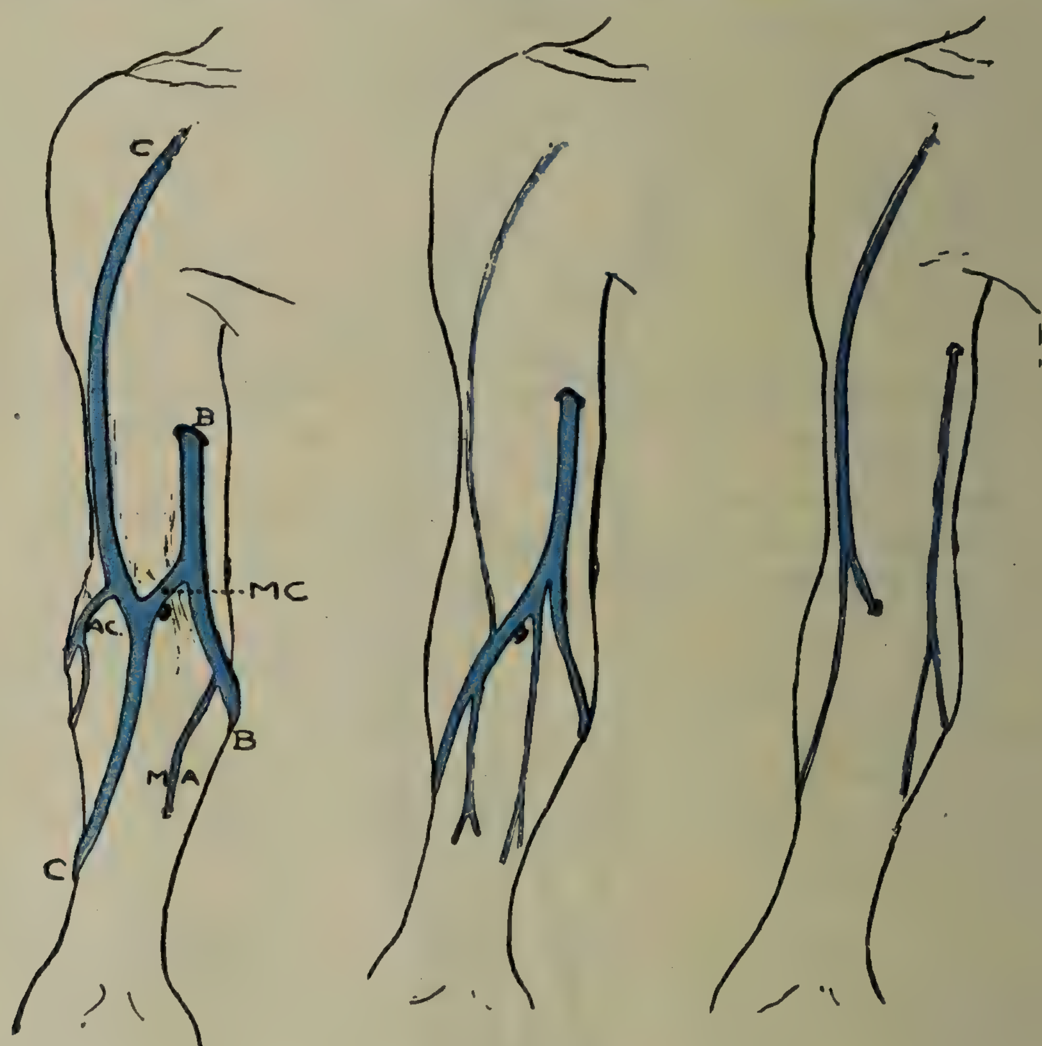


FIG. 282.—TO SHOW VARIATIONS IN SUPERFICIAL VEINS OF FRONT OF AR

The first figure gives the commonest variety: C-C, cephalic vein; B-B, basil vein; MC, median cubital joining these two: accessory minor veins ma include MA, median antebrachial, and AC, accessory cephalic. The r maining figures show two only out of a very large number of possible varietie The ‘ deep median ’ joins the superficial veins at the bend of the elbow wit the venæ comitantes of the deep arteries.

basilic vein, the larger of the two, passes inwards and upwards, crossin the bicipital aponeurosis, which separates it from the brachial arter and the median nerve; the anterior branch of the medial cutaneou nerve of forearm descends behind or in front of it. Just a little wa above the medial epicondyle it is joined by the anterior and posterio ulnar veins, either separately or as a common trunk; the resultin vessel is the **basilic vein.**

The **radial vein,** usually continuous below with a vein on the bac of the thumb, drains the outer part of the plexus on the back of th

and, and ascends on the back of the outer side of the forearm. Winding round to the front of the limb, it joins the median cephalic vein little way above the lateral epicondyle.

The **anterior ulnar vein** commences on the inner aspect of the front of the wrist, and ascends in front of the inner side of the forearm, to end either in the median basilic or by joining the posterior ulnar vein.

The **posterior ulnar vein** is large, and commences in the inner part of the plexus on the back of the hand; it ascends on the back of the inner side of the forearm, and joins the median basilic, either independently or in common with the anterior ulnar vein.

The principal superficial veins of the arm are the cephalic and the basilic.

The **cephalic vein** is formed by the union of the median cephalic and the radial a little distance above the lateral epicondyle. It ascends, lying at first in the groove at the outer border of the biceps, and at a higher level between the pectoralis major and deltoid. Finally, it crosses the first part of the axillary artery, and, traversing the clavi-pectoral fascia, joins the axillary vein above the pectoralis minor.

The **basilic vein** is formed by the union of the median basilic with the anterior ulnar and posterior ulnar veins just above the medial epicondyle. It ascends in the groove on the inner border of the biceps, lying to the inner side of the brachial artery. In the lower part of the arm it is superficial, but passing through the deep fascia about the middle of the arm, it becomes continuous above with the **axillary vein** (p. 428). In relation with the basilic vein, just above the medial epicondyle, are one or two lymphatic glands.

Front and Inner Aspects of the Arm.

Deep Fascia.—The deep fascia provides a complete investment for the arm, its fibres being principally disposed transversely, but others run more or less longitudinally. It is continuous above with the axillary fascia and the fascial investments of the pectoralis major and deltoid, the tendons of which give expansions to it. It is thin over the biceps, and somewhat thicker over the triceps, but it becomes especially strong in the region of the elbow, where it is attached to the epicondyles of the humerus and olecranon process of the ulna. In front of the elbow it receives a considerable accession of fibres from the bicipital aponeurosis. At about the middle of the arm, on its inner aspect, it presents an opening for the passage of the basilic vein. The deep fascia is connected with the lower part of the humerus on either side by two **intermuscular septa.** The *lateral* septum is attached to the lateral epicondyle and the lateral supracondylar ridge. Arching across the spiral groove, containing the radial nerve and profunda artery, it extends upwards to the insertion of the deltoid, with which it is connected. It gives origin posteriorly to the medial head of the triceps, and above to the lateral head of the muscle. Anteriorly,

from above downwards, it gives origin to a small part of brachial to the brachio-radialis, and to the extensor carpi radialis longu The posterior terminal branch of the profunda artery descends behi it. The *medial* septum is stronger than the lateral and is attach to the medial epicondyle and the medial supracondylar ridge as hi as the insertion of the coraco-brachialis. It gives origin anterio to brachialis, and posteriorly to the medial head of the triceps. is pierced at its upper part from before backwards by the ulnar ner and ulnar collateral artery, and a little above the elbow by t posterior branch of the supratrochlear artery. Connected with t medial septum there is a fibrous band, known as the *medial brach ligament* (Struthers), which extends from the humerus below t tendon of insertion of the teres major to the medial epicondy By means of the humerus and the two intermuscular septa the low part of the arm is subdivided into two compartments: an anteri containing the flexor muscles, and a posterior containing the extens muscles.

The Supratrochlear Lymphatic Glands.—These glands, usual two in number, are situated about $1\frac{1}{2}$ inches above the medial ep condyle of the humerus. They lie in the subcutaneous tissue close proximity to the commencement of the basilic vein. The *afferent* vessels are derived from the inner three fingers, the inn part of the palm, and the ulnar side of the forearm. Their *effere* vessels ascend with the basilic vein, and join the deep lymphati accompanying the brachial artery; they terminate in the *later* axillary glands.

The Antecubital Lymphatic Glands are very inconstant. Whe present, they are found in the subcutaneous tissue at the bend of t elbow. They receive *afferent* vessels from the middle of the palm an the front of the forearm. Their *efferent* vessels accompany the basil vein, and end in the lateral axillary glands.

Coraco-brachialis—*Origin.*—The tip of the coracoid process of t scapula and the inner aspect of the tendon of the short head of t biceps.

Insertion.—An impression on the inner aspect of the shaft of t humerus about the middle of the bone. Some of the upper fibres a inserted into a fibrous band, which arches across the tendons of t latissimus dorsi and teres major, and is attached above to the humer immediately below the lesser tuberosity.

Nerve-supply.—A branch of the musculo-cutaneous, containin fibres from the seventh cervical nerve.

The muscle is directed downwards, outwards, and slightly bac wards.

Action.—Adducts the arm and flexes the shoulder-joint.

The muscle is traversed by the musculo-cutaneous nerve.

Biceps Brachii (Fig. 284)—*Origin.*—The **short head** arises from t tip of the coracoid process of the scapula in common with the corac brachialis; the **long head** arises by tendon from the supraglenoid tuberc

: the scapula, where it is continuous on either side with the labrum enoidale. The tendon lies within the limits of the capsular ligament : the shoulder-joint.

Insertion.—The posterior rough portion of the tuberosity of the ıdius, being separated from the anterior smooth portion by a bursa; ıd into the deep fascia covering the flexor muscles arising from the ıedial epicondyle of the humerus by means of the bicipital aponeurosis.

The short head arises y a short tendon, the ːndon of the long head ːing about 4 inches in ngth. This latter tendon ːches over the head of ıe humerus, and leaves ıe joint by entering the icipital groove, which is ɔnverted into a canal by ıe transverse humeral gament. Within the ɔint it is invested by a ːflexion of the synovial ıembrane, which is pro-ɔnged downwards for a ıort distance into the icipital groove, where it rovides a synovial sheath ɔr the tendon. After aving the bicipital groove ıe tendon is replaced by conical bundle of fleshy bres, and these, joining ıe fibres derived from ıe short head about the ıiddle of the arm, give se to an elongated, oval, eshy belly. At the level [the epicondyles of the umerus the belly gives lace to the strong ten-on of insertion, which, s it sinks backwards into the antecubital space to reach its insertion, twisted upon itself in such a manner that its outer edge comes to ɔok forwards. From the inner side of the upper part of this tendon strong band of fibres is prolonged downwards and inwards, and lends with the deep fascia covering the flexor muscles arising from ıe medial epicondyle. This band, called the *bicipital aponeurosis*, ridges across the brachial artery and median nerve; the median basilic ein and the medial cutaneous nerve of forearm lie superficially to it.

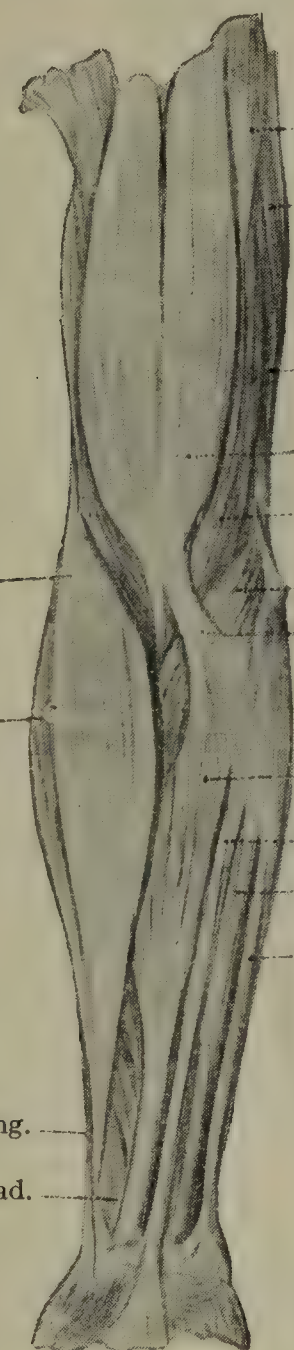


FIG. 283.—FRONT VIEW OF MUSCLES OF 'FREE' UPPER LIMB.

Nerve-supply.—Branches of the musculo-cutaneous, containi fibres from the fifth and sixth cervical nerves.

Action.—Flexes the elbow-joint, and is a powerful supinator of t forearm; it is also a flexor of the shoulder-joint.

Medial to the upper part of the muscle is the coraco-brachia and to its lower part the brachial artery and median nerve. To outer side is the cepha vein. As a rule, it is late to the brachial artery, b when well developed may in front of it for some d tance.

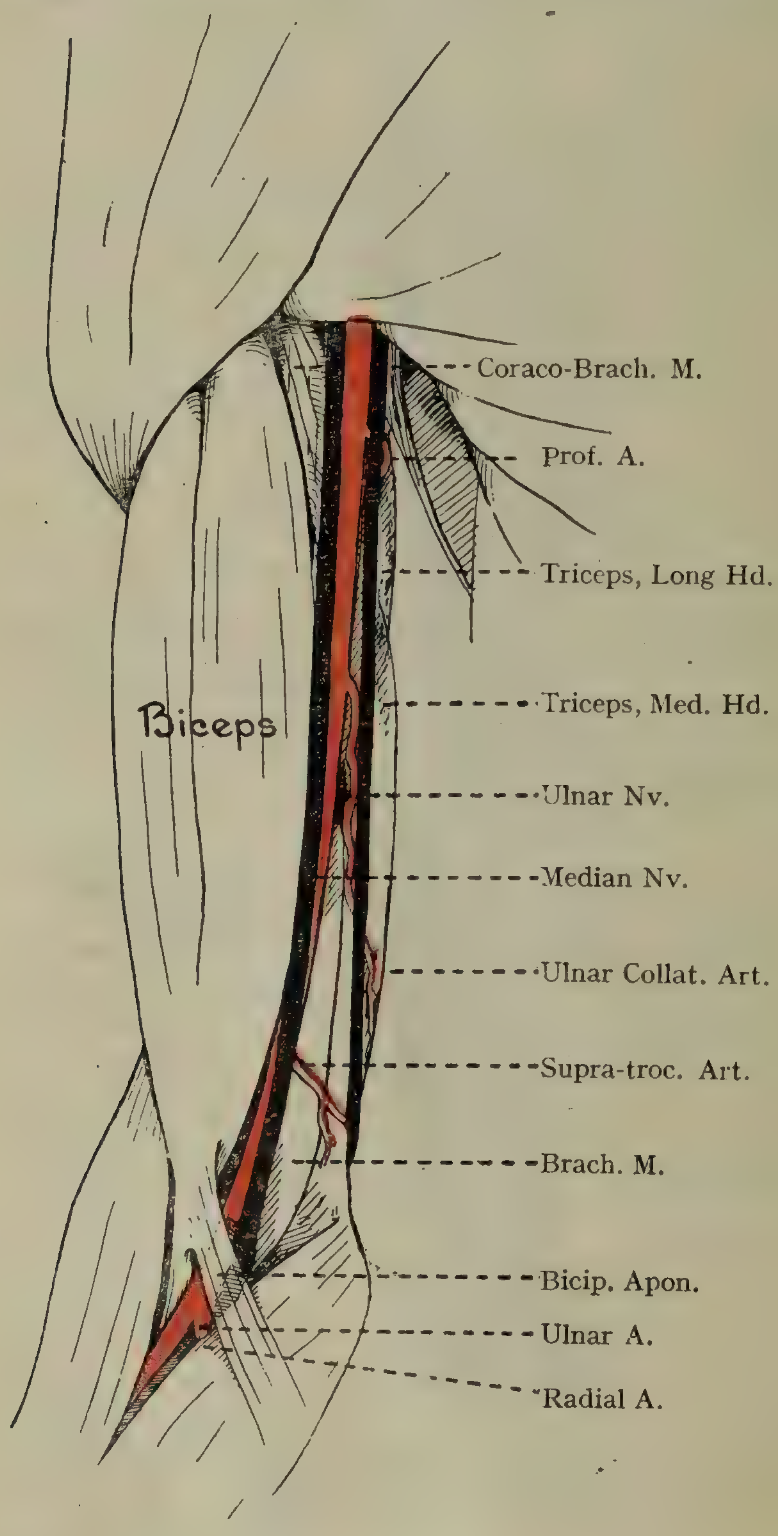


FIG. 284.—THE BRACHIAL ARTERY FROM IN FRONT, ILLUSTRATING ITS MAIN BRANCHES AND MORE IMPORTANT RELATIONS.

The biceps sometimes ha *third head*, which usually ari from the inner side of the h merus at or near the insertion the coraco-brachialis.

Brachialis—*Origin.*—T lower half of the front the humerus; the front the medial intermuscul septum for its whole exter and the front of the late intermuscular septum for short distance above.

Superiorly the area attachment of the musc bifurcates to embrace t lower part of the inserti of the deltoid, the outer sl occupying the floor of t spiral groove.

Insertion. — The rou triangular surface below t coronoid process of the uln

Nerve-supply.—Branch of the musculo-cutaneo nerve, containing fibres fro the fifth and sixth cervic nerves, and a twig from t radial nerve.

Action.—A flexor of t elbow-joint.

Brachial Artery (Fig. 284).—The brachial artery is the continuati of the axillary, and extends from the lower border of the teres maj to a point just below the bend of the elbow, where it divides opposi the upper part of the neck of the radius into the radial and uln arteries. It is at first medial to the humerus, but gradually inclin

o the front of the bone, and at the elbow is situated midway between he two epicondyles. The course of the vessel is indicated by a line lrawn from the inner border of the coraco-brachialis to a point midway etween the epicondyles of the bone. The artery is accompanied by wo venæ comites, which lie one on either side, are connected together y numerous transverse communications which lie both in front of nd behind the artery, and thus communicate with each other across he vessel at frequent intervals. It is for the most part superficial, eing only slightly overlapped by the coraco-brachialis and biceps. At he bend of the elbow, however, it sinks deeply under cover of the icipital aponeurosis, and lies in the antecubital space.

Relations—*Superficial.*—Skin, superficial and deep fasciæ, the nedian nerve towards the lower part of the arm, bicipital aponeurosis f the biceps, and, superficial to this, the median basilic vein. *Deep.*—he long head of the triceps, with the intervention of the radial nerve nd profunda artery, medial head of the triceps, insertion of the coraco-rachialis, and brachialis. *Lateral.*—The coraco-brachialis and biceps, oth of which slightly overlap the vessel, lateral vena comes, and the nedian nerve in the upper part of the arm. *Medial.*—The medial vena omes, medial cutaneous nerve of forearm (which may be slightly in ront of the vessel), the ulnar nerve in its upper part, and the median erve in its lower part, and the basilic vein. The nerve most intimately elated to the artery is the median, which, lying on its *outer side* in the pper part of the arm, crosses *in front* of it, and for some little distance bove the elbow lies on its *inner side.*

Branches.—A series of small irregular branches are distributed to he muscles and skin on the front of the arm. The named branches rise from the inner and back part of the trunk.

The **profunda artery** (Fig. 285) is a large vessel arising from the back f the brachial near its commencement. It passes downwards and ackwards with the radial nerve between the long and medial heads f the triceps, and winds round to the back of the shaft of the humerus, ying with the nerve in the spiral groove between the lateral and medial eads of the muscle. Towards the lower end of the groove it divides nto two terminal branches—anterior and posterior. The *anterior ranch* accompanies the radial nerve through the lateral intermuscular eptum, and descends between the brachio-radialis and brachialis to nastomose with the radial recurrent artery. The *posterior branch* escends behind the lateral intermuscular septum, and anastomoses ehind the lateral epicondyle with the posterior interosseous recurrent, nd across the back of the humerus above the olecranon fossa with the upratrochlear. In addition to the two terminal branches the pro-unda gives off *muscular* branches to the triceps; an *ascending branch,* assing upwards between the long and lateral heads of the triceps to nastomose with a branch of the posterior humeral circumflex; and a *utrient branch,* which enters a foramen on the back of the humerus.

The profunda may arise from the third part of the axillary, or may arise in ommon with the posterior humeral.

The **ulnar collateral artery** arises from the brachial about the mi of the arm. It accompanies the ulnar nerve, passing through medial intermuscular septum, descends with the nerve on medial head of the triceps to back of the medial epicondyle, wh it anastomoses with the su trochlear and posterior ulnar re rent arteries. It supplies muscu branches to the triceps.

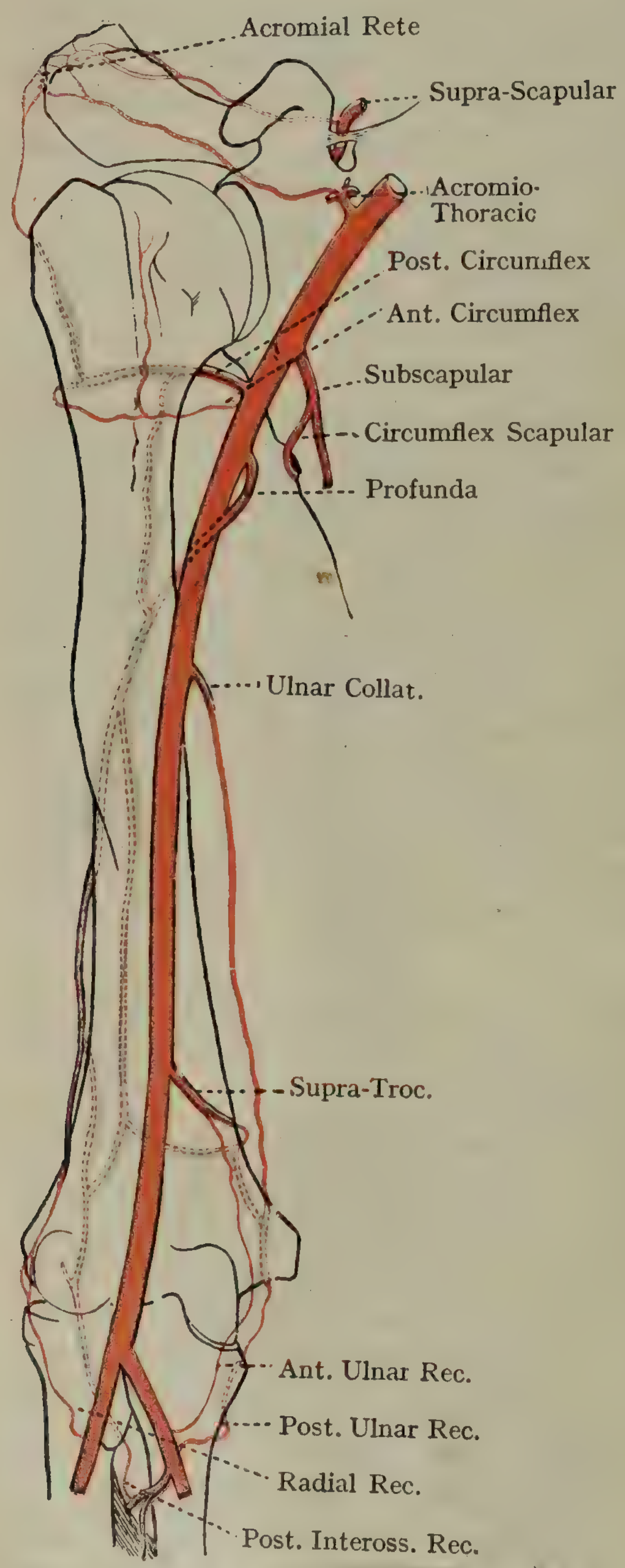


FIG. 285.—TO ILLUSTRATE THE RELATIONS OF THE BRACHIAL ARTERY AND ITS BRANCHES TO THE SKELETON, AND THEIR PROXIMAL AND DISTAL ANASTOMOSES.

The **nutrient artery** arises fr the brachial opposite the lo border of the insertion of coraco-brachialis, or it may co off from the ulnar collateral. passes downwards and enters nutrient foramen of the bone.

The **supra-trochlear artery** ar about 2 inches above the elb It passes inwards on brachialis, a divides into two branches—a sm anterior and a larger posterior. T *anterior branch* descends in front the medial epicondyle, and anas moses with the anterior ulnar rec rent artery. The *posterior bra* passes through the medial int muscular septum, and, passing o wards on the back of the hume above the olecranon fossa lyi deeply to the triceps, it comple an arterial arch with the poster branch of the profunda artery. sends a branch to the back of t medial epicondyle, where it ana tomoses with the ulnar collateral a posterior ulnar recurrent arteries.

Varieties.—1. The brachial artery m divide at a higher level than usual. most cases the abnormally early bran is the radial; more rarely it is the uln and in these cases the interosseous tru arises from the radial; still more rare the premature branch is the interosse trunk, or a large vas aberrans. T level at which a high division takes pla is most frequently in the upper third of the arm, less frequently in the low third, and rarely in the middle third. When two arteries are present, th usually lie one in front of the median nerve and the other behind it. Wh a vas aberrans is present, it usually arises from the upper part of the brach

tery, lies in front of the median nerve, and terminates below by joining, most mmonly, the radial artery.

2. In rare cases the brachial artery divides high up into two vessels of equal ze, which become reunited into one trunk a little above the elbow.

3. When a supracondylar process is present the brachial artery, together ith the median nerve, may descend behind it, and then pass forwards to the ont of the elbow below it. This course resembles that of the artery in the *elidæ*, in which a supracondylar foramen is normally present.

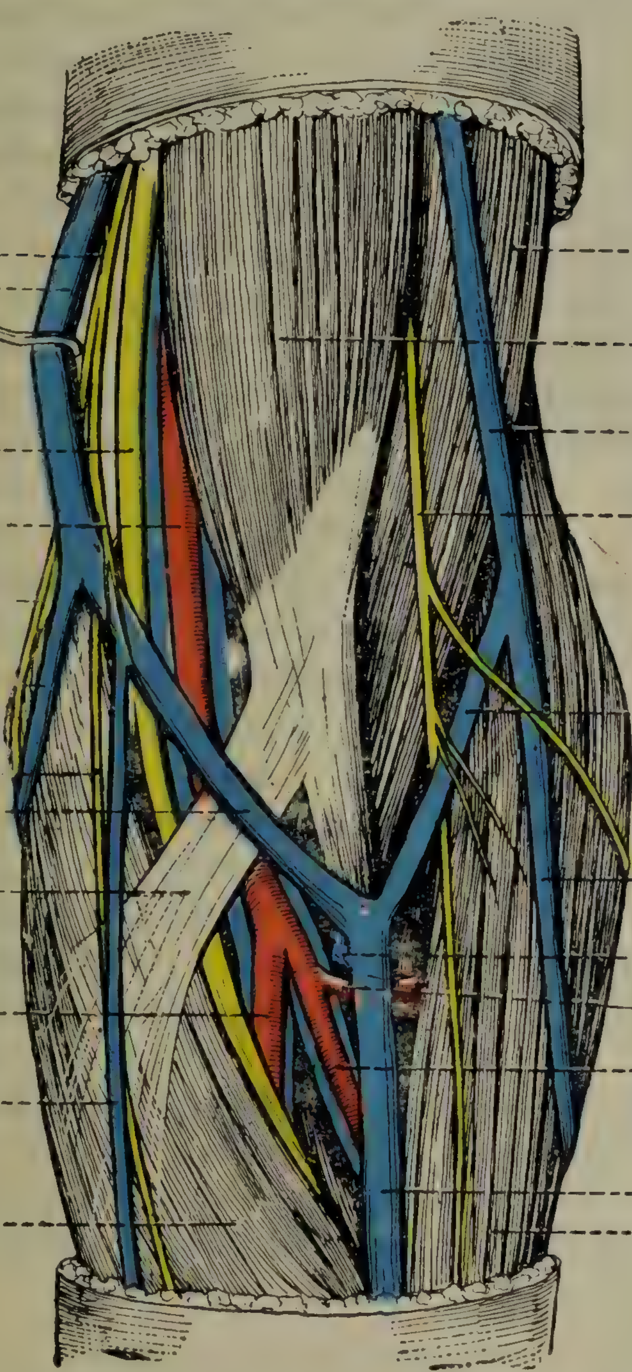


FIG. 286.—SUPERFICIAL DISSECTION OF THE FRONT OF THE LEFT ELBOW.

Collateral Circulation.—When the upper part of the brachial artery s tied, the circulation is maintained by the profunda artery, which nastomoses below with the radial recurrent, the posterior interosseous ecurrent, and the supratrochlear. When the artery is tied in the egion of the elbow, the ulnar collateral and supratrochlear, by anasto-nosing with the anterior and posterior ulnar recurrent, provide addi-ional channels.

The **medial cutaneous nerve of forearm** and the **medial cutaneous erve of arm** lie to the inner side of the brachial artery, the former

slightly overlapping it in front. In the upper part of the arm th **median nerve** lies on the outer side of the artery, but as it descends i crosses in front of it, and finally lies on its inner side. Instead c crossing in front of the vessel it may pass behind it. The median nerv gives off no branches in the arm, but sometimes receives a branch c communication from the musculo-cutaneous. The **ulnar nerve** lies o the inner side of the artery as low as the insertion of the coraco-brachialis Parting company with the brachial artery, it descends with the ulna collateral artery, with which it passes through the medial intermuscula septum to the interval between the olecranon and medial epicondyle It has no branches in the arm. After the **musculo-cutaneous nerv** has traversed the coraco-brachialis, it passes obliquely downward and outwards between the biceps superficially and brachialis deeply In the region of the elbow it appears at the outer border of th biceps, and descends into the forearm as the lateral cutaneous nerv of forearm (p. 465). It supplies the coraco-brachialis (before reach ing it), and distributes branches to the biceps and brachialis as i lies between them. It sometimes communicates with the media nerve.

The Cubital Fossa (Fig. 286).—This is the triangular hollow in fron of the elbow. In the *roof* of the space are the skin, the median basili and median cephalic veins, the medial cutaneous nerve of forearm, th musculo-cutaneous nerve, deep fascia, and bicipital aponeurosis. Th *floor* is formed by brachialis and a small part of supinator. The *bas* is represented by an imaginary line connecting the epicondyles of th humerus. The *outer boundary* is formed by the brachio-radialis, th *inner* by the pronator teres; the two muscles converge as they extend downwards, and the *apex* of the space is the point where their adjacen margins meet, the pronator teres disappearing here under cover o the brachio-radialis. The space contains the terminal part of the brachial, and the commencement of the radial and ulnar vessels. Or the outer side of the brachial artery is the tendon of the biceps, and on its inner side is the median nerve. Under cover of the brachio-radialis the radial nerve gives off its posterior interosseous branch.

Back of the Arm.

Triceps (Fig. 287)—*Origin.*—The **long head** arises by tendon from the infraglenoid tubercle of the scapula. The **lateral head** arises from the outer part of the posterior surface of the humerus, extending as high as the insertion of the teres minor, and as low as the spiral groove and slightly from the back of the lateral intermuscular septum above the level at which the radial nerve passes through it. The **medial head** arises from the posterior surface of the humerus below the spiral groove reaching upwards on the inner side of the groove as high as the in sertion of the teres major, the whole extent of the back of the media intermuscular septum, and the back of the lateral intermuscular septum below the level at which the radial nerve passes through it.

Insertion.—By a tendon attached to the back part of the upper surface of the olecranon process of the ulna, and slightly into the posterior ligament of the elbow-joint. An expansion from the outer side of the tendon sweeps downwards over the anconeous muscle, and blends with the deep fascia of the forearm.

The long and lateral heads end in a broad flat tendon occupying the lower part of the arm, the fibres of the long head ending on its inner side, those of the lateral head on its upper and outer parts. Most of the fibres of the medial head end on the deep surface of the tendon, but the lowest fibres are attached directly to the olecranon. The deepest and lowest fibres of the inner head are inserted into the posterior ligament of the elbow-joint, forming the so-called **subanconeous.** There is usually a bursa over the front part of the upper surface of the olecranon, separating the tendon of the muscle from the posterior ligament of the elbow-joint.

The long head is related to the lower part of the capsular ligament of the shoulder-joint.

Nerve-supply.—Branches of the radial containing fibres from the sixth, seventh, and eighth cervical nerves.

Action.—Extends the elbow-joint. The long head also extends the shoulder-joint.

FIG. 287.—HUMERUS, WITH ATTACHMENT OF TRICEPS AND RADIAL NERVE, SEEN FROM BEHIND.

The Radial (Musculo-spiral) Nerve (Fig. 288) lies at first behind the third part of the axillary artery, between it and the subscapularis, and at a lower level behind the upper part of the brachial. Thence it passes downwards and backwards, with the profunda artery, between the long and medial heads of the triceps, and winds round the back of the humerus in the spiral groove, lying between the attachments of the lateral and medial heads of the triceps. Passing through the upper part of the lateral intermuscular septum, it descends into the groove between the brachio-radialis and brachialis a little way above the lateral epicondyle, where it gives off the posterior interosseous nerve.

Branches—*Medial Branches.*—Arise on the inner side of the humerus.

Muscular branches supply the long and medial heads of the tricep
the branches to the long head are short and enter its upper part. Th
branch to the medial head, or *ulnar-collateral nerve,* is a long, slend

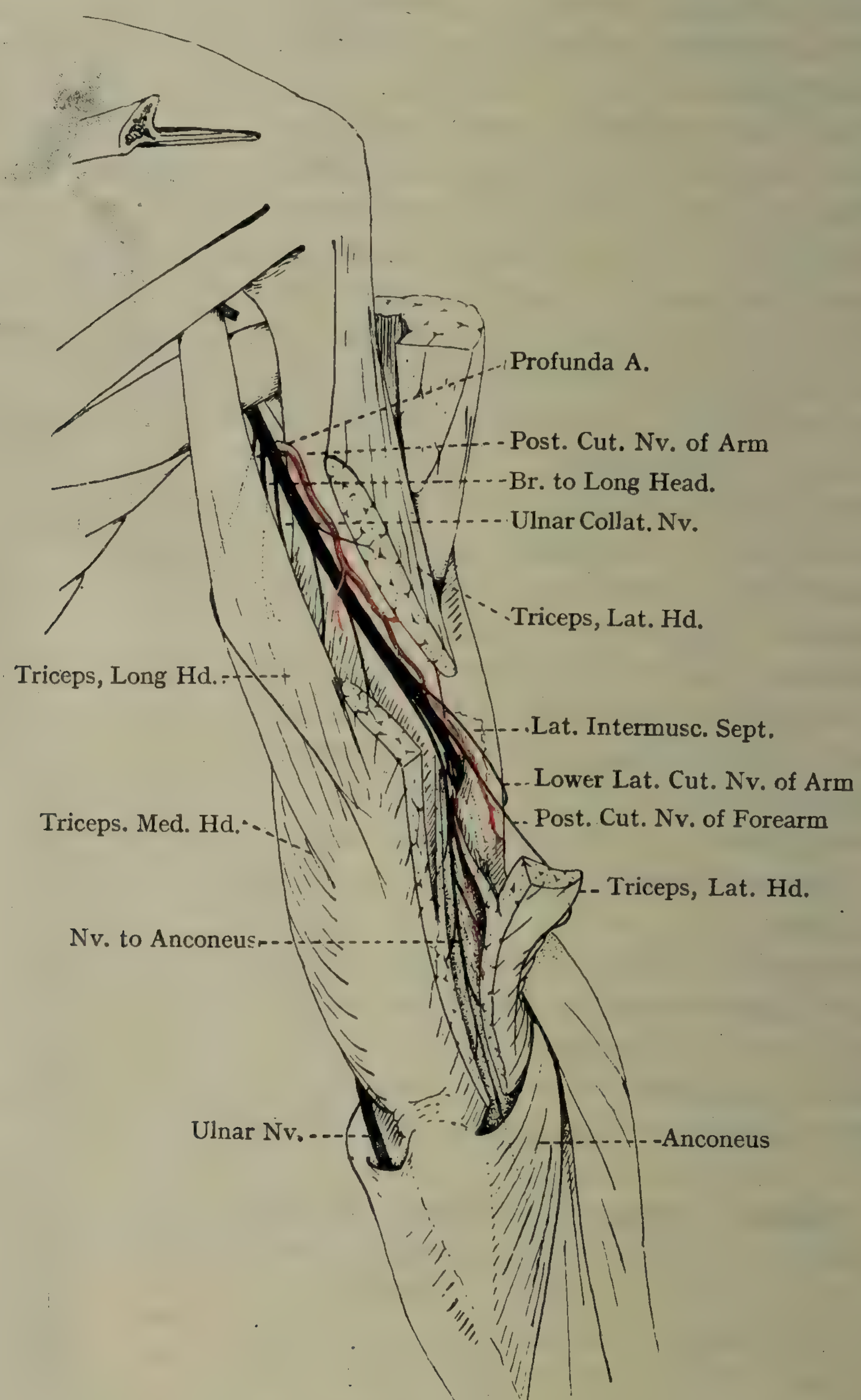


FIG. 288.—THE RADIAL NERVE AND THE PROFUNDA ARTERY FROM BEHIND.

The lateral head of the triceps has been partially removed to expose the artery and nerve as they lie on the back of the humerus. The lower part of the muscle has been incised vertically to display the nerve which terminally supplies the anconeus. There is a small elongated enlargement on the nerve at the back of the elbow-joint.

nerve which accompanies the ulnar nerve and enters the lower part of the muscle. The **posterior cutaneous nerve of arm** often arises in common with one of the muscular branches; it is distributed to the

skin on the back of the arm, and extends downwards nearly as low as the elbow.

Posterior Branches arise behind the humerus, and are distributed to the lateral and medial heads of the triceps and to the anconeus. The nerve to the anconeus is the terminal twig of one of the largest branches supplying the inner head. This branch passes downwards through and distributes branches to the muscle, finally escaping from its lower edge to end in the anconeus. As this nerve lies on the back of the elbow-joint it presents a small elongated swelling (pseudo-ganglion).

Lateral Branches appear on the outer side of the humerus, and are cutaneous, muscular, and articular. The lower lateral cutaneous nerve of arm and the posterior cutaneous nerve of forearm have been already described (p. 448). The **muscular branches** supply the brachio-radialis, extensor carpi radialis longus, and brachialis, the last branch being inconstant. The **articular branches** are distributed to the elbow-joint.

The Shoulder-Joint.

The articular surfaces are the glenoid cavity of the scapula and the head of the humerus. The glenoid cavity is deepened by the labrum glenoidale, a circumferential rim of fibro-cartilage. The joint is surrounded by a capsular ligament with which certain accessory ligaments, the coraco-humeral and gleno-humeral, are associated.

The **capsular ligament** (Fig. 289) is attached to the margin of the glenoid cavity of the scapula, close to the labrum glenoidale, with which many of its fibres are connected. Above it extends to the root of the coracoid process, and below it is related to the long head of the triceps. At the humerus it is attached to the bone bordering the articular surface, and extends for some little distance on to the shaft, this being more particularly the case below. The ligament is so extensive and loose that when the surrounding muscles are divided the head of the humerus can be withdrawn from the glenoid cavity for a distance of an inch or more. The ligament presents two deficiencies. One, the *foramen ovale*, is situated in front, behind the tendon of the subscapularis. Through it the synovial membrane of the joint is continuous with a large bursa underlying the subscapularis, and intervening between it and the neck of the scapula. Opposite the upper end of the bicipital groove of the humerus the attachment of the capsular ligament to the bone is interrupted, and it blends there with the transverse ligament. This interruption gives passage to the tendon of the long head of the biceps, which as it descends into the canal formed by the bicipital groove bridged over by the transverse ligament is invested by a synovial sheath continuous above with the synovial membrane of the joint. A deficiency on the posterior aspect of the capsule, whereby the synovial membrane is continuous with a bursa underlying the infraspinatus, is sometimes present.

The **coraco-humeral ligament** is a strong band which extends fron the root and inferior aspects of the coracoid process to the greate tuberosity of the humerus. It strengthens the upper part of th capsule, with which it is closely blended.

The **gleno-humeral ligaments** (Fig. 291) are three thickenings c the capsular ligament projecting from its deep surface into the join They are best studied by opening the shoulder-joint from behind and examining the deep surface of the anterior part of the capsula ligament from this point of view. The *superior* extends from th upper end of the anterior margin of the glenoid cavity to the lesse

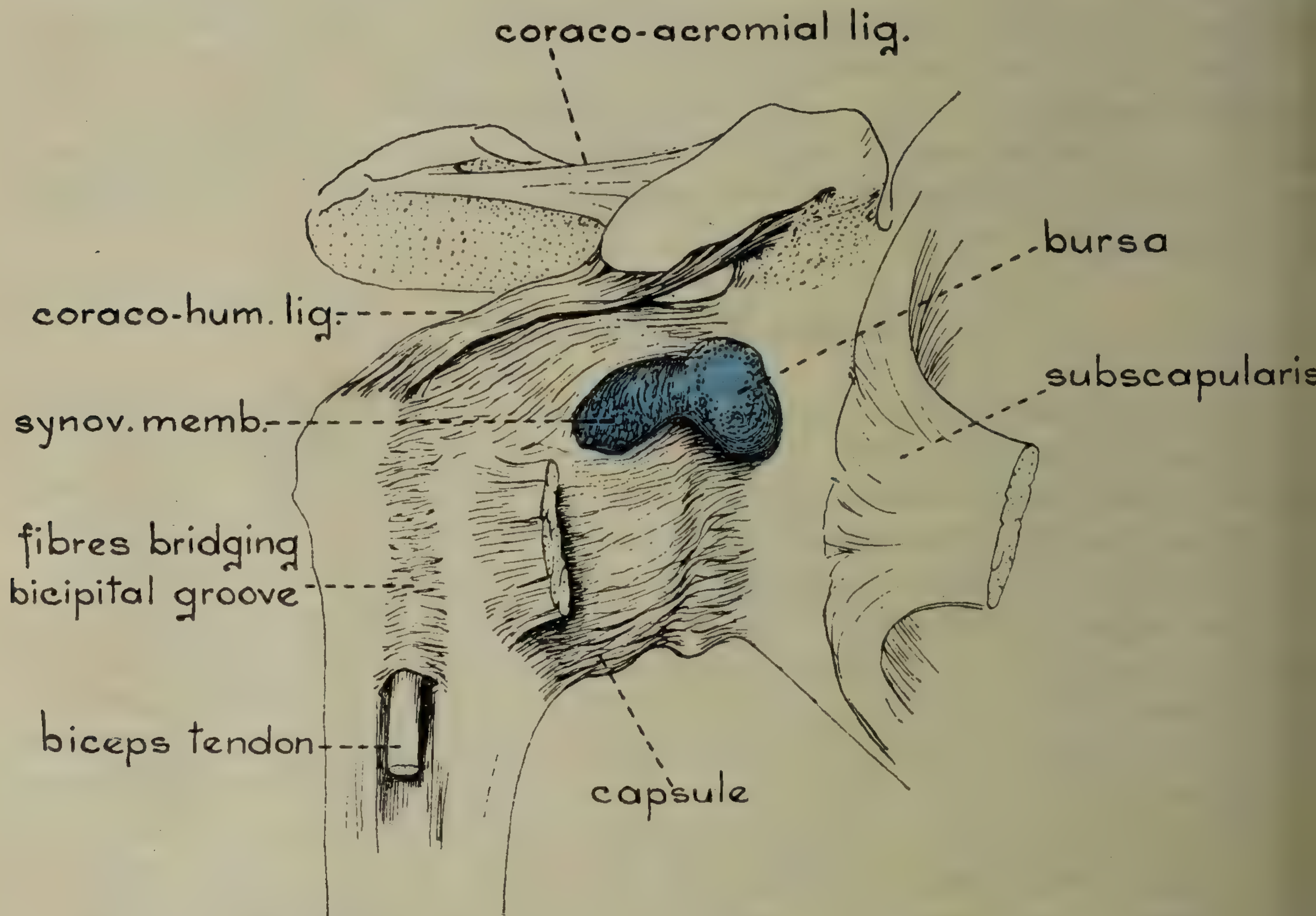


FIG. 289.—THE SHOULDER-JOINT FROM IN FRONT.

The subscapularis has been reflected to expose the bursa between it and the neck of the scapula, and the continuity of this bursa with the synovial membrane of the joint.

tuberosity of the humerus. It is closely applied to the front edge of the tendon of the biceps, to the presence of which it is largely due. The *middle* (Flood's ligament) is inseparable from the superior at its glenoid attachment, but diverges from it as it extends downwards to the lower part of the lesser tuberosity. It has a well-defined upper edge, forming the lower boundary of the deficiency in the front of the capsular ligament, this deficiency being covered in front by the tendon of the subscapularis. The *inferior* (Schlemm's ligament) extends from about the middle of the anterior margin of the glenoid cavity to the inferior aspect of the head of the humerus. With the

xception of its upper edge, it is a somewhat ill-defined band which below merges imperceptibly with the general capsular ligament.

The **transverse ligament,** with which the capsular ligament blends p. 461), consists of transverse fibres which extend between the two uberosities of the humerus, and bridge across the upper end of the icipital groove.

The **labrum glenoidale** is a dense fibro-cartilaginous ring, triangular n section, the base being implanted on the edge of the glenoid cavity. t deepens the glenoid cavity for the reception of the head of the umerus. Peripherally it is connected with the capsular ligament, nd above is incorporated with the tendon of origin of the long head f the biceps.

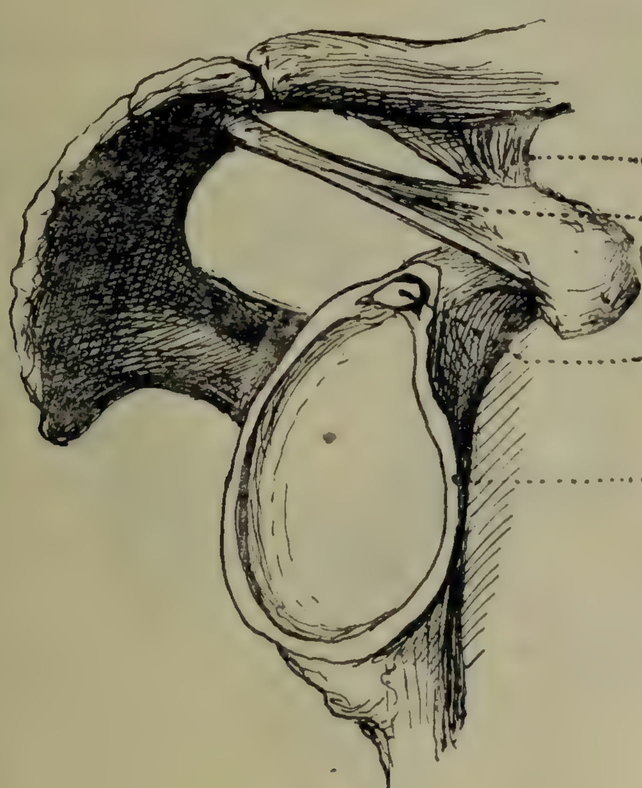


FIG. 290.—THE RIGHT GLENOID CAVITY AND THE ADJACENT LIGAMENTS.

The tendon of the **long head of the biceps** may be regarded as a upplementary ligament, as it straps over the head of the humerus, nd is concerned in preventing its upward displacement.

The **synovial membrane** may be traced from the free margin of he labrum glenoidale on to its outer aspect, and thence on to the eep surface of the capsular ligament, for which it provides a comlete lining. It is reflected from the humeral attachment of the apsular ligament, and provides a slight investment for the bone urrounding the articular head of the humerus, especially below, here it is prolonged for some little distance downwards on the inner spect of the shaft. It ceases at the margin of the cartilage clothing he head of the humerus. Through the deficiencies on the front constant) and back (occasional) of the capsular ligament, it is connuous with the bursæ underlying the subscapularis and infraspinatus espectively. A fold of the synovial membrane is reflected from the

upper part of the capsular ligament, and surrounds the tendon of th long head of the biceps, which is thereby excluded from the synovi cavity. This fold is continuous with the synovial sheath investi the tendon of the biceps as it lies in the bicipital groove.

Muscular Relations.—*Above*, the supraspinatus; *behind*, from abo downwards, infraspinatus and teres minor; *below*, long head of th triceps; and *in front*, subscapularis. The tendons of all these muscl are all more or less intimately blended with the capsular ligamen

Nerve-supply.—The suprascapular and circumflex nerves.

Movements.—As regards both range and variety of movement, the should joint enjoys a greater mobility than any other joint in the body. Flexio

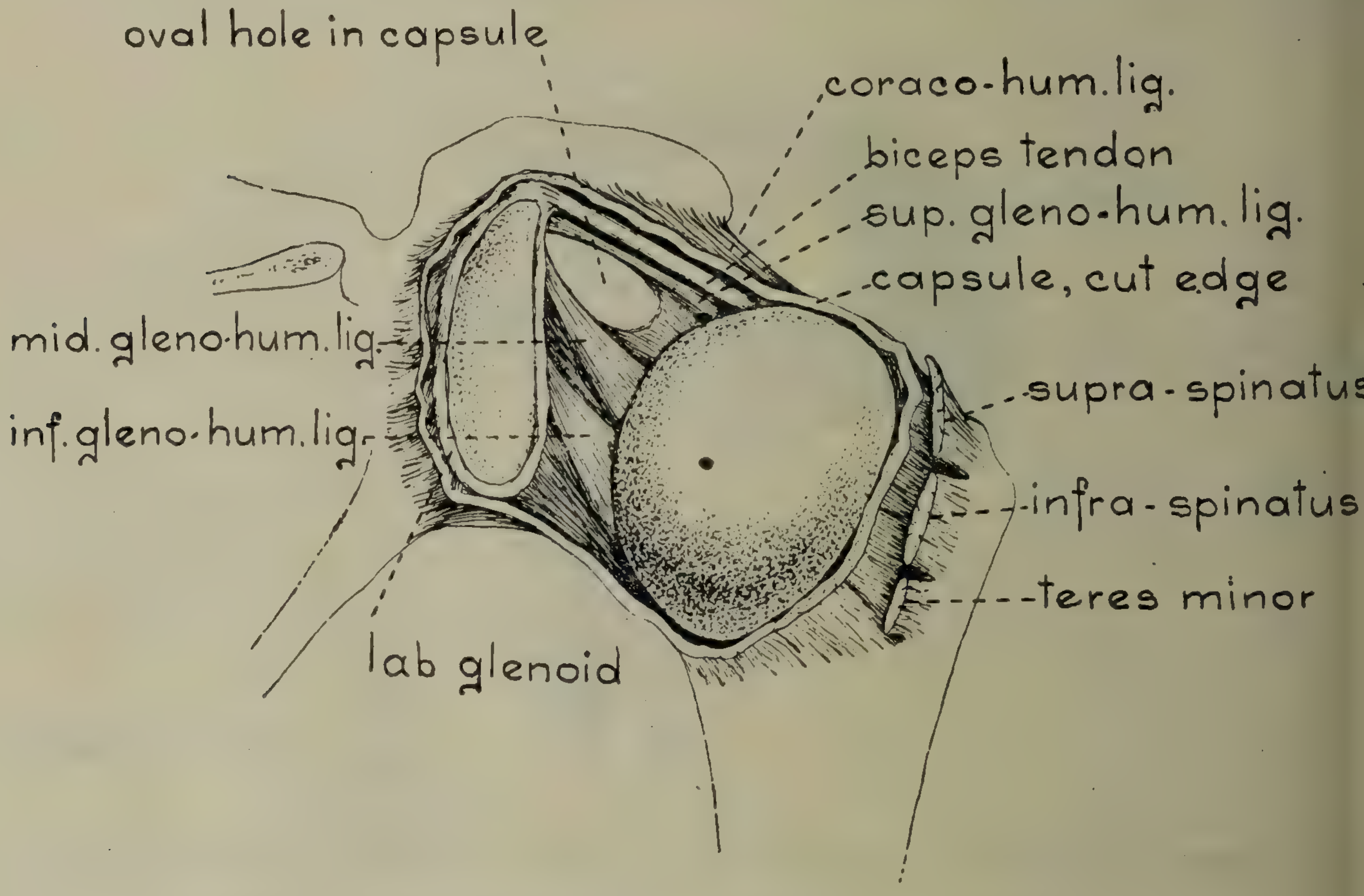


FIG. 291.—THE SHOULDER-JOINT FROM BEHIND.

The posterior part of the capsular ligament has been removed, and the hea of the humerus withdrawn from the glenoid cavity to bring the three glen humeral ligaments into view.

extension, abduction, adduction, a combination of these four movements takin place in succession or circumduction, and rotation, all occur with considerab freedom.

Bursæ.—The **subscapular bursa** lies between the tendon of th subscapularis muscle and the neck of the scapula, from which it extend outwards and overlaps the capsular ligament. It is continuous wit the synovial membrane of the joint through the *foramen ovale.*

The **subacromial** or **subdeltoid bursa,** one of the largest bursæ i the body, is situated under cover of the acromion process of th scapula, the coraco-acromial ligament, and the acromial portion o the deltoid muscle. It intervenes between these structures and th

pper part of the capsular ligament, together with the tendons in-
rted into the greater tuberosity of the humerus. It is usually multi-
cular, and is independent of the synovial cavity of the joint.

The **bursa of the infraspinatus muscle** is not constant. When
esent, it is situated between the tendon of that muscle and the
ck part of the capsule. It may communicate with the synovial
embrane of the joint.

The **bursa of the latissimus dorsi muscle** is situated between the
ndon of this muscle and that of the teres major close to their in-
rtions.

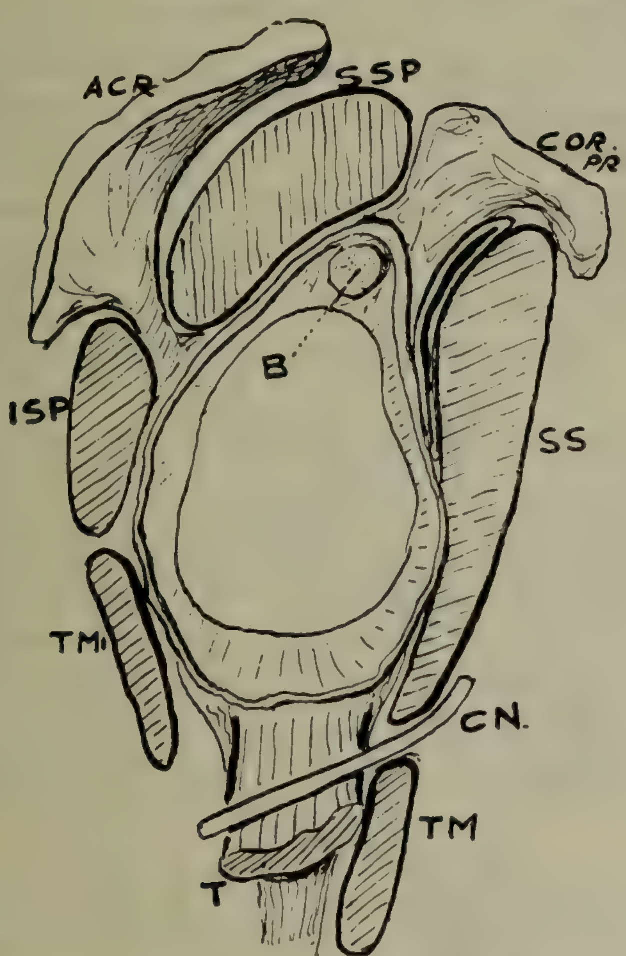


FIG. 292.—SCHEME TO SHOW RELATIONS OF SHOULDER CAPSULE.

CR, acromion; SSP, supraspinatus; SS, subscapularis; CN, circumflex nerve; TM, teres major; T, long head of triceps; TMi, teres minor; ISP, infraspinatus; B, long tendon of biceps.

The **bursa of the teres major muscle** is situated behind the tendon
f this muscle between it and the shaft of the humerus.

The **bursa of the coraco-clavicular ligament** is situated between
e conoid and trapezoid ligaments.

The **bicipital synovial sheath** invests the long tendon of the biceps
the upper part of the bicipital groove of the humerus.

The Forearm and Hand.

Cutaneous Nerves (Figs. 280, 293).—On the outer side of the front
f the forearm is the lateral cutaneous nerve of forearm, on its inner
de the medial cutaneous nerve of forearm. A small cutaneous branch
f the ulnar nerve occasionally supplies the skin about the middle

of the front of the forearm; it is disposed on the inner side of the med
cutaneous of forearm, with which it communicates.

On the outer side of the back of the forearm is the posterior bran
of the lateral cutaneous of forearm; on its inner side the poster
branch of the medial cutaneous of forearm. Between the two is t
posterior cutaneous of forearm.

The skin of the palm of the hand is supplied by the palmar cutaneo
branches of the ulnar, median, and the terminal branches of the late
cutaneous of forearm. The **palmar cutaneous branch** of the **uln**
arises about the middle of the forearm, and descends for some distan

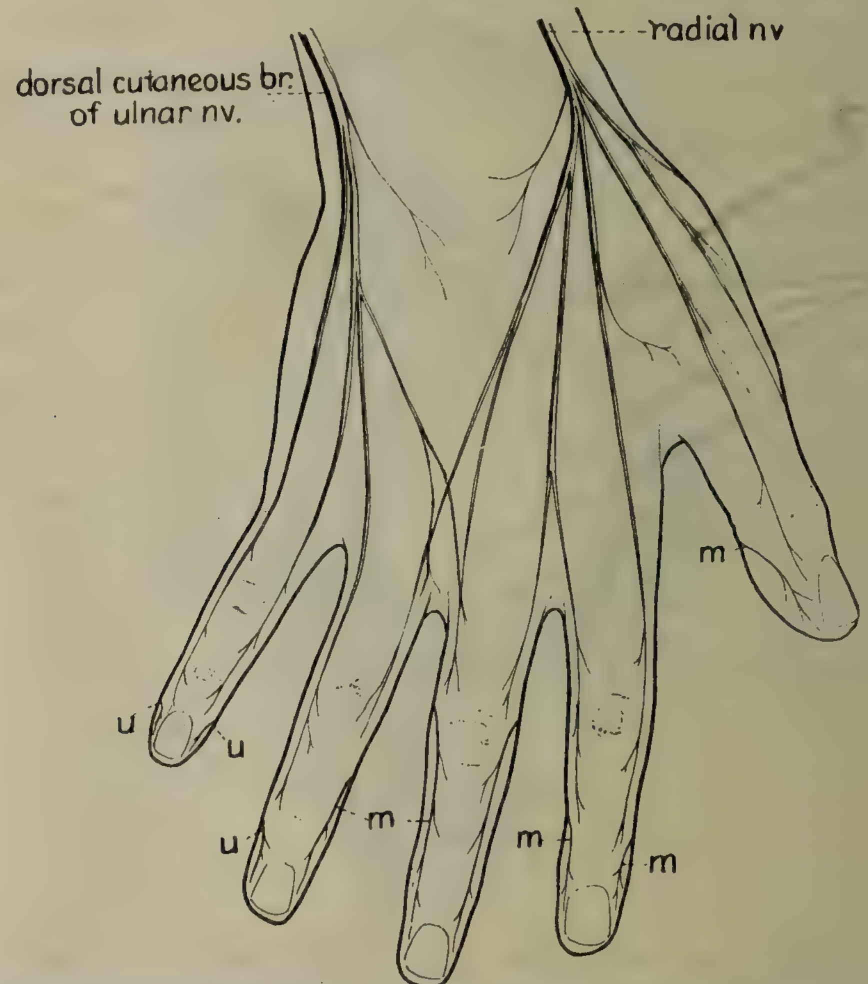


FIG. 293.—PLAN OF THE CUTANEOUS NERVE-SUPPLY OF THE DORSUM OF TH
HAND AND FINGERS.

m and *u* are branches of the palmar digital nerves derived from the media
nerve and ulnar respectively.

in front of the ulnar artery. As it approaches the wrist, it travers
the deep fascia and becomes cutaneous on the outer side of the tendo
of the flexor carpi ulnaris. It passes in front of the flexor retinaculu
and is distributed to the skin of the inner part of the palm. Th
palmar cutaneous branch of the **median** arises a little above the wris
and traverses the deep fascia just above the flexor retinaculum, i
the interval between the tendons of the flexor carpi radialis and th
palmaris longus. It descends superficially to the flexor retinaculum
and is distributed to the skin of the central part of the palm, an
slightly to that of the thenar eminence. It communicates internall
with the palmar cutaneous branch of the ulnar nerve, and laterall

ith that of the lateral cutaneous of forearm. The **terminal branch** : the lateral cutaneous of forearm is distributed to the skin of the ıenar eminence. It communicates with a branch of the radial nerve, hich may take some small share in supplying the skin of the thenar ninence.

The skin on the dorsum of the hand and of the fingers is supplied by ıe radial nerve and the dorsal branch of the ulnar (Fig. 293). The **ıdial nerve** winds backwards deeply to the tendon of the brachio-ıdialis about 3 inches above the wrist, and divides into two branches -lateral and medial. The *lateral branch* supplies the outer side of the ack of the thumb, and may supply some of the skin of the thenar ninence. The *medial branch* communicates with the terminal branch of ıe lateral cutaneous of forearm, sends a branch to the back of the rist, communicating with the dorsal branch of the ulnar, and divides ıto **four digital nerves.** The **first** supplies the inner side of the thumb, ıe **second** the outer side of the index finger, the **third** divides into vo collateral branches supplying the adjacent sides of the index and ıiddle fingers, and the **fourth** passes to the cleft between the middle ıd ring fingers.

The **dorsal branch** of the **ulnar nerve** arises about $2\frac{1}{2}$ inches above ıe wrist, and winds backwards deeply to the tendon of the flexor ırpi ulnaris. It sends a branch to the back of the wrist, which ɔmmunicates with a branch of the radial, and subdivides into digital ranches: one supplies the inner side of the little finger; a second ıpplies the skin lining the cleft between the little and ring fingers, ıd gives a branch to the cleft between the ring and middle fingers, verlapping the supply of the radial to these two fingers. It also ıpplies the skin of the back of the hand.

The extent to which the skin on the dorsum of the hand and of the fingers supplied by the ulnar nerve and by the radial nerve respectively varies con-derably, and the above description refers to the average arrangement only.

The dorsal digital nerves do not extend to the finger-tips, and are ıpplemented by branches of the palmar digital branches of the ıedian and ulnar nerves, passing backwards and supplying the skin ɔvering the more distal parts of the fingers. As a rule, the dorsal igital nerves extend farther on the marginal digits than they do ı the central, reaching the base of the nail of the thumb and of the ttle finger, the distal interphalangeal joint of the index finger, and ı the ulnar side of the ring finger, but only supply the skin on the ıck of the proximal phalanx of the middle finger and of the radial de of the ring finger.

Veins.—On the back of the hand is a dorsal venous plexus, and smaller less important plexus occupies the front of the wrist. The **ɔrsal venous plexus** receives the superficial digital veins, which ɔmmence in plexuses in the region of the nails. Two in each finger, ıe digital veins are placed one on either side towards the dorsal aspect. he two veins communicate with one another on the backs of the

fingers above and below the interphalangeal joints. At the clef the two collateral veins, from the adjacent sides of two fingers, uni to form a single trunk, which ends in the dorsal venous plexus. Tl superficial digital vein from the inner side of the little finger is co tinuous with the posterior ulnar vein. The outer side of the dors venous plexus is drained by the radial and median veins, the inn side by the ulnar veins. The radial vein communicates with the dee veins at the proximal end of the first interosseous space; the posteri ulnar vein has also a deep communication in the region of the wris The venous plexus on the front of the wrist receives small veins from tl palm; it is drained by the median and anterior ulnar veins.

Deep Fascia of the Forearm.—The deep fascia is of considerab strength, its fibres being mainly transverse; some, however, are di posed longitudinally and obliquely. Above it blends with the b cipital aponeurosis, and behind receives an accession of fibres fro the tendon of the triceps. In front of the elbow it presents an openin for the passage of the deep median vein. In the region of the ep condyles it serves as a common tendon of origin to the muscles arisin from these prominences, and is continuous with strong intermuscul septa between them. These septa afford additional origin to tl muscles, and are easily recognized on the surface as white lines. It attached above to the epicondyles of the humerus, to the margins the triangular surface on the back of the olecranon process, and on tl back of the forearm to the posterior subcutaneous border of the uln The deep fascia is thicker and stronger on the back of the forearm tha it is on the front, and in the upper part of the forearm than it is in tl lower. On the front of the wrist it blends with the flexor retinaculun and at the back is thickened to form the extensor retinaculum.

Front of the Forearm.

Muscles.—The muscles of the front of the forearm are disposed i two layers—superficial and deep.

Superficial Layer (Fig. 294).—The muscles of this layer are fiv in number—pronator teres, flexor carpi radialis, palmaris longu flexor digitorum sublimis, and flexor carpi ulnaris.

The five muscles have a common attachment to the medial ep condyle of the humerus, from which they diverge fanwise as the descend; the outermost, the pronator teres, crosses the upper part the forearm obliquely; the innermost, the flexor carpi ulnaris, descenc vertically and occupies the inner margin of the limb. The flex digitorum sublimis is only partially superficial, appearing betwee the flexor carpi ulnaris and the palmaris longus; the greater part the muscle lies deeply to the palmaris longus, the flexor carpi ulnari and the pronator teres. The five muscles, in addition to their commc origin from the medial epicondyle, have extensive attachments t the deep fascia covering them, and to the intermuscular septa inte vening between each muscle and the adjoining muscles. Three of the

—the pronator teres, flexor digitorum sublimis, and flexor carpi ulnaris —have second or supplementary heads of origin from the bones of he forearm.

Pronator Teres arises by two heads. The *superficial* or *humeral ead* is considerably the larger, and *arises* from the front and upper art of the medial epicondyle and lower part of the medial supracon-lylar ridge of the humerus; the deep fascia covering it; and the inter-nuscular septa between t and the flexor carpi adialis medially, and lexor digitorum sublimis leeply. The *deep* or *ulnar ead* is small, and *arises* rom the inner margin of he rough triangular area n the inferior aspect of he coronoid process of he ulna; it joins the deep urface of the superficial ead at an acute angle.

Insertion.—By means f a flat tendon into a ough impression about he middle of the outer urface of the radius, and t the summit of the onvexity of the outward urve involving the shaft f the bone.

Nerve-supply.—Bran-hes of the median, the bres of which are derived om the sixth cervical erve. The branches to ie two heads are usually ndependent, and arise om the median above the vel of the elbow-joint.

The muscle is directed ownwards and outwards.

FIG. 294.—FRONT VIEW OF MUSCLES OF 'FREE' UPPER LIMB.

Action.—Pronates the forearm, and assists in flexing the elbow-oint.

The median nerve lies between the two heads of the muscle; the lnar vessels are on its deep aspect, and the radial vessels and nerve ross it superficially close to its insertion.

The muscle may have a *third head*, arising from the medial intermuscular ptum of the arm, or from a supracondylar process, and, when present, bridges er the brachial artery and median nerve.

The deep or ulnar head of pronator teres is relatively larger in the hum embryo than it is in the adult. It may be independent of the main part of muscle, or may be associated with one of the adjoining muscles—*e.g.*, the fle carpi radialis or palmaris longus. Possibly it represents the proximal end a deep pronating muscle, present in some animals, occupying the whole ext of the radius and ulna, and of which the pronator quadratus is a distal surviv

Flexor Carpi Radialis (Fig. 294)—*Origin.*—The front of the med epicondyle; the deep fascia covering it, and the intermuscular sep separating it from pronator teres laterally, the palmaris longus medial and the flexor digitorum sublimis deeply.

Insertion.—The front of the base of the second metacarpal bo and by a small slip into the front of the base of the third.

The muscle has a fusiform, fleshy belly in the upper half of t forearm, and a strong, flat tendon in the lower half.

Nerve-supply.—A branch of the median, containing fibres from t sixth cervical nerve.

The muscle extends from the inner side of the elbow towards t outer side of the wrist.

Action.—Flexes the wrist, and assists in flexing the elbow.

The tendon of the muscle passes through a special compa ment of the flexor retinaculum, where it occupies the groove on t trapezium. The radial vessels lie to the outer side of the tendon the lower part of the forearm.

Palmaris Longus (Fig. 294)—*Origin.*—The front of the med epicondyle; the deep fascia covering it; and the intermuscular sep separating it from the flexor carpi radialis laterally, flexor carpi ulna medially, and flexor digitorum sublimis deeply.

Insertion.—The central division of the palmar aponeurosis, wi which it is continuous, and the front of the flexor retinaculum.

Nerve-supply.—A branch of the median, containing fibres of t sixth cervical nerve.

Action.—Renders tense the central part of the palmar aponeuros and assists in flexing the wrist and elbow-joints.

The palmaris longus is a very variable muscle, and is not infrequently abse It is the representative of a superficial flexor of the proximal phalanges, t distal part of which persists as the palmar fascia and its digital slips.

Flexor Digitorum Sublimis (Fig. 296)—*Origin.*—The *upper humero-ulnar head* has an extensive and continuous attachment the medial epicondyle above, the medial ligament of the elbow-joi intermediately, and below to the tubercle marking the upper limit the ridge on the inner side of the rough triangular area on the inferi aspect of the coronoid process of the ulna. The *lower* or *radial hea* is broad and thin; it arises from the anterior oblique line of the radiu The fibres of both heads also arise from the deep aspect of an inte muscular septum between it and the overlying muscles.

The fibres of the radial head are mainly associated with the tendon of t middle finger.

Insertion.—By four tendons attached to the four fingers. Each tendon ultimately subdivides into two slips, which are attached on either side of the shaft of the middle phalanx.

In the lower part of the forearm the muscle fibres are replaced by four tendons, which are disposed in pairs as they cross the front of the wrist deeply to the flexor retinaculum, the tendons destined for

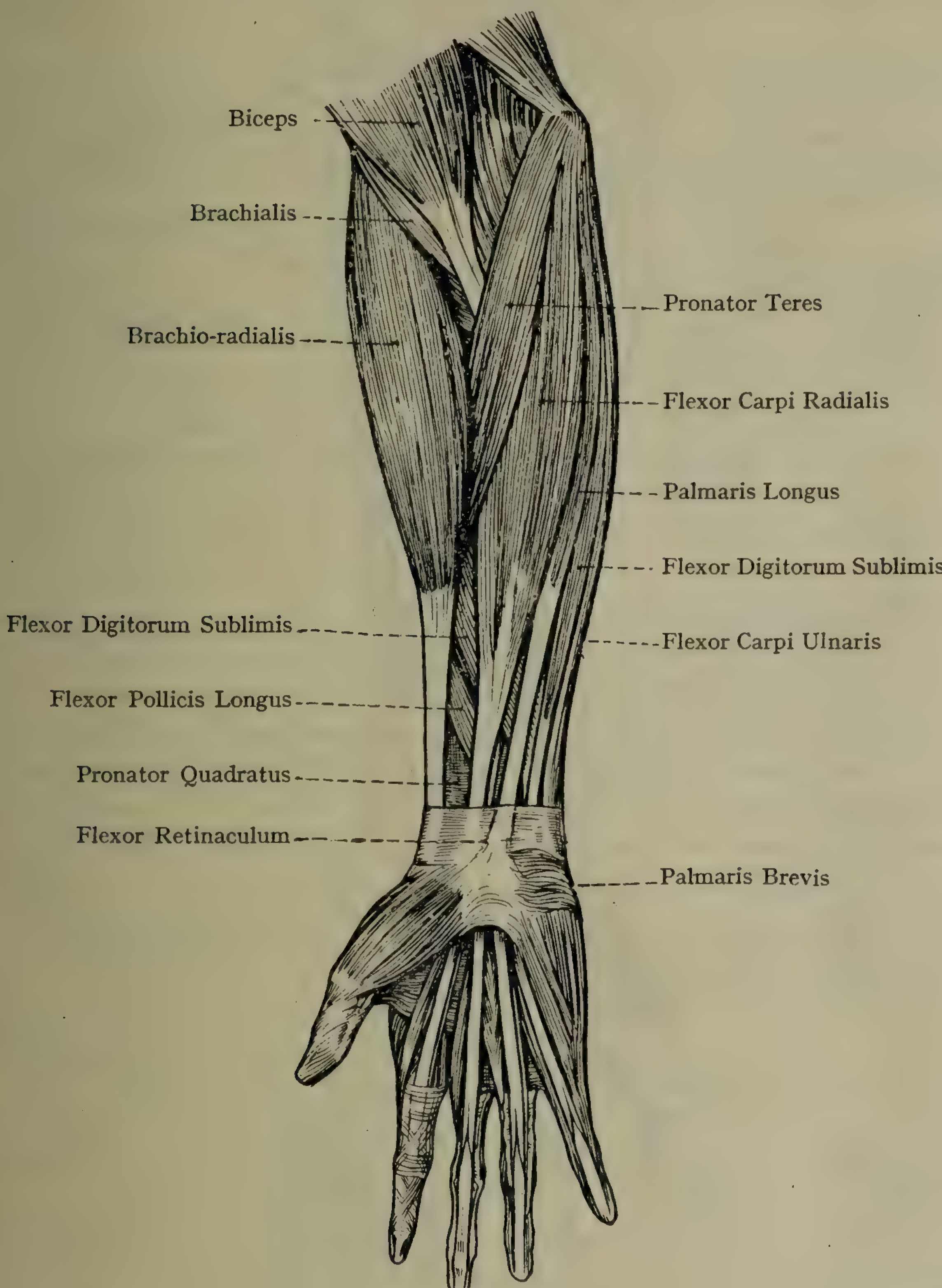


FIG. 295.—THE SUPERFICIAL MUSCLES OF THE FRONT OF THE FOREARM.

the middle and ring fingers lying in front of those for the index and little fingers. In this situation they are invested by the great palmar synovial sheath (p. 491). In the palm the four tendons diverge, each tendon being accompanied by a tendon of the flexor digitorum profundus, which lies deeply to it. On the finger each pair of tendons is contained in the digital sheath, a fibrous arcade which, with the

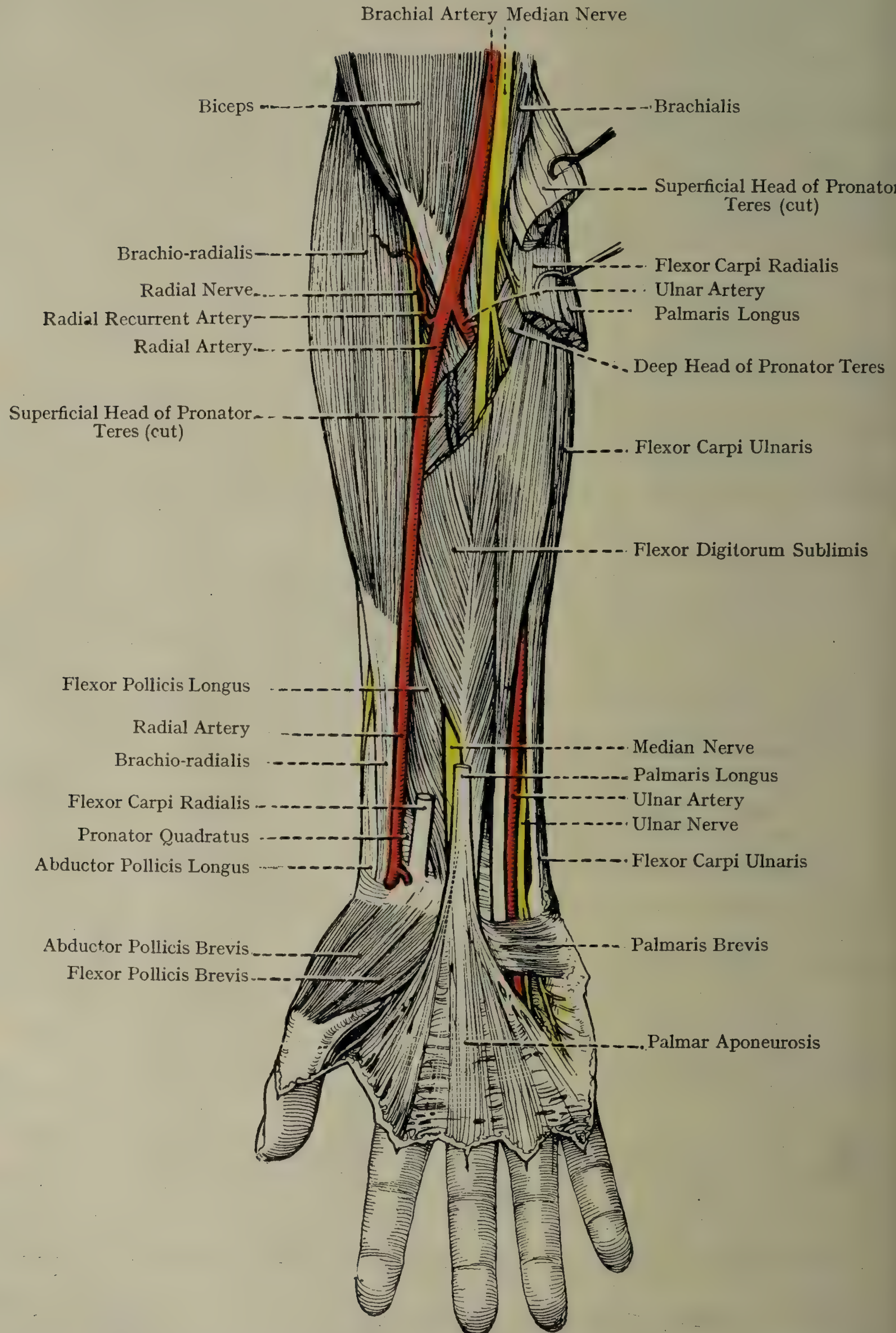


FIG. 296.—THE FRONT OF THE FOREARM, AND PALM OF THE HAND.

palmar aspects of the proximal and middle phalanges, completes a tunnel in which the tendons are contained. Opposite the base of the proximal phalanx the flexor sublimis tendon splits into two parts to allow the tendon of the flexor profundus to pass through it. The two parts of the superficial tendon are folded round the deep tendon, and unite on its deep aspect towards the distal end of the proximal phalanx. Finally, the superficial tendon splits for a second time into its two slips of insertion.

Nerve-supply.—Branches from the median containing fibres from the sixth cervical nerve.

Action.—Flexes the middle phalanges of the four fingers; further contraction of the muscle flexes the metacarpo-phalangeal joints and the wrist; it also assists in flexion of the elbow-joint.

The Flexor Carpi Ulnaris arises by two heads. The *humeral head* arises from the front of the medial epicondyle; from the deep fascia covering it, more particularly from the bicipital aponeurosis, as it blends with the deep fascia; and the intermuscular septa between it and the palmaris longus and the flexor digitorum sublimis. The *ulnar head* arises from the inner aspect of the olecranon process, and indirectly from the upper two-thirds of the posterior border of the ulna, by means of the deep fascia which is attached to this border, and from which the fibres of the muscle arise.

Insertion.—The pisiform bone. Fibres of the tendon of insertion are also prolonged into the **piso-hamate** and **piso-metacarpal ligaments,** the former being attached to the hook of the hamate bone, the latter to the base of the fifth metacarpal. An expansion from the outer side of the tendon blends with the flexor retinaculum.

Nerve-supply.—Branches of the ulnar containing fibres from the eighth cervical and first thoracic nerves.

The fibres of the muscle are directed downwards and forwards, and are implanted on the posterior and inner aspects of the tendon, which commences about the middle of the forearm.

Action.—Flexes and adducts the wrist-joint, and is a feeble flexor of the elbow-joint.

The ulnar nerve and posterior ulnar recurrent artery lie between the two heads of the muscle.

The Radial Artery is one of the two terminal branches of the brachial which, in the cubital fossa and opposite the upper part of the neck of the radius, subdivides into the radial and ulnar arteries. It is smaller than the ulnar, and its direction is at first continuous with that of the parent trunk. The upper part of the vessel curves downwards and outwards, but for the greater part of its extent it descends vertically downwards in the forearm. At the lower end of the forearm its direction suddenly changes, and it winds round the outer side of the wrist, below the styloid process of the radius, and lying on the lateral ligament of the wrist-joint. Gaining the back of the wrist, it descends for a short distance to the proximal end of the interspace between the first and second metacarpal bones, where it passes forwards between

the two heads of the first dorsal interosseous muscle (abductor indici into the palm, and there joins the deep branch of the ulnar artery complete the deep palmar arch. The vessel may consequently be su divided into three parts, occupying t forearm, the back of the wrist, and t palm respectively.

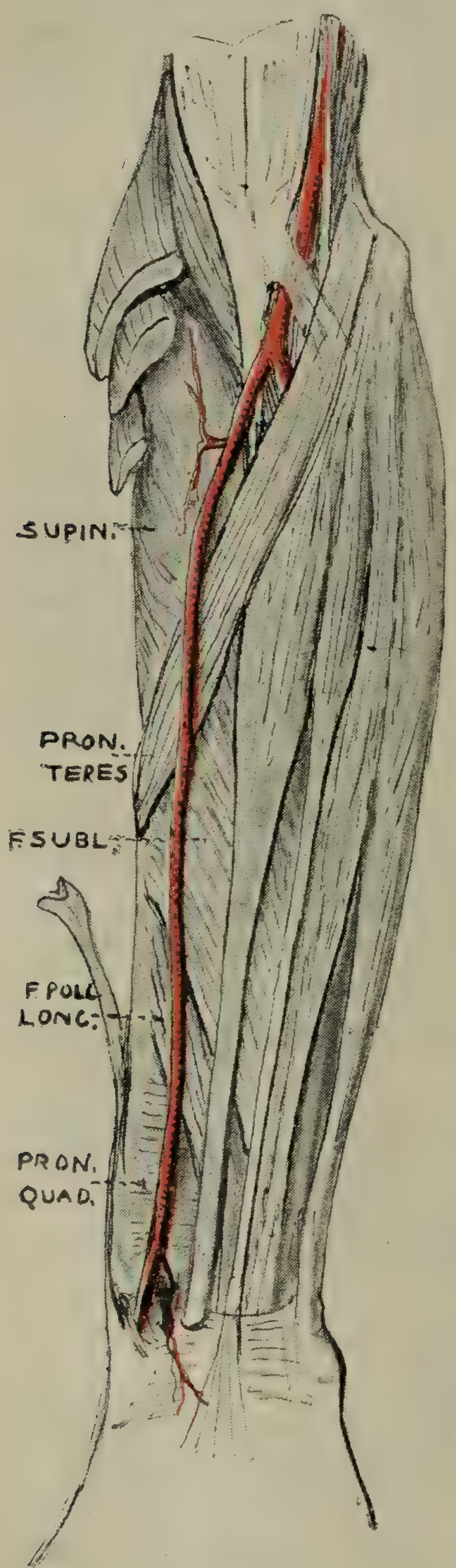


FIG. 297.—TO SHOW THE COURSE AND DEEP RELATIONS OF THE RADIAL ARTERY.

The First Part extends from the orig to the styloid process of the radius. I direction as a whole is downwards ar slightly outwards. Its course may be i dicated by a line drawn from a point ju below the bend of the elbow, midway b tween the epicondyles of the humerus, to point about $\frac{1}{2}$ inch medial to the stylo process of the radius. The upper part the vessel lies between the brachio-radial laterally and pronator teres medially, an is overlapped by the fleshy belly of th former muscle. For the rest of its exten it is placed between the brachio-radial laterally and the flexor carpi radialis med ally. In the lower part of the forearm where these muscles are replaced by tendon the vessel is quite superficial.

Relations—*Superficial.*—The inner mar gin of the brachio-radialis in the uppe third, or more. *Deep.*—From above dowr wards it lies upon the tendon of insertio of the biceps; supinator; the pronator tere close to its insertion; the radial head of th flexor digitorum sublimis; the flexor pollic longus; the pronator quadratus; and th lower end of the radius. *Lateral.*—Th brachio-radialis for the whole extent of th forearm. In the upper part of the forearn the radial nerve is at some distance from and to its outer side, but is a close later relation for about the middle third of th forearm. Some distance above the wris the nerve leaves the artery, and winds t the back of the limb under cover of th tendon of the brachio-radialis. *Medial.*— The pronator teres in the upper third of th forearm, and for the rest of its extent th flexor carpi radialis. The radial artery accompanied by two venæ comites, placed one on either side of i and connected together by numerous transverse communications.

Branches of the First Part.—Numerous small, irregularly dispose

branches are distributed to the muscles and skin. In addition it has three more constant branches.

The **radial recurrent artery** arises from the outer side of the radial close to its commencement. It passes upwards deeply to the brachio-radialis, and lies in front of supinator. Some of its branches are distributed to the muscles arising from the lateral epicondyle, others to the elbow-joint. One branch ascends with the radial nerve between the brachio-radialis and brachialis, and anastomoses in front of the lateral epicondyle with the anterior terminal branch of the profunda artery.

The **anterior carpal branch** is a small artery which arises from the inner side of the radial at the level of the lower border of the pronator quadratus, and passes inwards, lying deeply to the flexor tendons. It breaks up into small branches which anastomose with the anterior ulnar carpal artery to form the anterior carpal network or rete. This rete is joined from above by the anterior terminal branch of the anterior interosseous artery, and from below by recurrent branches of the deep palmar arch. Branches of the rete are distributed to the wrist-joint and the carpal articulations.

The **superficial palmar branch** arises below the preceding branch, and passes downwards superficial to, or through, the muscles of the thenar eminence, in which it may end. It usually reaches the palm, and ends by anastomosing with the ulnar artery to complete the superficial palmar arch.

Varieties of the First Part.—(1) The artery may arise from the upper part of the brachial, or from the axillary. (2) When of high origin, it may descend superficially to the bicipital aponeurosis of the biceps and deep fascia of the forearm. (3) The artery may wind backwards superficially to the brachio-radialis just below the middle of the forearm. (4) It may be joined by a vas aberrans from the brachial, or from the axillary. (5) It may end at the lower part of the forearm, its distribution being replaced by branches of the ulnar, median, or anterior interosseous.

The **second** and **third parts** of the radial artery are described on pp. 509 and 497.

Radial Nerve.—Having given off its posterior interosseous branch, the radial nerve descends deeply to the brachio-radialis, lying at first at some distance to the outer side of the radial artery, and accompanies it for about the middle third of the forearm. It finally winds round the lower end of the radius, under cover of the brachio-radialis, to the back of the limb, where it becomes superficial (p. 467). It has no branches in the forearm.

The Posterior Interosseous Nerve is described on p. 506.

The Ulnar Artery (Fig. 298) is the larger of the two terminal branches of the brachial, and arises in the cubital fossa opposite the upper part of the neck of the radius. Descending in the forearm, it reaches the palm by passing in front of the flexor retinaculum, and is thence prolonged into the hand as the superficial palmar arch. At first it curves downwards and inwards deeply to pronator teres, flexor carpi radialis,

palmaris longus, and flexor digitorum sublimis. Having gained the front of the ulna, it meets the ulnar nerve and descends on the outer side of the nerve, both structures lying on the flexor digitorum profundus, and being overlapped superficially by the flexor carpi ulnaris. A little above the wrist the artery may lie superficially on the outer side of the tendon of the flexor carpi ulnaris. It crosses in front of the flexor retinaculum, lying to the outer side of the pisiform bone, the ulnar nerve intervening between the two. On reaching the hand it curves outwards in the palm towards the thenar eminence. The vessel may be divided into three parts.

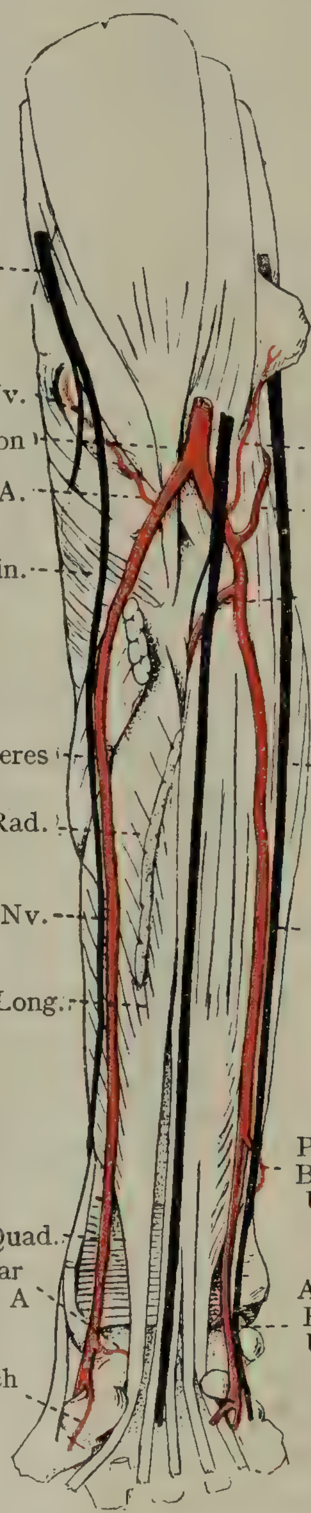


FIG. 298.—TO ILLUSTRATE THE DEEP AND NERVE RELATIONS OF THE RADIAL AND ULNAR ARTERIES.

The First Part extends from the origin to the upper border of the flexor retinaculum. On account of the curve involving the upper part of the vessel, no definite line can be given to indicate its entire course. In the lower half of the forearm the edge of the flexor carpi ulnaris is a useful guide to its position.

Relations—*Superficial.*—In the upper half of the forearm the artery is deeply placed, being covered by pronator teres, flexor carpi radialis, palmaris longus, and flexor digitorum sublimis. In the lower half it is overlapped by the tendon of the flexor carpi ulnaris, except for a short distance above the wrist, where it may lie superficially on the outer side of the tendon. The palmar cutaneous branch of the ulnar nerve descends in front of the artery in its lower half. *Deep.*—Brachialis for about 1 inch, and for the rest of its extent the flexor digitorum profundus. *Lateral.*—In its distal two-thirds the flexor digitorum sublimis. *Medial.*—The ulnar nerve for about its distal two-thirds, and possibly the tendon of the flexor carpi ulnaris for a short distance above the wrist. The nerves related to the first part of the artery are the median, ulnar, and palmar cutaneous branch of the ulnar. At its commencement the median nerve lies to its inner side,

but deeply to pronator teres the nerve crosses in front of it, the deep head of pronator teres intervening between them, and gains its outer side. The ulnar nerve, descending from behind the medial epicondyle, is at first separated from the artery by a considerable interval. As the nerve and artery descend, they converge and pass downwards to the wrist, lying side by side. The palmar cutaneous branch of the ulnar nerve descends in front of the lower part of the vessel. The ulnar artery is accompanied by two venæ comites, which are connected together by numerous transverse communications.

Branches of the First Part.—In addition to numerous small muscular and cutaneous twigs, the ulnar artery gives off the following branches:

The **anterior ulnar recurrent artery** is a small vessel which passes upwards and inwards on brachialis and under cover of the superficial head of the pronator teres. It supplies these muscles and anastomoses with the anterior branch of the supratrochlear of the brachial.

The **posterior ulnar recurrent artery,** a larger vessel, arises immediately below the preceding, or sometimes in common with it. It passes inwards under cover of the flexor digitorum sublimis, and then ascends with the ulnar nerve between the two heads of the flexor carpi ulnaris to the interval between the medial epicondyle and olecranon process. It supplies the adjacent muscles, ulnar nerve, and elbow-joint, and anastomoses with the ulnar collateral and posterior branch of the supratrochlear. It also gives twigs which ramify on the back of the olecranon, anastomose with the posterior interosseous recurrent, and takes part in forming the olecranon rete.

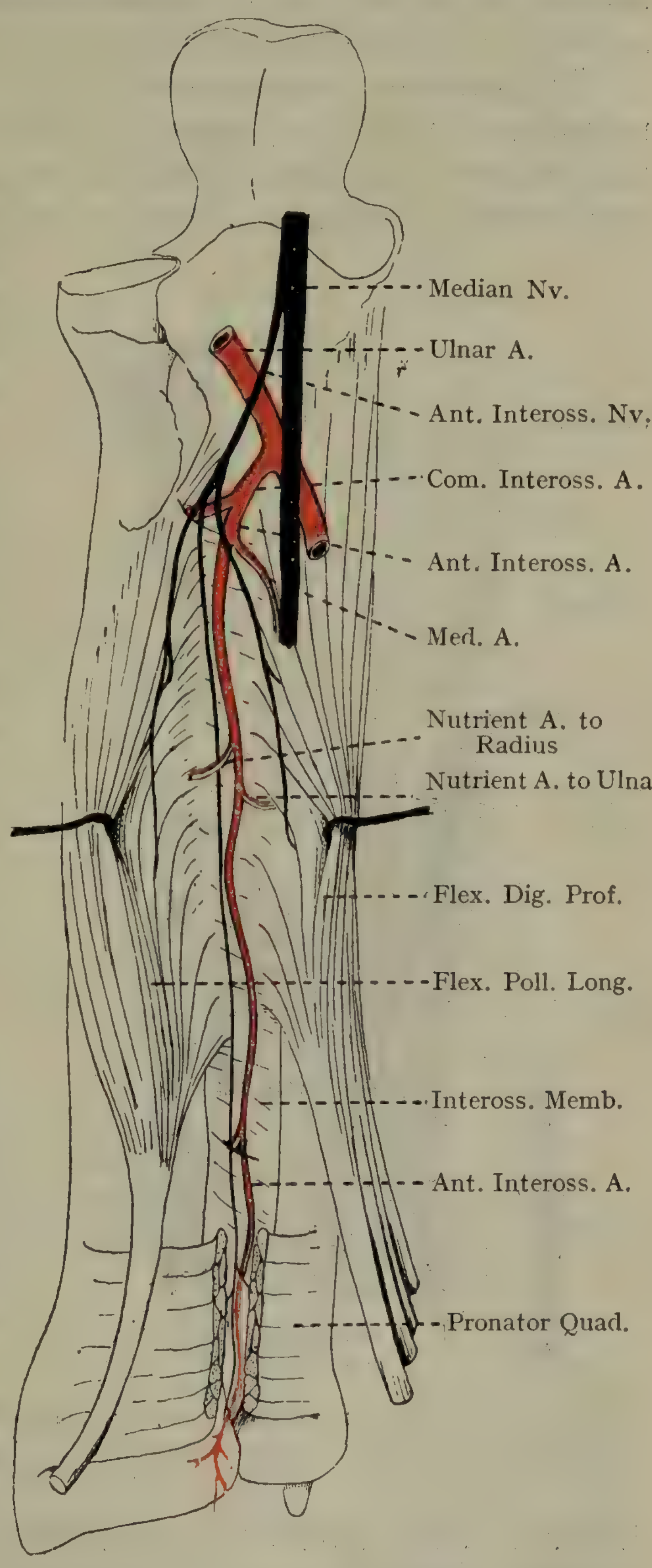


FIG. 299.—THE ANTERIOR INTEROSSEOUS ARTERY AND NERVE.

The two deep flexor muscles have been pulled aside, and the pronator quadratus incised vertically.

The **common interosseous artery** (Figs. 299 and 300) is a short thick trunk, which arises below the preceding, and about 1 inch from the commencement of the ulnar artery. It passes backwards to the upper border of the interosseous membrane, where it divides into the anterior and posterior interosseous arteries.

The *anterior interosseous artery* descends in front of the interosseous membrane with the anterior interosseous nerve on its outer side. It lies between the flexor pollicis longus laterally and the flexor digitorum profundus internally, being overlapped by the adjoining edges of the two muscles. At the upper border of the pronator quadratus it divides into two terminal branches, anterior and posterior.

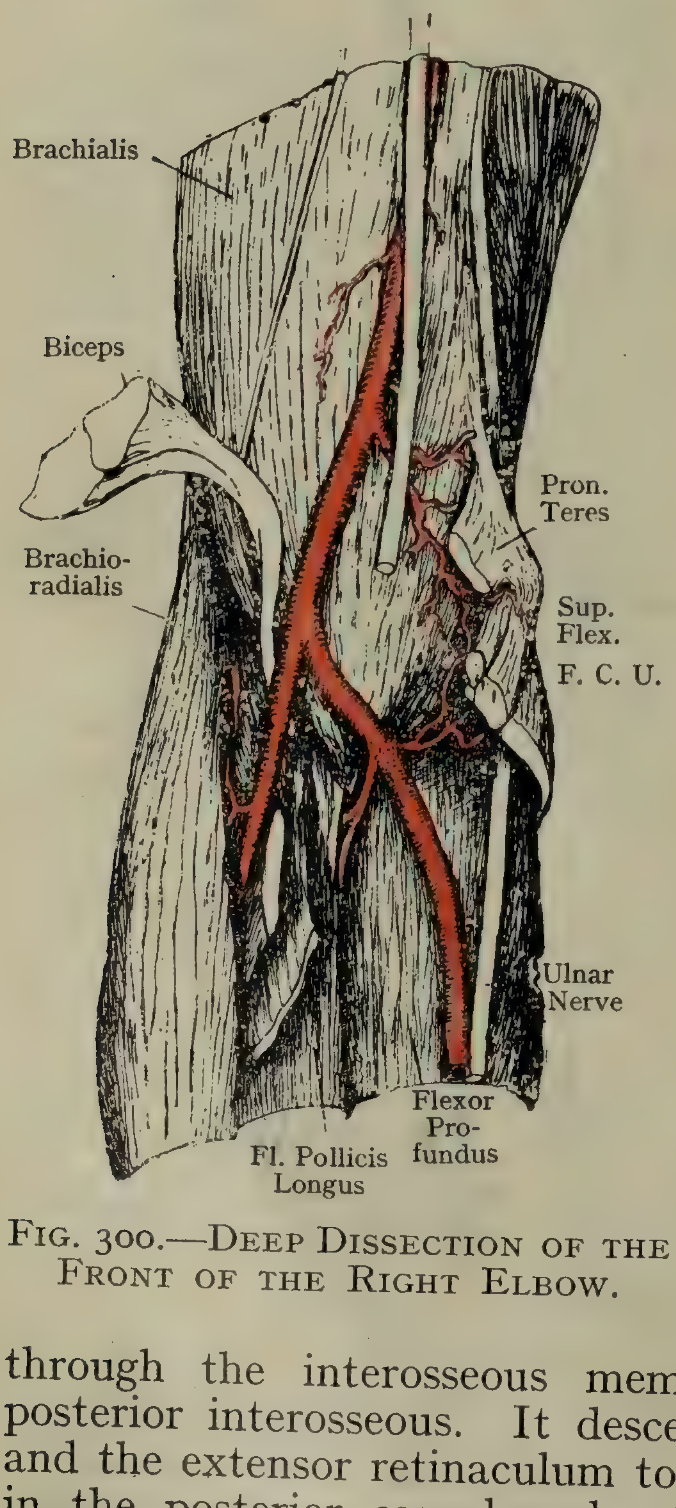


FIG. 300.—DEEP DISSECTION OF THE FRONT OF THE RIGHT ELBOW.

Branches.—The *median artery* (comes nervi mediani) is a long slender branch which arises from the commencement of the vessel, and is frequently a direct branch of the ulnar artery. It is a close companion of the median nerve, which it accompanies.

It may be a large vessel, and pass deeply to, or in front of, the flexor retinaculum into the palm, where it may join the superficial palmar arch, or may terminate by furnishing digital arteries.

Muscular branches are given off to the deep layer of muscles, and to the extensor muscles on the back of the interosseous membrane. The branches to the latter muscles pass through the membrane. Nutrient branches enter the radius and ulna respectively. The anterior terminal branch descends deeply to the pronator quadratus, and joins the anterior carpal rete. The posterior terminal branch passes backwards through the interosseous membrane, and anastomoses with the posterior interosseous. It descends deeply to the extensor tendons and the extensor retinaculum to the back of the wrist, where it ends in the posterior carpal arch. The posterior interosseous artery is described on p. 507.

The **posterior carpal branch** arises a little way above the pisiform bone, and passes backwards under cover of the tendon of the flexor carpi ulnaris to the back of the wrist, where it anastomoses with the posterior carpal branch of the radial artery to complete the posterior

:arpal arch. It may give off a dorsal digital artery to the inner side of the little finger.

The **anterior carpal branch** arises opposite the lower border of the pronator quadratus. It passes outwards along the lower border of that muscle deeply to the flexor digitorum profundus, and anastomoses with the anterior carpal branch of the radial artery, the anterior branch of the anterior interosseous, and the recurrent branches of the deep palmar arch, to form the anterior carpal rete.

Anastomoses about the Elbow-Joint.—The anastomoses of arteries about the elbow-joint are very numerous. In front of the medial epicondyle of the humerus the anterior branch of the supratrochlear of the brachial anastomoses with the anterior ulnar recurrent. Behind the medial epicondyle the ulnar collateral and the posterior branch of the supratrochlear anastomose with the posterior ulnar recurrent. In front of the lateral epicondyle the anterior terminal branch of the profunda anastomoses with the radial recurrent. Behind the lateral epicondyle the posterior terminal branch of the profunda anastomoses with the posterior interosseous recurrent. Upon the back of the shaft of the humerus, immediately above the olecranon fossa, a transverse anastomosis takes place between the posterior branches of the profunda and supratrochlear. Upon the back of the olecranon process is the olecranon arterial rete, supplied by branches of the posterior interosseous recurrent and of the posterior ulnar recurrent arteries.

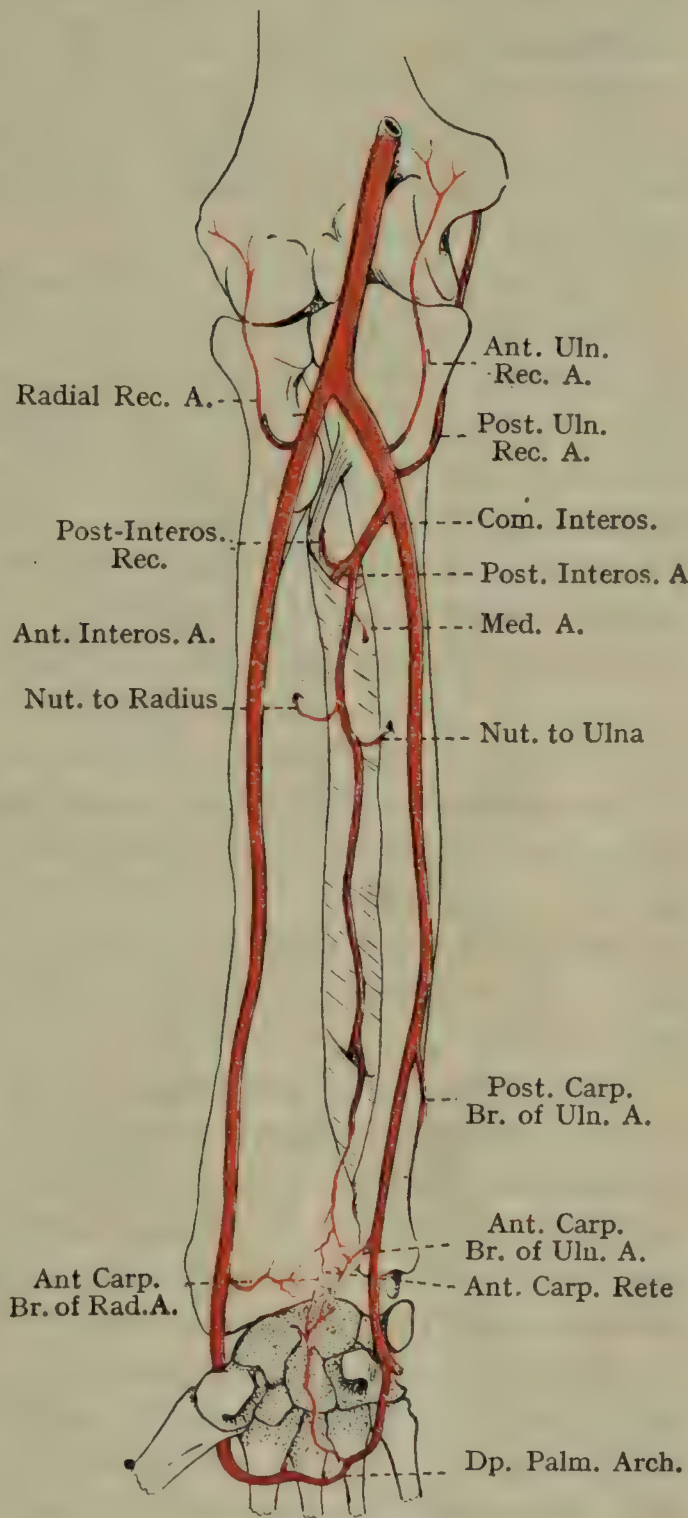


FIG. 301.—TO ILLUSTRATE THE RELATIONS OF THE RADIAL AND ULNAR ARTERIES AND THEIR BRANCHES TO THE SKELETON, AND THE ARTERIES TAKING PART IN THE FORMATION OF THE ANTERIOR CARPAL RETE.

Varieties.—The ulnar artery may have a high origin from the brachial, or from the axillary. In cases of high origin the vessel usually lies superficially to the muscles arising from the medial epicondyle of the humerus. In such cases the common interosseous is a branch of the main trunk, and furnishes the anterior and posterior ulnar recurrent arteries. An ulnar artery, normal in origin, may lie superficially to the muscles arising from the medial epicondyle.

The Second Part of the Ulnar Artery lies upon the flexor retinaculu and extends from its upper to its lower border. The ulnar nerve is c its inner side. It lies on the outer side of the pisiform bone, but c the inner side of the hook of the hamate bone, where it is under cov of the piso-hamate ligament.

Relations—*Superficial.*—The expansion from the flexor car ulnaris tendon to the front of the flexor retinaculum, and the pis hamate ligament. *Deep.*—The flexor retinaculum. *Laterally.*—Tl hook of the hamate bone. *Medially.*—The ulnar nerve and the pis form bone.

The third part of the ulnar artery is described on p. 487.

The Ulnar Nerve (Fig. 298).—The ulnar nerve gains the forear by passing downwards in the interval between the medial epicondy and olecranon process, and between the two heads of the flexor car ulnaris. Descending under cover of that muscle, it lies upon tl flexor digitorum profundus. At about the junction of the upper thi with the lower two-thirds of the forearm it comes into relation with tl ulnar artery, and lies upon the inner side of that vessel for the rest (its extent in the forearm. It reaches the hand by passing in front (the flexor retinaculum close to the outer side of the pisiform bon At a lower level it lies to the inner side of the hook of the hamate bon

Branches.—Articular branches, two or three in number, suppl the elbow-joint and are given off from the nerve as it lies behind th medial epicondyle.

Muscular branches arise in the upper part of the forearm, an supply the flexor carpi ulnaris and the inner part of the flexor digitoru profundus.

The cutaneous branches are described on pp. 448 and 467.

The Median Nerve (Fig. 298).—In the cubital fossa the media nerve lies on the inner side of the brachial and ulnar arteries. O leaving the space it passes between the two heads of pronator tere and here crosses in front of the ulnar artery, the deep head of the muscl intervening between the two. Descending between the two heads c the flexor digitorum sublimis, it gains its deep aspect, and lies deepl to it until it approaches the wrist. Here it escapes from under cove of the muscle, and lies between it and the flexor carpi radialis. Cross ing the wrist on the deep aspect of the flexor retinaculum, it passe into the palm. It is accompanied by the median artery, a branch c the anterior interosseous. As the median nerve descends in the fore arm, it lies midway between the radial and ulnar arteries.

Branches.—Articular branches, one or two in number, enter th elbow-joint from in front.

Muscular branches supply all the muscles on the front of the fore arm, with the exception of the flexor carpi ulnaris and the inner pai of the flexor digitorum profundus. The branches to pronator tere arise from the nerve above the level of the elbow-joint. The branche for the flexor carpi radialis, palmaris longus, and flexor digitoru sublimis arise from the nerve as it passes into the forearm. The flexc

ollicis longus, outer portion of the flexor digitorum profundus, and pro-ator quadratus are supplied by the *anterior interosseous branch.* This ong branch arises from the median just below the neck of the radius, nd descends on the front of the interosseous membrane. It lies n the outer side of the anterior interosseous artery, the two being verlapped by the adjacent edges of the flexor digitorum profundus nd of the flexor pollicis longus. In the lower part of the forearm ne nerve lies deeply to the pronator quadratus, and ends in two ranches; one enters the deep surface of the muscle, the other supplies ne wrist-joint. The branch to the outer part of the flexor digitorum rofundus arises high up, and communicates in the substance of the nuscle with the branch of the ulnar nerve supplying its inner part. 'he anterior interosseous nerve furnishes an interosseous branch istributed to the interosseous membrane. It gives off nutrient fila-nents which accompany the nutrient arteries to the radius and ulna.

Cutaneous Branch.—A short distance above the wrist a *palmar utaneous* branch arises from the median nerve as it lies between the endons of the flexor carpi radialis and the flexor digitorum sublimis. t passes downwards in front of the flexor retinaculum, and is dis-ributed to the skin covering the central part of the palm.

Deep Layer of Muscles (Fig. 298).—Consists of three muscles.

Flexor Digitorum Profundus—*Origin.*—The anterior and inner urfaces of the shaft of the ulna for about the upper three-fourths f their extent. The area of attachment extends from the posterior ubcutaneous border, to which the muscle is attached by means of fascial layer from which its fibres arise, to the interosseous or outer order. The area of attachment on the inner surface of the bone xtends upwards to the inner side of the olecranon process. From ne anterior surface of the ulna the attachment extends outwards on o the interosseous membrane, from the inner part of which it arises.

Insertion.—Towards the lower part of the forearm the muscle bres are replaced by tendon. The common tendon subsequently ivides into four tendons, which are inserted into the bases of the istal phalanges of the four fingers. The tendon of the index finger ecomes distinct from the main tendon some little way above the rist; the other three on the front of the wrist under cover of the exor retinaculum. In the palm the four tendons diverge, and are ere associated with the four lumbrical muscles. Each tendon passes nto a fibrous flexor sheath of a finger accompanied by a tendon of ne flexor sublimis, deeply to which it lies, but opposite the shaft of ne proximal phalanx it passes through the tendon of the flexor sub-mis in order to reach its more distal destination, the base of the distal halanx.

Nerve-supply.—A branch of the anterior interosseous nerve de-ived from the median, and containing fibres from the seventh and ighth cervical and the first thoracic nerves, supplies the outer part of ne muscle; a branch of the ulnar nerve, containing fibres from the ighth cervical and first thoracic nerves, supplies the inner part.

Action.—Flexes the distal phalanges of the four inner fingers; assis in flexing the middle phalanges and metacarpo-phalangeal joint and also assists in flexing the wrist-joint.

Flexor Pollicis Longus (Fig. 298)—*Origin.*—The anterior surfa of the radius, from the anterior oblique line above to the upper bord of the pronator quadratus below; the outer half of the front of t interosseous membrane; and as a rule by a tendinous slip from t inner margin of the coronoid process of the ulna, or more occasional from the medial epicondyle of the humerus.

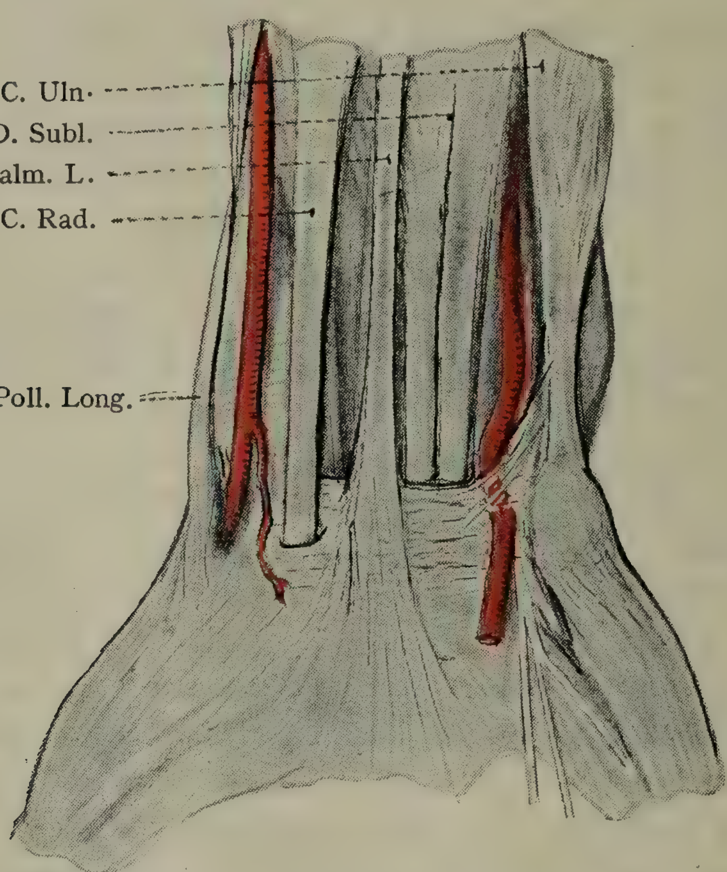


FIG. 302.—FRONT OF RIGHT WRIST, TO SHOW RELATIVE POSITIONS OF STRUCTURES.

Insertion.—The base the distal phalanx of t thumb.

The tendon appears the front of the musc about the middle of t forearm. The muscle fibr are attached obliquely either side of it, and e tend downwards to ne the wrist,

Nerve-supply.— branch of the anteri interosseous nerve, co taining fibres from t seventh and eighth cervic and first thoracic nerves

Action. — Flexes t distal phalanx of t thumb; assists in flexi its metacarpo-phalange joint; and is an auxilia flexor of the wrist-joint.

Pronator Quadratus (Fig. 298)—*Origin.*—The anterior surface the lower end of the ulna.

Insertion.—The anterior surface, and to a slight extent the inn aspect of the lower end of the radius.

Nerve-supply.—A branch of the anterior interosseous nerve, co taining fibres from the seventh and eighth cervical and first thorac nerves.

The fibres are disposed, for the most part, transversely, and t muscle is covered by a dense fascial layer.

Action.—Pronates the radius upon the ulna.

Front of the Wrist and Palm.

Landmarks.—Below the styloid process of the radius the tuberc of the scaphoid can be felt, and below this the crest on the trapeziur On the inner aspect of the front of the wrist the pisiform bone c

asily be felt, and below and lateral to it (*i.e.*, nearer the middle line f the wrist) is the hook of the hamate bone. The interval between hese two projections indicates the position of the ulnar vessels and erve. The centre of the palm presents a triangular depression, the pex of which is directed upwards and inwards towards the wrist, nd the base downwards towards the roots of the fingers. In the latter tuation there is a transverse prominence, broken up by grooves eading to the three inner digits. The palmar depression is bounded iterally by the thenar eminence, and medially by the hypothenar minence.

The skin of the palm presents four furrows, two being disposed ansversely, and two more or less longitudinally. The lower transerse furrow is about 1 inch above the roots of the inner three digits, nd is most conspicuous when the fingers are flexed. It commences t the inner border of the palm, and, passing outwards in a slightly rched manner, it terminates at the cleft between the index and iddle fingers. It is produced by the flexion of the metacarpohalangeal joints of the inner three fingers. These joints are situated bout midway between this line and the roots of the fingers when these re extended. The upper transverse furrow commences at the outer order of the palm about $\frac{3}{4}$ inch above the root of the index finger, id it passes inwards and slightly upwards to the inner border of ie palm, lying about $\frac{1}{2}$ inch above the lower furrow. The outer art of this furrow is due to flexion of the metacarpo-phalangeal joint the index finger, and the remainder to complete flexion of the etacarpo-phalangeal joints of the inner three fingers. One of the ngitudinal furrows commences about the centre of the wrist, and irves downwards and outwards to meet the upper transverse furrow. is produced by the movement occurring in the joint between the apezium and the first metacarpal bone when the thumb is opposed the fingers. The second longitudinal furrow runs downwards om the wrist medial to the preceding, and meets the lower transverse irrow. It is due to the movement of opposition of the little finger. he palmar aspect of each of the four fingers presents three transverse irrows. The distal pair correspond with the interphalangeal joints, it the proximal furrow is about $\frac{1}{2}$ inch below the metacarpo-phalangeal int. The thumb presents only two such transverse furrows. The vel of the free edge of the skin fold between any two fingers corresponds the middle of the proximal phalanx; the metacarpo-phalangeal int is at least $\frac{3}{4}$ inch proximal to it.

The position of the superficial palmar arch corresponds to a curved ie drawn from the outer side of the pisiform bone parallel to the irved edge of the thenar eminence, and not extending into the palm eyond the level of the extended and abducted thumb. From the nvexity of the arch three palmar digital arteries pass downwards line with the webs of the fingers, and occupy the intermetacarpal aces. An incision, therefore, may be made with safety in the palm the direction of the middle line of a finger, but it should not be

carried nearer the wrist than the line indicating the position of t superficial palmar arch. The deep palmar arch lies about 1 in nearer the wrist than the superficial. The digital arteries are plac on the lateral aspects of the fingers.

On the back of the hand the dorsal radial tubercle may be f about the middle of the lower end of the bone, and the heads of t metacarpal bones, which form the knuckles, are conspicuous wh the fingers are flexed. Towards the outer side of the wrist, when t thumb is abducted, is a well-marked triangular depression, the ba of which is directed upwards. In this depression the pulsation the radial artery may be felt in the living subject. The depressi is bounded *medially* by the tendon of the extensor pollicis long *laterally* by the tendons of the abductor pollicis longus and extens pollicis brevis, and *above* by the lower end of the radius. Lying deep in it are the tendons of the two radial extensors of the wrist. T scaphoid and trapezium form its floor, the commencement of the rad vein and branches of the radial nerve occupy the subcutaneo tissue superficial to it. This depression is known as the *anatomi snuff-box.*

The middle line of the hand, away from which and towards whi abduction and adduction of the digits naturally take place, is presented by the axial line of the middle finger.

The Superficial Fascia covering the hollow of the palm is fine lobulated, the fatty lobules being separated by fibrous processes whi extend from the skin to the central part of the palmar aponeurosis.

The Palmaris Brevis (Fig. 303) is a thin, flat, subcutaneous musc quadrilateral in outline, and usually consisting of two or three bundl

Origin.—The front of the flexor retinaculum, and the inner marg of the central part of the palmar aponeurosis.

Insertion.—The skin covering the inner aspect of the hypother eminence.

Nerve-supply.—A branch from the superficial division of the ulr nerve.

Action.—Wrinkles the skin on the inner side of the palm, and drawing it towards the middle line of the hand probably renders t palm a more efficient grasping organ.

The muscle lies in the superficial fascia covering the proxin part of the hypothenar eminence, and in front of the ulnar vess and nerve.

The Superficial Transverse Ligament of Palm is composed of bundle of transverse fibres contained within the folds of skin whi limit the clefts between the four fingers.

The Palmar Aponeurosis (Fig. 303) consists of three parts—a cent and two lateral.

The **central part** is triangular, the apex being towards the wri where it is mainly continuous with the tendon of the palmaris long its deeper fibres being continuous with the flexor retinaculum. T superficial fibres are longitudinal and the deep fibres transverse, t

atter being most conspicuous towards the fingers. The base is directed owards the four fingers, on approaching which it divides into *four* igital processes. These diverge and join the sheaths of the flexor

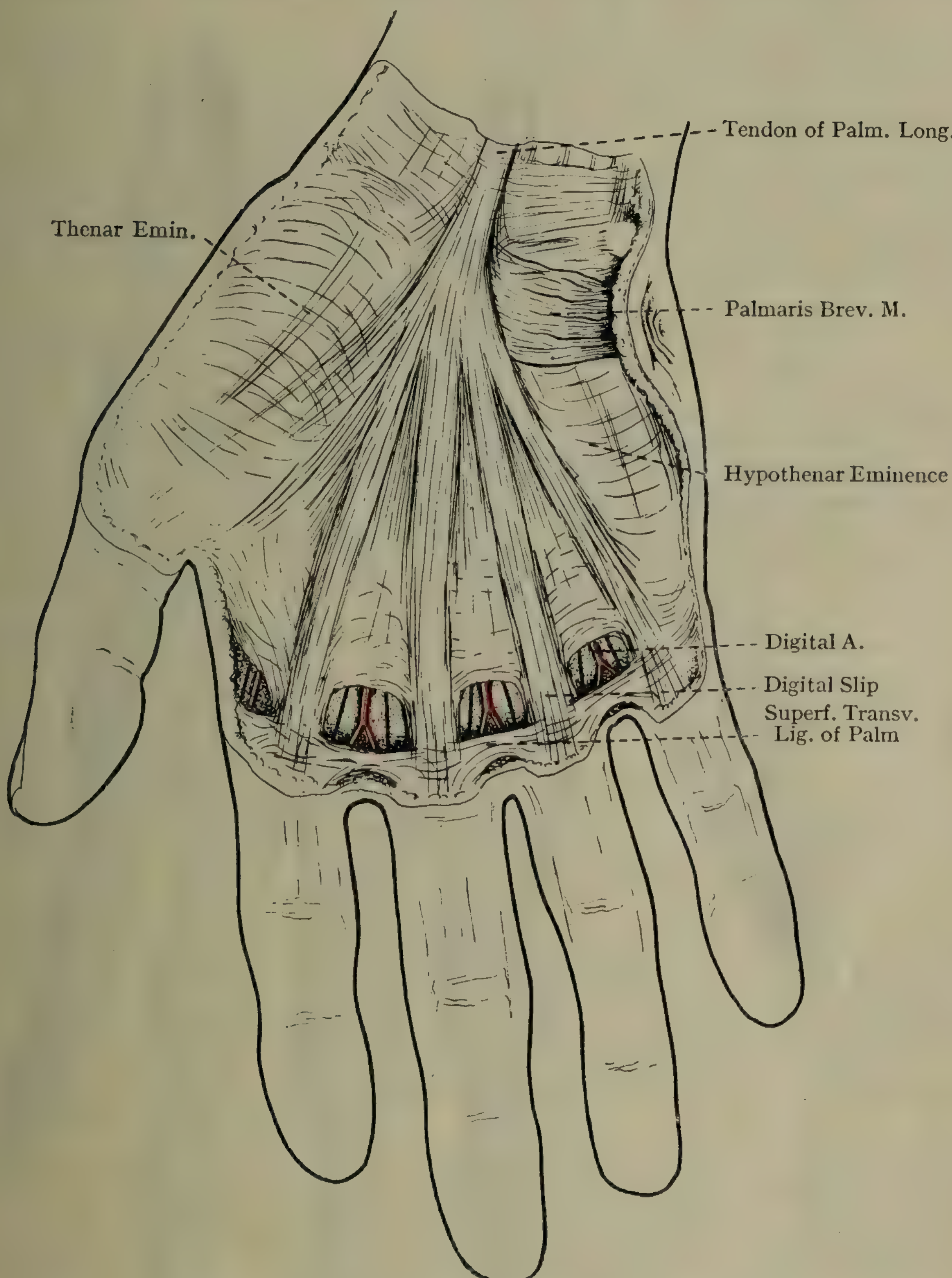


FIG. 303.—THE FASCIAL COVERINGS OF THE PALM.

he pads of fat between the digital processes of the central part of the palmar aponeurosis have been removed in order to expose the digital arteries and nerves.

endons on the palmar aspects of the fingers. From each process bres pass to the superficial transverse ligament, and to the skin folds miting the clefts between the fingers. Two deep prolongations are ven off, one from either side of a digital process, and join the trans-

verse metacarpal ligament on either side of the head of a metacar
bone (p. 526). A digital process and its two deep prolongations fo
the roof and the side walls respectively of a short canal in which
two flexor tendons of a finger are contained. Between the fo

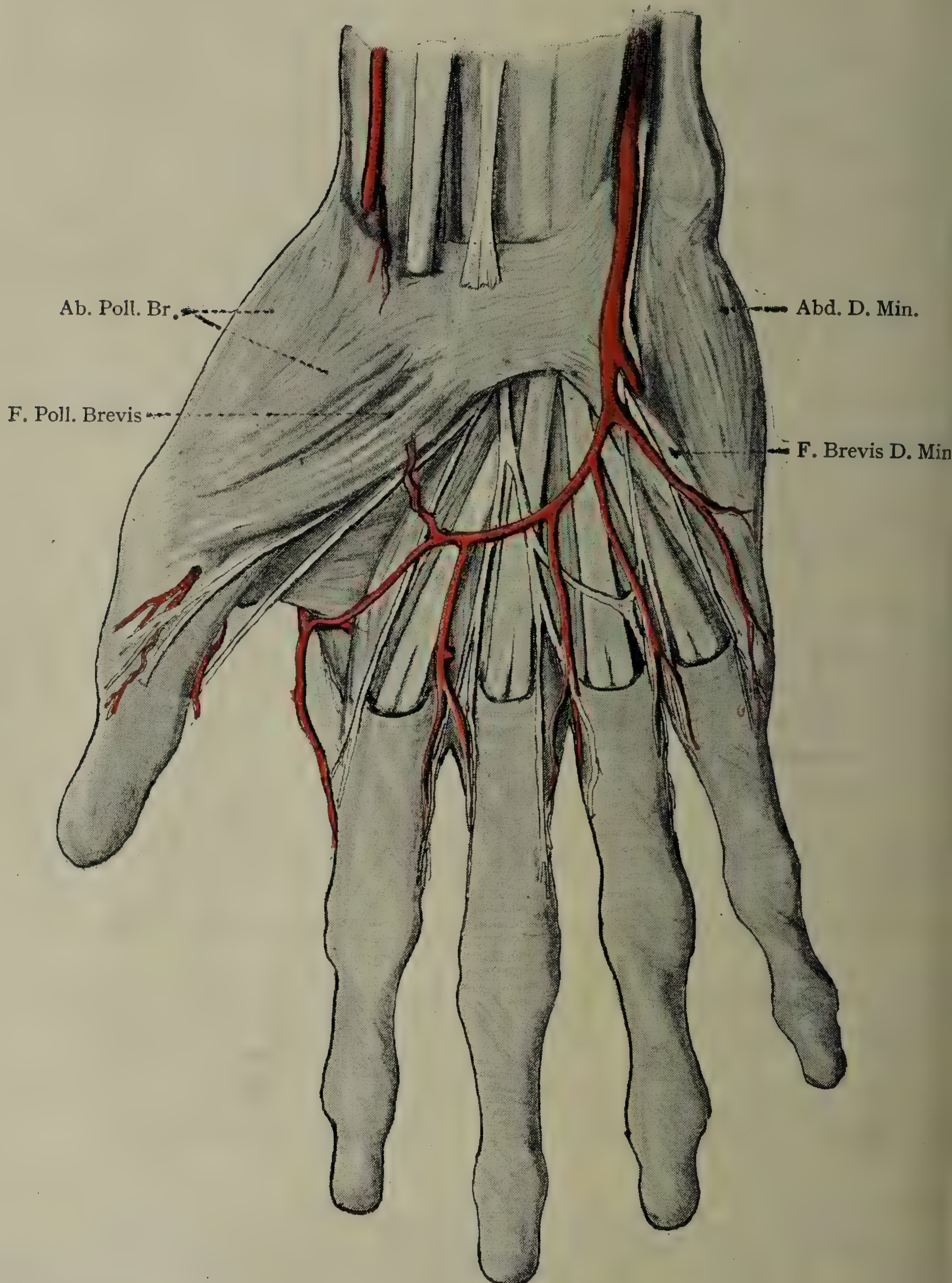


FIG. 304.—DISSECTION OF PALM.

diverging digital processes are three intervals occupied by fat,
which the digital arteries and nerves and lumbrical muscles are en
bedded. The central part of the palmar aponeurosis is bound to th
skin by fibrous processes which enclose spaces containing very fine

lobulated fat. Its deep surface is related to the superficial palmar arch, the digital nerves, and the palmar synovial sheath investing the flexor tendons. From either margin a deep septum projects into the hand and joins the interosseous fascia investing the flexor of the palm. The outer septum marks the inner limit of the thenar muscles, while the inner septum marks the outer limit of the hypothenar muscles. The central portion of the palmar aponeurosis forms the roof, the two septa the side walls, and the interosseous fascia the floor of a large central palmar compartment containing the flexor tendons, lumbrical muscles, and the palmar bloodvessels and nerves. On either side of this central compartment are two marginal compartments, containing the short muscles of the thumb and of the little finger respectively. The central part of the palmar aponeurosis affords protection to the superficial palmar arch and the digital arteries and nerves.

The central part of the palmar aponeurosis, together with the palmaris longus, represent a superficial flexor of the proximal phalanges, a muscle present in some animals. The four digital slips and the two deep lateral prolongations with which each slip is provided represent the four tendons of this muscle, each of which subdivides before reaching its insertion, the base of the proximal phalanx, and thereby gives passage to the flexor tendons attached to the intermediate and distal phalanges.

The **lateral** or **thenar division** is thin, and covers the thenar muscles. Above it is connected with the tendon of the palmaris longus and flexor retinaculum; it also receives fibres from the tendon of the abductor pollicis longus.

The **medial** or **hypothenar division** is also thin. It is connected above with the flexor retinaculum, and ends below by blending with the tendons of the muscles inserted into the inner side of the base of the proximal phalanx of the little finger.

The Third Part of the Ulnar Artery (Fig. 305) is the superficial palmar arch. It descends for a short distance deeply to the palmaris brevis and arches outwards across the palm. The arch is completed by one of the branches of the radial artery—either the superficial palmar, the radialis indicis, or the princeps pollicis. The convexity of the arch is towards the fingers.

Relations—*Superficial.*—The skin and subcutaneous tissue, the palmaris brevis for a short distance, and the central division of the palmar aponeurosis. *Deep.*—From within outwards it rests upon the flexor digiti minimi, the digital branches of the ulnar nerve, the flexor tendons, and the digital branches of the median nerve.

Branches.—Cutaneous to the skin of the palm, muscular to the adjacent superficial muscles, the deep branch, and the digital branches.

The *deep branch* of the ulnar artery arises at the level of the lower border of the flexor retinaculum. It passes deeply into the palm, in company with the deep division of the ulnar nerve, between the abductor and flexor digiti minimi, and deeply to, or through, the opponens digiti minimi. It ends by joining the terminal part of the radial artery, and with it completes the deep palmar arch.

The **palmar digital arteries** arise from the convexity of the supe ficial palmar arch, and are four in number. They are destined for t

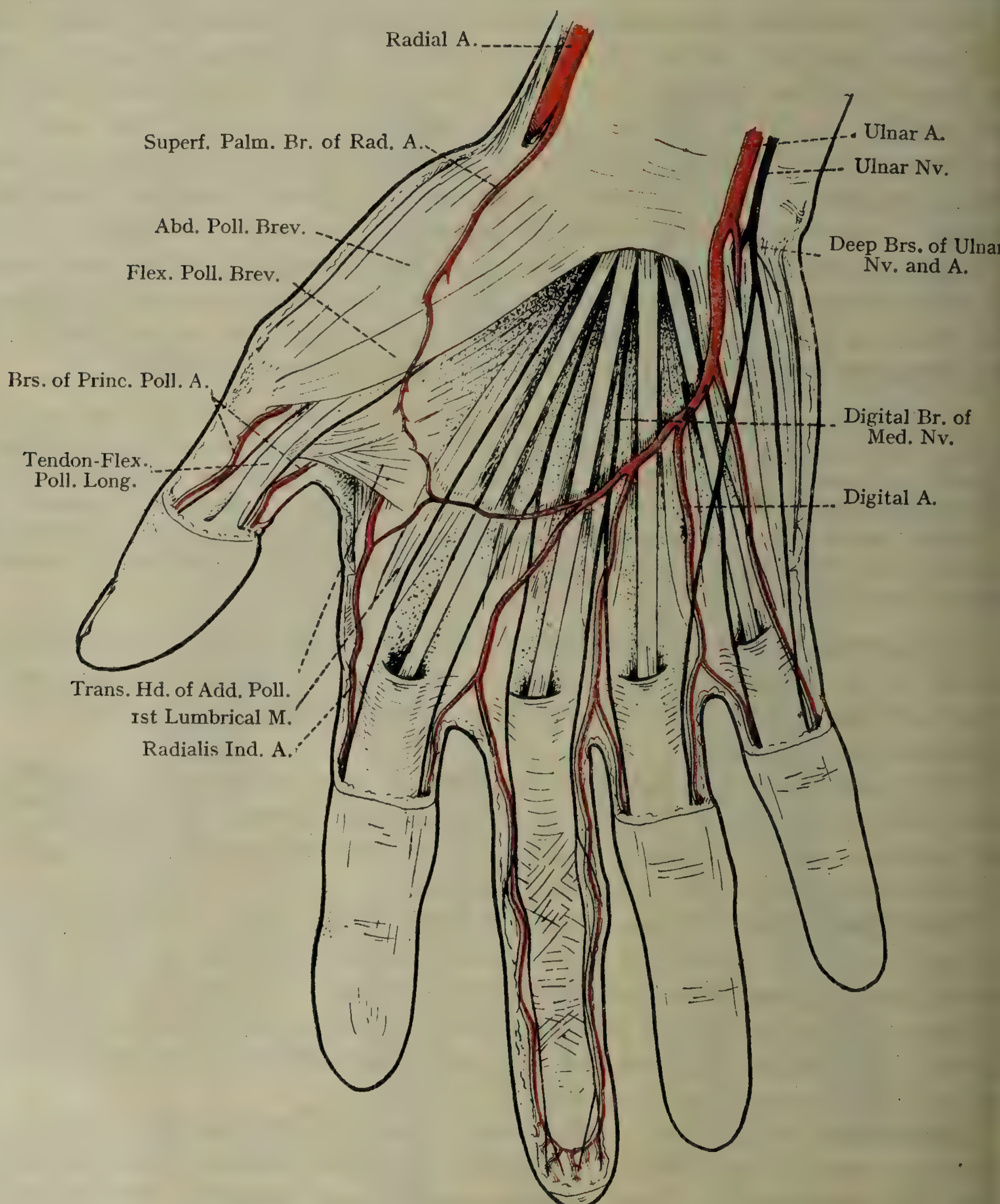


FIG. 305.—THE SUPERFICIAL PALMAR ARTERIAL ARCH, THE DIGITAL NERVES AND OTHER PALMAR STRUCTURES, WHICH ARE EXPOSED WHEN THE PALMA APONEUROSIS IS REMOVED.

The superficial palmar arch is represented as completed on the outer side o the hand by communications with the superficial palmar and radiali indicis arteries.

supply of the inner three and a half fingers, and are called first, second third, and fourth, from within outwards. The **first** digital artery i small, and passes downwards and inwards over the hypothenar muscles

o which it gives twigs. It is distributed to the inner side of the little nger.

The **second, third,** and **fourth** digital arteries pass downwards owards the clefts between the fingers. Each one divides into two ollateral digital arteries which supply the adjacent sides of two ngers. The second digital artery supplies the adjacent sides of the ttle and ring fingers, the third those of the ring and middle fingers, nd the fourth those of the middle and index fingers. The outer side f the index finger and the two sides of the thumb are supplied respecively by the radialis indicis and princeps pollicis, branches of the adial artery. As the digital arteries approach the fingers they lie etween the flexor tendons, and superficial to the digital nerves and umbrical muscles. On the sides of the fingers, however, the digital erves are superficial to the arteries. Shortly before the outer three livide into their collateral branches each artery is joined by a palmar netacarpal artery derived from the deep palmar arch. The two rteries, one on either side of a finger, supply the structures on the almar aspect of the phalanges and are connected together by numerous ransverse communications most marked on the proximal side of the nterphalangeal joints. Dorsal branches from these arteries are disributed to the structures on the back of the intermediate and distal halanges. One well-marked dorsal branch joins with its fellow on he opposite side at the root of the nail, forming an arterial arcade, ranches of which supply the nail-bed. The two arteries end by oining one another in an arterial arcade on the palmar aspect of the listal phalanx, from which numerous twigs are given off to supply the ery vascular pulp on the tip of the finger.

The **Veins** accompanying the superficial palmar arch and the digial arteries are very small, as the blood from the fingers is largely lrained by vessels joining the plexus of veins on the dorsum of the and (p. 467).

The Median Nerve reaches the palm by passing deeply to the flexor etinaculum. In this situation it presents a distinct enlargement or seudo-ganglion, and gives off articular twigs to the wrist-joint. At he lower border of the ligament it gives off a short *muscular* branch, vhich subdivides into three, and supplies the three superficial short nuscles of the thumb, the abductor pollicis brevis, opponens pollicis, nd flexor pollicis brevis. It finally subdivides into five *digital* ranches. The first and second supply the two sides of the thumb; he third gives a branch to the first or most lateral lumbrical muscle, nd supplies the outer or radial side of the index finger. The fourth nd fifth, as they approach the clefts between the fingers, both subdivide nto two collateral branches supplying the adjacent sides of two fingers. The fourth gives a branch to the second lumbrical muscle, and supplies he adjacent sides of the index and middle fingers; the fifth has a comnunicating branch with the adjoining digital branch of the ulnar nerve, nd supplies the adjacent sides of the middle and ring fingers. In the alm the digital nerves lie deeply to the superficial palmar arch and

its digital branches, but on the sides of the fingers the nerves are sup ficial to the arteries. Occasionally a digital artery may pass throu a digital nerve as the latter gains its superficial position. The digi nerves give branches to the skin on the palmar aspects of the finge and on these small swellings, called Pacinian bodies, are found. Th also supply the metacarpo-phalangeal and interphalangeal joints. the extremities of the fingers each nerve ends in branches for the pu of the tip of the finger. They also give dorsal branches which supp the skin on the back of the distal phalanges and the nail-beds (p. 46

Summary of the Median Nerve—Muscular.—It supplies all the muscles the front of the forearm, except the flexor carpi ulnaris and the inner porti

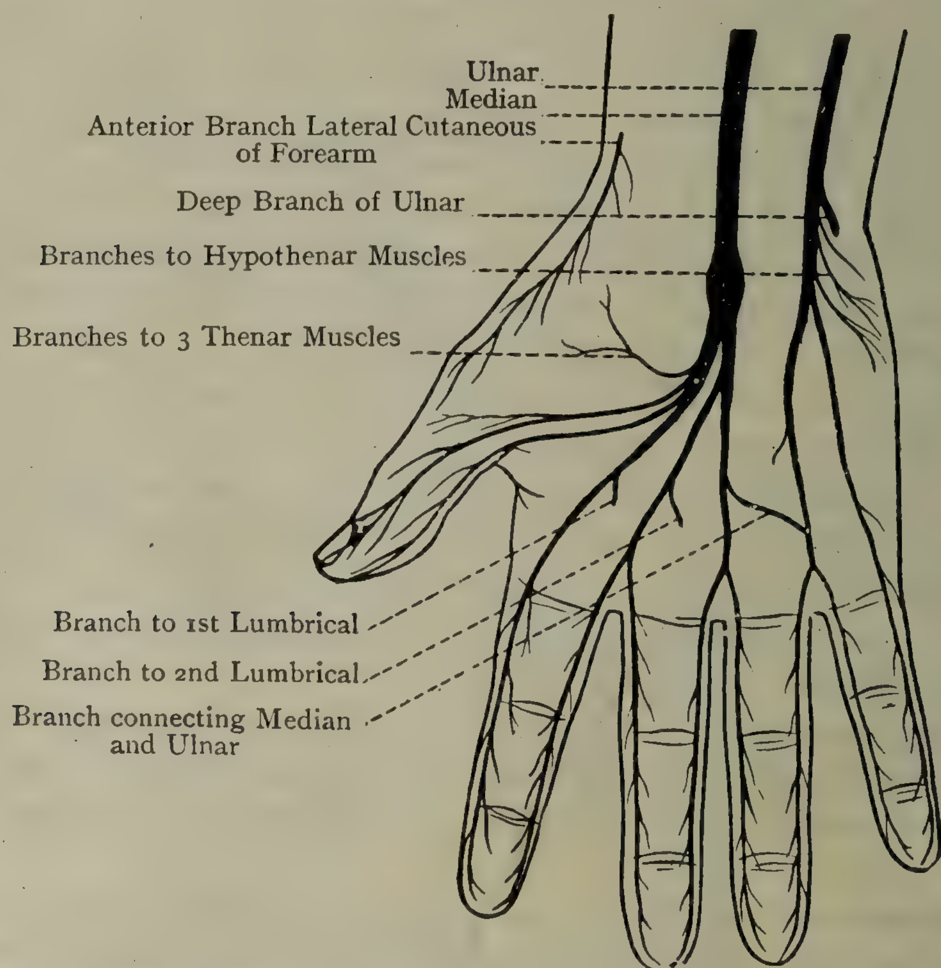


Fig. 306.—Diagram of the Nerves of the Palm.

of the flexor profundus digitorum; three short muscles of the thumb—namel the abductor, opponens, and flexor pollicis brevis; and the two outer lumbric muscles. **Cutaneous.**—The palmar cutaneous branch supplies the middle of th palm, and the digital branches the outer three and a half digits. **Articular.**—It supplies branches to the elbow- and wrist-joints, as well as to several join of the hand.

Synovial Sheaths (Fig. 307).—The flexor tendons occupying th carpal canal, the roof of which is the flexor retinaculum, are provide with two synovial sheaths. The inner and larger invests the tendon of the flexor sublimis and flexor profundus; the outer and smalle invests the tendon of the flexor pollicis longus. The synovial sheath are reflected from the tendons, and line the wall of the canal in whic they are contained. The layer lining the roof of the canal covers th

leep aspect of the median nerve. The two sheaths may be independent, out sometimes communicate with one another. Both sheaths are prolonged for some distance upwards into the forearm, where they end it the level at which the tendons become continuous with the muscle bellies. The outer sheath is prolonged downwards into the palm, and hence on to the thumb, following the tendon of the flexor pollicis ongus to its insertion at the base of the terminal phalanx. The inner heath is also prolonged into the palm, where it broadens as the tendons liverge. About the middle of the palm it ends in three small diverticula opposite the second, third, and fourth metacarpal bones. On the nner side, however, a prolongation follows the flexor tendons of the

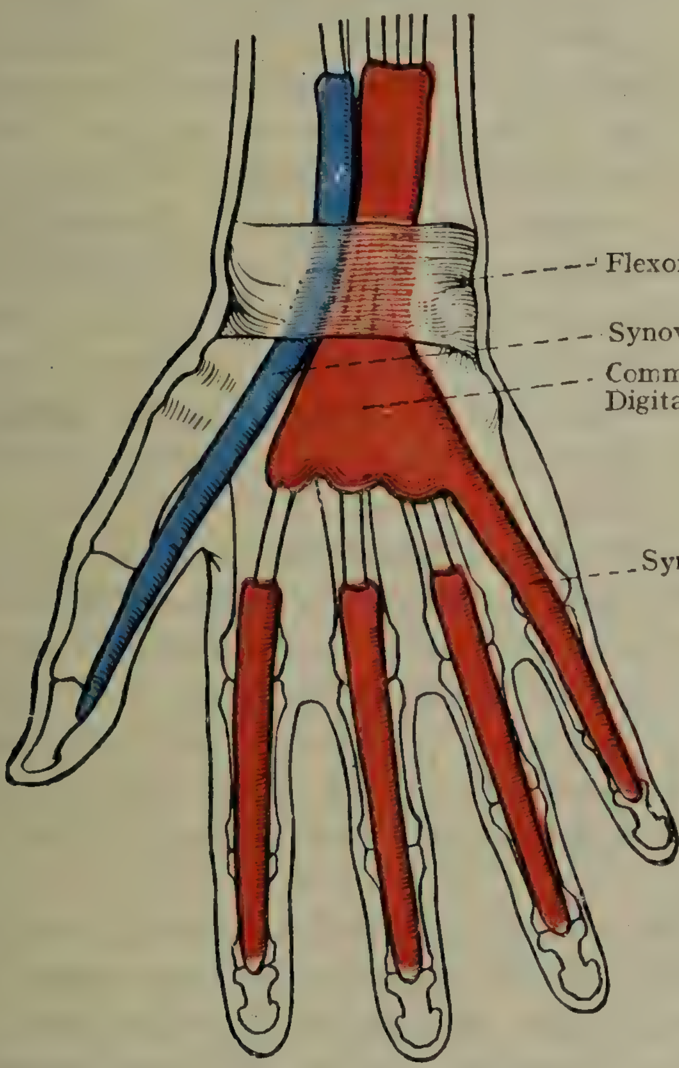


FIG. 307.—THE SYNOVIAL SHEATHS OF THE FLEXOR TENDONS.

ittle finger, and extends to the base of its terminal phalanx. The lexor tendons of the index, middle, and ring fingers are provided with ndependent sheaths, which, commencing at the distal ends of the respective metacarpal bones, are prolonged to the bases of the distal phalanges of these digits.

The arrangement of the synovial sheaths is of some considerable clinical mportance, as it is obvious that deep septic inflammation involving the thumb or little finger is more likely to spread upwards into the palm, and thence to the wrist and forearm, than it is in the case of one of the other digits.

Sheaths of the Flexor Tendons.—The two flexor tendons (superficial and deep) of each finger are contained in a fibro-osseous canal. The

osseous wall is formed by the palmar aspects of the proximal and int mediate phalanges, and the fibrous wall by an arched sheath. T sheath, over the greater parts of the proximal and intermedi phalanges, is thick and strong, and these parts of it are known the **digital vaginal ligaments.** The fibres disposed transversely, and are attached to rough lateral margins of the palmar surfa of the phalangeal shafts. Opposite the join in order not to interfere with the moveme of flexion, the vaginal ligaments are replac by thin membranes, superadded to which obliquely decussating fibres. Each fib osseous canal is lined by synovial membra which is reflected over the contained tend in such a manner as to furnish a separ investment for each. To certain bands of synovial membrane reflected from the tend which it invests to the wall of the fibro-osseo canal which it lines the name **vincula tendin** (Fig. 308) is given. They are of two kinds vincula brevia and vincula longa. The *vinc brevia* are two in number—one for the sup ficial and one for the deep flexor tend They are broad, laterally compressed, triangu bands which are thickened by the presence elastic fibres, and connect each tendon, cl to its insertion, with the distal end of t phalanx proximal to that into which it inserted. The *vincula longa,* few and inconstant, are narrow ban which pass between the tendons and the phalanges, or from one tend to the other.

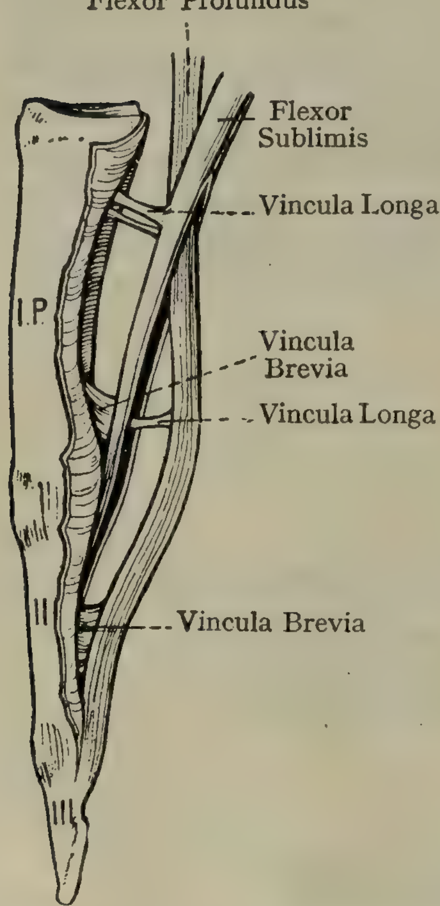


FIG. 308.—THE FLEXOR TENDONS OF A FINGER.

The Lumbricals (Fig. 295) are four tapering muscles which a connected with the deep flexor tendons in the palm, and are disti guished numerically, the most lateral being the first. The first a second arise in each case from the outer side of the deep flexor tend for the index and the middle finger respectively; the third and four arise from the adjacent sides of the two deep flexor tendons betwe which they lie, the tendons concerned being those for the middle, rin and little fingers. Each muscle tapers and ends distally in a tend which, winding round the outer side of a metacarpo-phalangeal join expands and blends with the outer side of the broad expansion of t extensor tendon on the back of the proximal phalanx.

The lumbrical muscles are embedded in loose connective tissue continuo with cellular tissue lying deeply to the flexor tendons, between them and t floor of the palm. This cellular tissue occupies two spaces known respective as the middle palmar and thenar spaces, which are separated from the ove lying tendons by a fibrous membrane, and from one another by a dense fibro septum. The middle palmar space has three distal diverticula prolonged in the connective tissue sheaths of the three inner lumbricals associated with th

exor tendons of the little, ring, and middle fingers respectively. The thenar ompartment is related superficially to the flexor tendons of the index finger nd that of the flexor pollicis longus; it is similarly prolonged distally into the onnective tissue sheath of the first lumbrical muscle. The two spaces communicate with one another proximally.

Nerve-supply.—The first and second are supplied by the median erve, the branches being derived from the third and fourth digital erves respectively (p. 489). The third and fourth are supplied by e deep division of the ulnar nerve.

The branches from the median nerve supplying the first and second lumbricals nter their superficial aspects; the branches of the ulnar nerve to the third and ourth enter their deep aspects. The nerve-supply of the second lumbrical is nconstant. It is sometimes supplied by the deep branch of the ulnar nerve, nd may have a double nerve-supply, a branch from the median entering its uperficial aspect, another from the ulnar entering its deep aspect.

Action.—Flex the metacarpo-phalangeal joints, and extend the nterphalangeal joints.

The Flexor Retinaculum (Fig. 307) is a strong fibrous band which ridges over the concavity on the palmar aspect of the carpus, and onverts it into a fibro-osseous canal. Laterally it is attached to the ubercle of the scaphoid and trapezium; medially to the ridge on the isiform and the hook of the hamate. Its upper border is continuous vith the deep fascia on the front of the forearm; its lower border is onnected with the palmar aponeurosis; at its upper and inner part it eceives an expansion from the tendon of the flexor carpi ulnaris; and he deep aspect of the tendon of the palmaris longus is attached to it. The retinaculum is crossed by the last-mentioned tendon and the lnar vessels and nerve, the latter structures lying close to the pisiform one, where they are overlapped by a slip from the tendon of the flexor arpi ulnaris. At either side the retinaculum affords origin to the short nuscles of the thumb and of the little finger respectively. The fibro-osseous canal formed by the retinaculum and the anterior concavity of he carpus gives passage to the tendons of the flexors digitorum sublimis nd profundus, the tendon of the flexor pollicis longus, and the median erve. Towards the outer side of the wrist a deep slip of the retinaculum s attached to the lip of the groove below the crest of the trapezium, nd with the main part of the retinaculum superficially converts the roove into a canal containing the tendon of the flexor carpi radialis, vhich may consequently be regarded as traversing the flexor retinaculum.

The Short Muscles of the Thumb—I. **Abductor Pollicis Brevis** Fig. 305)—*Origin.*—The front of the flexor retinaculum; the tubercle of the scaphoid; and the crest on the trapezium.

Insertion.—The outer side of the base of the proximal phalanx of he thumb, in common with flexor pollicis brevis, and the outer margin of the tendon of the extensor pollicis longus on the back of the proximal phalanx.

Nerve-supply.—The median nerve.

The muscle is triangular, and is directed downwards and ou wards.

Action.—Abducts the thumb and assists in flexing its proxim phalanx, the result being that the thumb is drawn forwards and little inwards. It also assists in extending the distal phalanx.

The muscle is superficial, and lies on the opponens pollicis an partially flexor pollicis brevis, a part of which appears on its inner sid

2. **Opponens Pollicis** (Fig. 309)—*Origin.*—The front of the flex retinaculum, and the crest on the trapezium.

Insertion.—The outer border of the shaft of the metacarpal bone the thumb, and the adjacent part of its palmar surface.

Nerve-supply.—The median nerve.

The muscle is triangular, consists of two or more laminæ, and directed downwards and outwards.

Action.—Flexes the first metacarpal bone, the result being that th thumb is drawn forwards and inwards across the palm, bringing it in a position in which its tip may be readily opposed to the tip of any on of the four fingers.

The muscle is deep to the abductor pollicis brevis, the flexor pollic brevis lying along its inner border.

3. **Flexor Pollicis Brevis** (Fig. 309) arises from the outer two-thir of the lower border of the flexor retinaculum, and the crest on th trapezium.

Insertion.—Ending in a tendon, it is inserted, in common with th abductor pollicis brevis, into the outer side of the base of the proxim phalanx of the thumb. A sesamoid bone occupies the commo tendon of insertion opposite the metacarpo-phalangeal joint.

Nerve-supply.—A branch of the median nerve.

Action.—Flexes the metacarpo-phalangeal joint of the thum and thus assists in the movement of opposition of the thumb.

4. **First Palmar Interosseous**—*Origin.*—The inner aspect of th proximal extremity of the first metacarpal bone.

Insertion.—It ends in a tendon which joins with those of th oblique and transverse heads of adductor pollicis, with which it inserted into the inner side of the base of the proximal phalanx of th thumb. A sesamoid bone is contained in the common tendon.

Nerve-supply.—The deep division of the ulnar nerve.

Action.—Assists in flexing the metacarpo-phalangeal joint of th thumb.

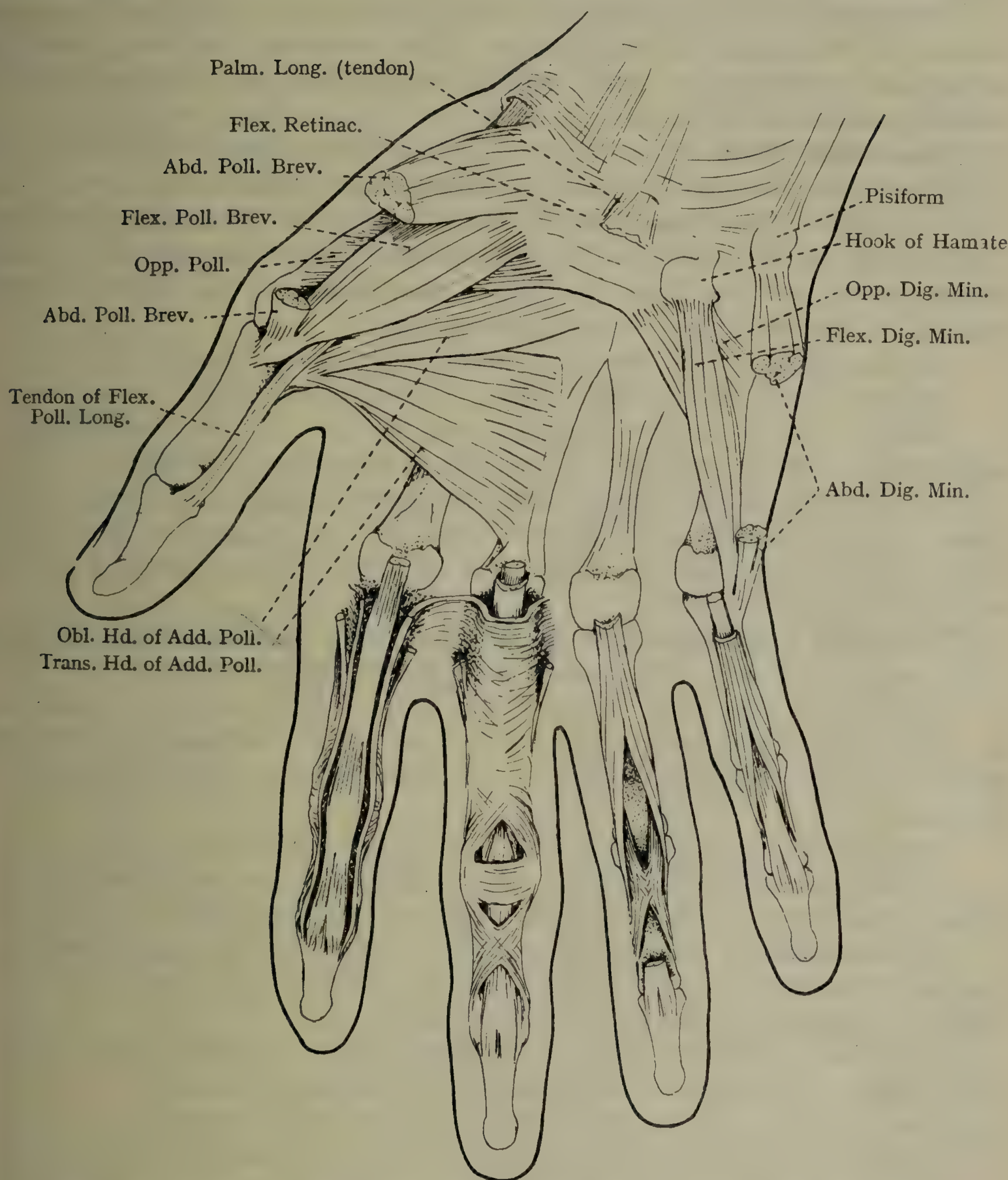
5. **Adductor Pollicis** (Fig. 309) consists of two fleshy heads, obliqu and transverse.

Oblique Head—*Origin.*—By several slips from the bases of th second and third metacarpal bones; the trapezoid and capitate; and th sheath of the tendon of the flexor carpi radialis.

Insertion.—The muscle is inserted with the first palmar interosseou and the transverse head into the inner side of the base of the proxima phalanx of the thumb.

A large fleshy slip from the outer side of the muscle passes outwarc

eply to the tendon of the flexor pollicis longus, and joins the flexor llicis brevis.



. 309.—The Insertions of the Long Flexor Tendons and the Short Muscles of the Thumb and Index Finger.

e abductor of the thumb and of the little finger has in each case been partially removed. On the middle finger the flexor sheath (vaginal ligament) is shown; on the little finger are the two long flexor tendons; on the ring finger is the tendon of the flex. dig. subl., that of the flex. dig. prof. having been removed; on the index finger is the tendon of the flex. dig. prof., the tendon of the flex. dig. subl. having been removed.

Nerve-supply.—The deep division of the ulnar nerve.
The muscle is directed downwards and outwards.

Action.—Adducts the thumb and assists in the movement opposition.

The muscle has the flexor pollicis brevis on its outer side, t tendon of the flexor pollicis longus lying between the two; the tra verse head occupies its inner and lower border, the deep palmar a passing between the two.

Transverse Head (Fig. 309)—*Origin.*—The distal two-thirds of t anterior border of the shaft of the third metacarpal bone.

Insertion.—The inner side of the base of the proximal phalanx the thumb, in common with the oblique head and the first palm interosseous; and the inner margin of the tendon of the extensor polli longus on the back of the proximal phalanx.

Nerve-supply.—The deep division of the ulnar nerve.

The muscle is triangular, and is directed outwards.

Action.—Adducts the thumb and assists in the movement opposition. It also assists in extending the distal phalanx.

The **tendon of the flexor pollicis longus** crosses the tendon of t flexor carpi radialis at the wrist, and in the palm lies between t flexor pollicis brevis on its outer side and the oblique head of adduct pollicis on its inner side.

The Short Muscles of the Little Finger—1. **Abductor Digiti Mini** (Fig. 309)—*Origin.*—The lower part of the pisiform bone.

Insertion.—The inner side of the base of the proximal phalanx the little finger, in common with the flexor digiti minimi; and the inn margin of the expansion of the extensor tendon on the back of t phalanx.

Nerve-supply.—The deep division of the ulnar nerve.

Action.—Adducts the little finger, flexes its metacarpo-phalange joint, and assists in extending its intermediate and distal phalanges.

2. **Flexor Digiti Minimi** (Fig. 309)—*Origin.*—The inner surface the hook of the hamate bone close to its tip, and the front of t adjacent portion of the flexor retinaculum.

Insertion.—The inner side of the base of the proximal phalanx of t little finger, in common with the abductor digiti minimi.

Nerve-supply.—The deep division of the ulnar nerve.

Action.—Flexes the metacarpo-phalangeal joint of the little finge

The muscle is small, and lies on the outer side of, and partially und cover of, the abductor digiti minimi, from which it is separated, clo to its origin, by the deep branch of the ulnar artery and the de division of the ulnar nerve.

3. **Opponens Digiti Minimi** (Fig. 309)—*Origin.*—The inner surfa of the hook of the hamate bone under cover of the preceding muscl and the adjacent part of the flexor retinaculum.

Insertion.—The inner aspect of the shaft of the fifth metacarp bone.

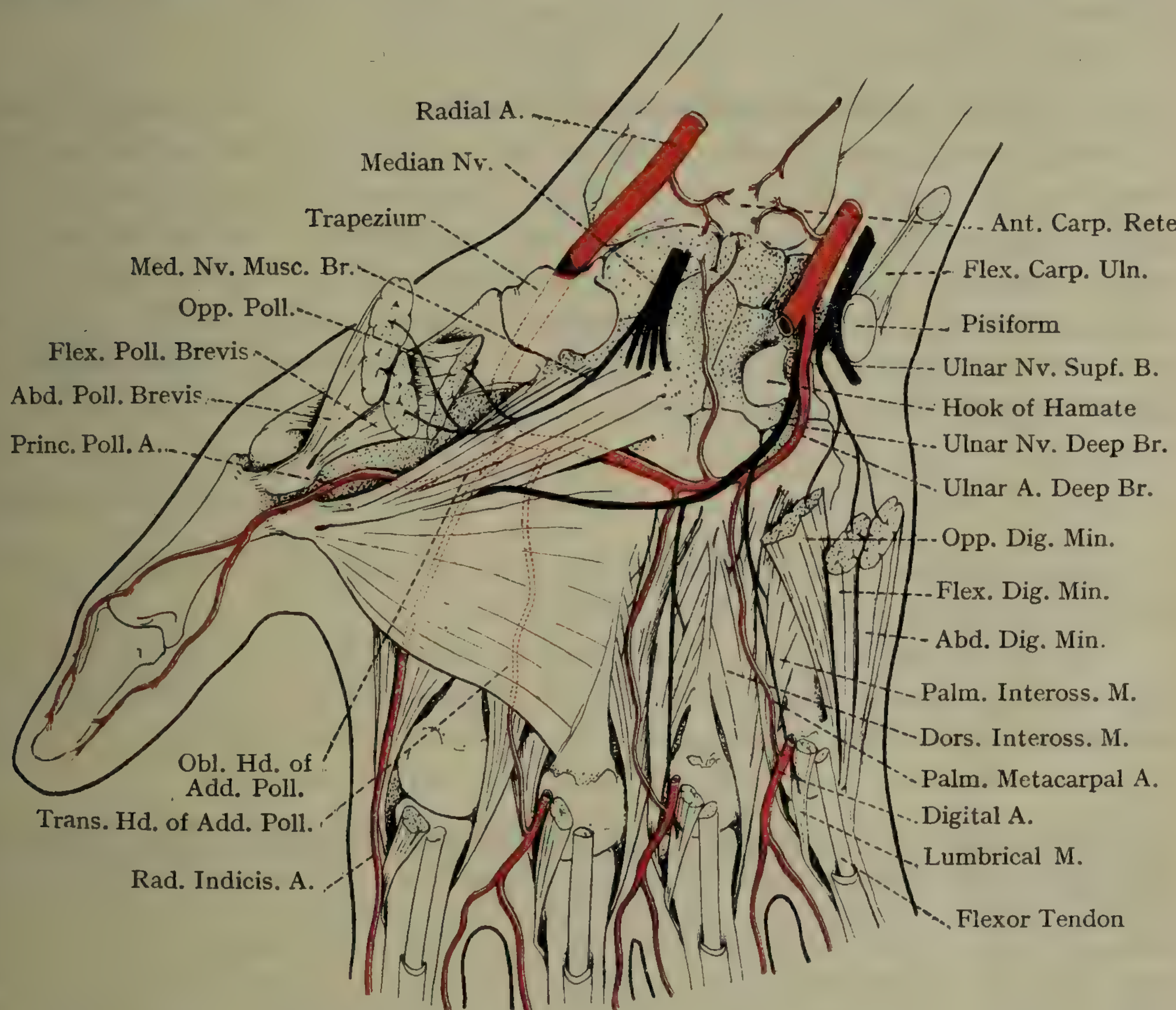
Nerve-supply.—The deep division of the ulnar nerve.

Action.—Flexes and adducts the fifth metacarpal bone.

The muscle lies deeply to the abductor and flexor digiti minim

nd its deep surface is in relation with the interosseous muscles of ne fourth interspace. The deep branches of the ulnar artery and of ne ulnar nerve may pass through it on their way to the deep part of ne palm.

The Third Part of the Radial Artery (Fig. 310) forms the greater ortion of the *deep palmar arch,* and extends inwards from the proximal nd of the first intermetacarpal space to join the deep branch of the lnar artery. It enters the palm by passing forwards between the vo heads of the first dorsal interosseous muscle and crosses the floor f the palm, lying upon the bases of the second, third, and fourth



IG. 310.—THE DEEP PALMAR ARCH AND THE DEEP BRANCH OF THE ULNAR NERVE, TOGETHER WITH THE MUSCULAR STRUCTURES OCCUPYING THE FLOOR OF THE PALM.

etacarpal bones and the adjacent interosseous muscles. Towards ne outer side of the palm it lies deeply to the oblique head of adductor ollicis, but emerging between this head and the transverse head, it lies eeply to the flexor tendons and lumbrical muscles towards the inner de of the palm. The deep palmar arch describes a slight curve with ne convexity directed towards the fingers, and is about 1 inch nearer ne wrist than the superficial palmar arch. The deep division of the lnar nerve lies in front of it.

Branches of the Deep Palmar Arch.—The **princeps pollicis artery** rises from the outer extremity of the arch, and passes downwards

between the two heads of adductor pollicis superficially and the fi
dorsal interosseous muscle deeply. At the distal end of the fi
metacarpal bone, and on the deep aspect of the tendon of the fle
pollicis longus, it divides into two collateral branches which are d
tributed to either side of the thumb.

The **radialis indicis artery** passes downwards on the outer side
the second metacarpal bone, lying on the first dorsal interosseous, a
deeply to both heads of adductor pollicis; it is finally distributed to t
outer side of the index finger.

The princeps pollicis and radialis indicis arteries not infrequently arise
a common trunk. The final distribution of the two arteries is similar to t
of a digital branch of the superficial palmar arch.

The three **palmar metacarpal arteries** arise from the convexity
the arch, and pass downwards in the second, third, and fourth int
metacarpal spaces lying upon and supplying the interosseous muscl
They terminate by joining the digital arteries of the superficial palm
arch, meeting these vessels just before they subdivide into th
collateral branches. The innermost palmar metacarpal artery usual
gives off a communicating branch, which joins the digital artery fro
the superficial arch supplying the inner side of the little finger.

When the digital arteries from the superficial arch are deficient, the palm
metacarpal arteries may take their place in supplying blood to the fingers.

The **recurrent branches,** few and small, pass upwards and ta
part in forming the anterior carpal rete.

The three **perforating arteries** pass backwards through the proxim
ends of the inner three intermetacarpal spaces and between the tw
heads of the corresponding dorsal interosseous muscles. On the ba
of the hand they join the dorsal metacarpal arteries.

Varieties of the Ulnar and Radial Arteries in the Hand—The Ulnar Artery.
The digital branches furnished by the superficial palmar arch may be deficie
or the ulnar artery may end in the deep palmar branch, in which case the sup
ficial arch is absent. Under these circumstances the digital arteries are usua
derived from the palmar metacarpal branches of the deep arch. In some cas
a large median together with a large superficial palmar branch furnish the digit
arteries.

The Radial Artery.—The princeps pollicis and radialis indicis arteries, norma
arising from the radial, may be derived from the superficial arch, from an enlarg
median artery, or from the superficial palmar branch.

Veins.—The deep palmar arch is accompanied by two small ven
comites which receive tributaries corresponding to the branches of tl
arch.

Summary of the Palmar Arches.—The **superficial palmar arch** is form
mainly by the ulnar artery, and is completed by the superficial palmar bran
of the radial, or, failing this, by a branch from the radialis indicis artery, or fro
the princeps pollicis artery, its digital branches corresponding in position
the intermetacarpal spaces. In order to avoid them, incisions in the pal
should be made in line with the middle line of a finger, and should not be pr
longed farther upwards than the line indicating the position of the superfici

lmar arch. On the fingers the digital arteries are placed laterally, conse-
ently in cases of whitlow the incision should be made along the middle line
a finger.

The **deep palmar arch** is formed mainly by the radial artery, and is com-
eted by the deep branch of the ulnar. It lies about 1 inch proximal to the
perficial arch.

The Ulnar Nerve (Fig. 310) gains the hand by passing superficially the flexor retinaculum, where it lies on the inner side of the ulnar ssels, and is overhung by the pisiform bone. More distally it lies the piso-hamate ligament, and grooves the inner aspect of the hook the hamate bone. It subdivides into two divisions—superficial d deep. The *superficial division* passes downwards deeply to the lmaris brevis, to which it gives a branch, and ends by dividing into o **digital nerves.** One is distributed to the inner side of the little ger. The other divides into two collateral digital nerves for the pply of the adjacent sides of the little and ring fingers. This nerve mmunicates with the innermost digital branch of the median. The stribution of the nerves on the fingers corresponds with that of the edian palmar branches; they supply the joints as well as the skin, d furnish dorsal branches to the backs of the fingers. The *deep vision* accompanies the deep branch of the ulnar artery, passes be-een the abductor and flexor digiti minimi, and through, or deeply to, e opponens digiti minimi. Gaining the floor of the palm, it accom-nies the deep palmar arch, in front of which it lies. It has an tensive muscular distribution, supplying the abductor, flexor, and ponens digiti minimi, the inner two lumbricals, the eight interossei, d one thumb muscle—namely, the two heads of adductor pollicis. also gives articular twigs to the wrist-joints and to the metacarpo-alangeal joints.

Summary of the Ulnar Nerve—Muscular.—In the forearm it supplies the xor carpi ulnaris and inner part of the flexor digitorum profundus; in the hand supplies the palmaris brevis, the three short muscles of the little finger, the ner two lumbricals, the eight interossei, and one thumb muscle—namely, th heads of adductor pollicis. **Cutaneous.**—It supplies the skin of the front the forearm for a variable extent, the inner part of the palm, and the inner e and a half fingers. **Articular.**—It supplies branches to the elbow- and wrist-ints and several of the joints of the hand.

Back of the Forearm and Hand.

The skin on the outer side of the back of the forearm is supplied y the posterior branch of the lateral cutaneous nerve of forearm, at on the inner side by the posterior branch of the medial cutaneous forearm. Between the two, and occupying a more central position, the posterior cutaneous nerve of forearm.

Muscles on the Back of the Forearm.—The muscles exposed to ew (Fig. 312) when the skin and fascial layers are removed from the ck of the forearm are disposed as follows:

To the inner side of the posterior subcutaneous border of the ulna

is the flexor carpi ulnaris, which, although it is a flexor muscle a was described with the muscles on the front of the forearm, occup the back of the limb to a considerable extent.

The extensor muscles proper are all disposed to the outer side the posterior border of the ulna, and are arranged in the followi groups:

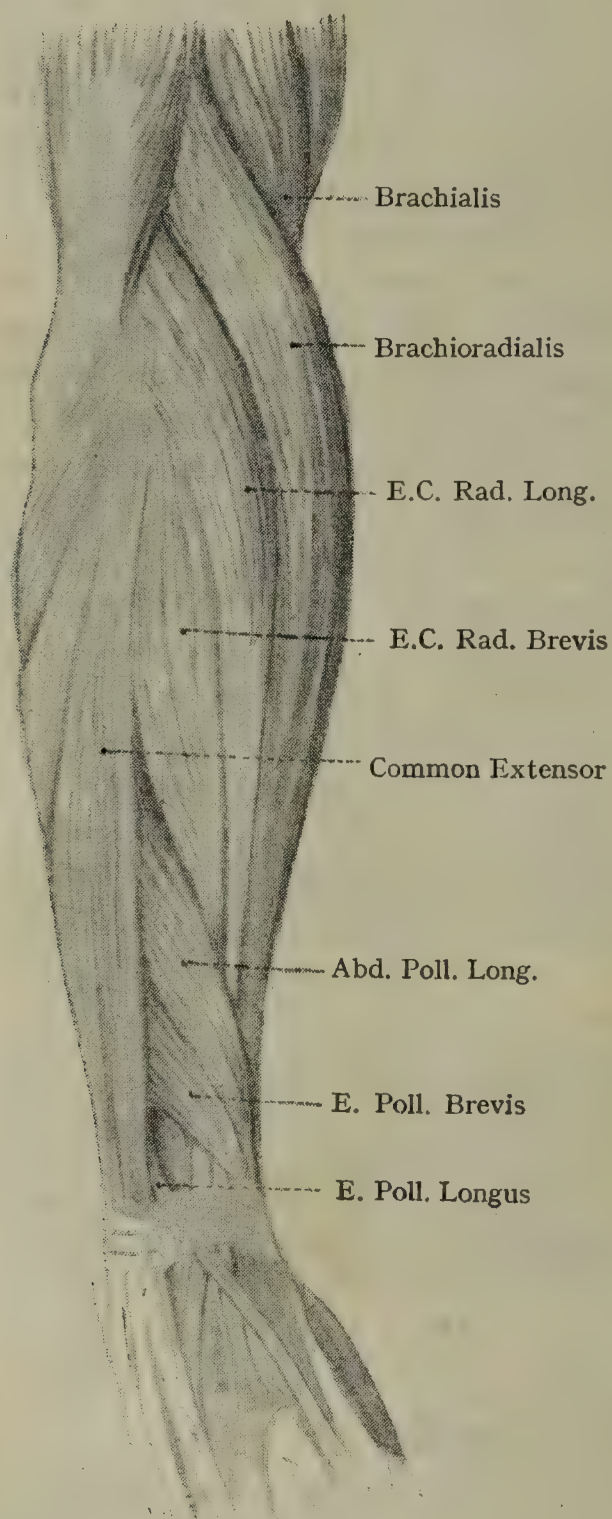


Fig. 311.—Muscles on Lateral Aspect of Forearm.

1. A small triangular muscle, t anconeus, is confined to the region the elbow.

2. An outer marginal group three muscles, in order from witho inwards—the brachio-radialis, exte sor carpi radialis longus, and extens carpi radialis brevis—occupy the ou aspect of the limb.

3. An inner group of three exte sor muscles which, as a group, follo the posterior border of the ulna; t extensor digitorum, extensor dig minimi, and extensor carpi ulnaris in this order from without inwards.

4. In the upper part of the fo arm groups 2 and 3 are in juxt position, but towards the lower pa they diverge from one another, a in an elongated angular interval b tween them there appear three muscl of the thumb—the abductor pollic longus, extensor pollicis brevis, a extensor pollicis longus, in this ord from above downwards. The thr muscles are for the most part on deep plane, but, outcropping as were between the two superfici groups, incline obliquely downwar and outwards to reach the thum and cross the lower ends of thr outer marginal muscles superficial before attaining their destination They will be described with the de extensor muscles.

1. **Anconeus** (Fig. 312)—*Origin.*— The back of the lateral epicondyle the humerus.

Insertion.—The outer surface of the olecranon process, and th upper third of the posterior surface of the shaft of the ulna, its attacl ment being limited below by the oblique line on the bone.

The muscle is triangular, the upper fibres being short and tran

versely disposed, whilst the lower fibres pass obliquely downwards and inwards.

Nerve-supply.—A branch of the radial nerve, which is chiefly concerned in supplying the medial head of the triceps (p. 461).

Action.—Assists the triceps in extending the elbow-joint.

The posterior interosseous recurrent artery ascends under cover of the muscle to the back of the lateral epicondyle.

The anconeus is frequently inseparable from the medial head of the triceps. The muscle may be regarded as a part of the triceps displaced downwards into the forearm.

2. **Outer Marginal Group—Brachio-radialis** (Fig. 312)—*Origin.*—The upper two-thirds of the lateral supracondylar ridge of the humerus, and the front of the lateral intermuscular septum to a corresponding extent.

Insertion.—The outer side of the lower end of the radius some little distance above the styloid process, chiefly to the floor of the upper end of the groove lodging the tendon of the abductor pollicis longus, on the deep aspect of which the insertion lies.

Nerve-supply.—The radial nerve.

Action.—The muscle is mainly a flexor of the forearm, acting most effectively when the limb is in a state of semipronation. An important use of the muscle is to maintain the forearm in the flexed position, as in holding a book. When the forearm is fully pronated the muscle is a feeble supinator, bringing the limb to a position midway between complete pronation and complete supination, but only to the extent of semisupination. On the other hand, when the forearm is fully supinated, it can act as a pronator, again bringing the limb into the intermediate position.

Above the muscle has a fleshy belly, which towards the lower part of the forearm is replaced by a flat tendon, first appearing on the deep surface of the muscle. In the arm the muscle belly is flattened from side to side, but in the region of the elbow it is twisted upon itself in such a way that in the forearm it is flattened from before backwards.

Extensor Carpi Radialis Longus—*Origin.*—The lower third of the lateral supracondylar ridge of the humerus, and the front of the lateral intermuscular septum to a corresponding extent.

Insertion.—The outer part of the base of the second metacarpal bone, a small bursa underlying the tendon at its insertion.

Nerve-supply.—The radial nerve.

Action.—Extends and assists in abducting the wrist-joint.

The relatively small muscle belly ends in the lower part of the forearm in a tendon which descends at first superficially to, and at a lower level on the outer side of, the tendon of the extensor carpi radialis brevis. The two tendons pass deeply to the extensor retinaculum, and occupy the outermost groove on the back of the lower end of the radius.

Extensor Carpi Radialis Brevis (Fig. 312)—*Origin.*—The lat epicondyle of the humerus; the lateral ligament of the elbow-jo and the intermuscular septa between it and the adjacent muscles.

Insertion.—The outer part of the base of the third metaca bone, and often by a small sli the base of the second metacar A small bursa underlies the ten at its insertion.

Nerve-supply.—The de branch of the radial nerve.

Action.—Extends and ass in abducting the wrist-joint.

The tendon appears about middle of the forearm, and comes free from fleshy fibres in lower third. It descends dee to the tendon of the long ra extensor, except near its inserti where it lies internal to it. accompanies the long ten under cover of the extensor ret aculum, and passes with it thro the outermost groove on the b of the lower end of the radius.

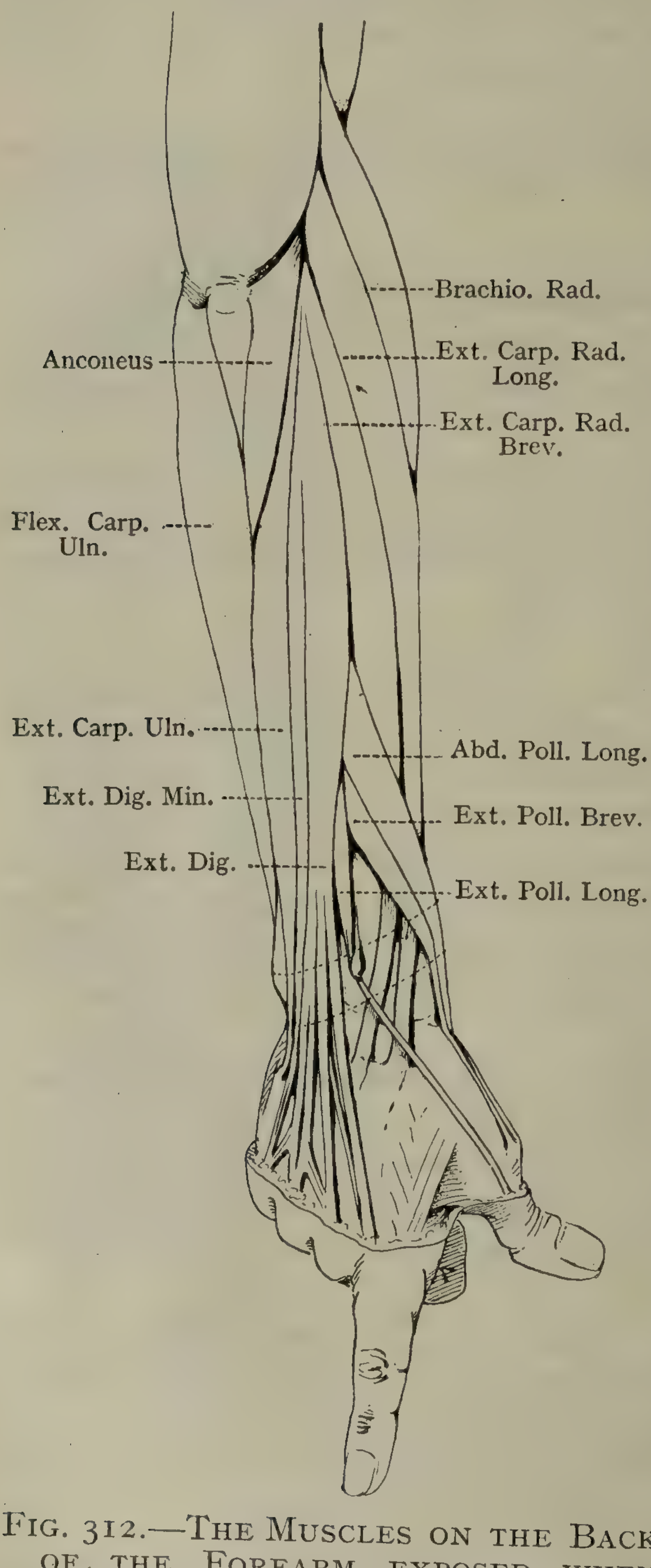


Fig. 312.—The Muscles on the Back of the Forearm exposed when the Skin and Fascial Layers are removed.

3. **The Inner Group of Extens** all arise by a common tend from the lateral epicondyle of humerus.

Extensor Digitorum (Fig. 3 —*Origin.*—The lateral epicond of the humerus; the deep fasc and the intermuscular septa tween it and adjacent muscles.

Insertion.—The muscle ends four tendons, the innermost which does not attain its in pendence until the back of hand is attained. The tend pass deeply to the extensor ret aculum, where they occupy broad innermost groove on back of the lower end of radius, and diverge from another on reaching the han The arrangement of the tendons on the back of the hand is som what variable, but is usually as follows: The two outer tendons prolonged on to the index finger and the middle finger respective Between the two tendons, and connecting them together, is an adhere

ickened band of the deep fascia (vinculum), consisting of more or ss transversely disposed fibres. The tendon to the index finger ends with the tendon of the extensor indicis, which is disposed on its ner (ulnar) side. The two inner tendons in each case split into two, e two bands of the one passing to the middle and ring fingers, those the other to the ring and little fingers. The band to the middle nger blends with the main tendon to that digit; the band to the little nger blends with the tendon of the extensor digiti minimi. The bands om the two inner tendons passing to the ring finger blend to form e extensor tendon of that digit.

From the arrangement of their tendons and from the fact that they are ovided with special extending muscles, it follows that of the four fingers the dex and little are endowed with the greatest mobility as far as independent tension is concerned, while the possibility of extending the ring finger indeendently is extremely limited.

On the dorsal aspect of the proximal phalanx the extensor tendon idens (*extensor expansion*), and is here joined by the tendons of the mbrical and interosseous muscles. Towards the distal end of the roximal phalanx the tendon contracts, and, passing across the proximal terphalangeal joint, the central part is inserted into the base of the termediate phalanx. The lateral parts converge, and blending toether on the back of the intermediate phalanx, form a single tendon, hich is inserted into the base of the terminal phalanx.

Nerve-supply.—The posterior interosseous nerve.

Action.—Extends the distal phalanges on the proximal, the proximal halanges on the metacarpal bones, and the hand on the forearm.

Extensor Digiti Minimi (Fig. 312)—*Origin.*—The lateral epicondyle f the humerus; the deep fascia; and the intermuscular septa on either de of it.

In many cases the muscle, which is very narrow, does not extend upwards s high as the lateral epicondyle, but arises from the deep fascia and the interuscular septa only.

Insertion.—Its tendon passes deeply to the extensor retinaculum, here it occupies a groove between the radius and ulna. On the back f the hand the tendon splits into two, which reunite at the distal end f the fifth metacarpal bone, where it is joined by a slip from the nermost tendon of the extensor digitorum. The final insertion is imilar to that of a digital extensor tendon described above.

Nerve-supply.—The posterior interosseous nerve.

Action.—In addition to extending the little finger, it aids to some light extent in extending the wrist-joint.

Extensor Carpi Ulnaris—*Origin.*—The lateral epicondyle of the umerus, the deep fascia covering it, and by its means has an indirect ttachment to the posterior border of the ulna (*cf.* flex. carp. uln., . 473); the intermuscular septum on its outer side; some of its fibres re directly attached to the oblique line of the ulna, marking the lower mit of the attachment of the anconeus.

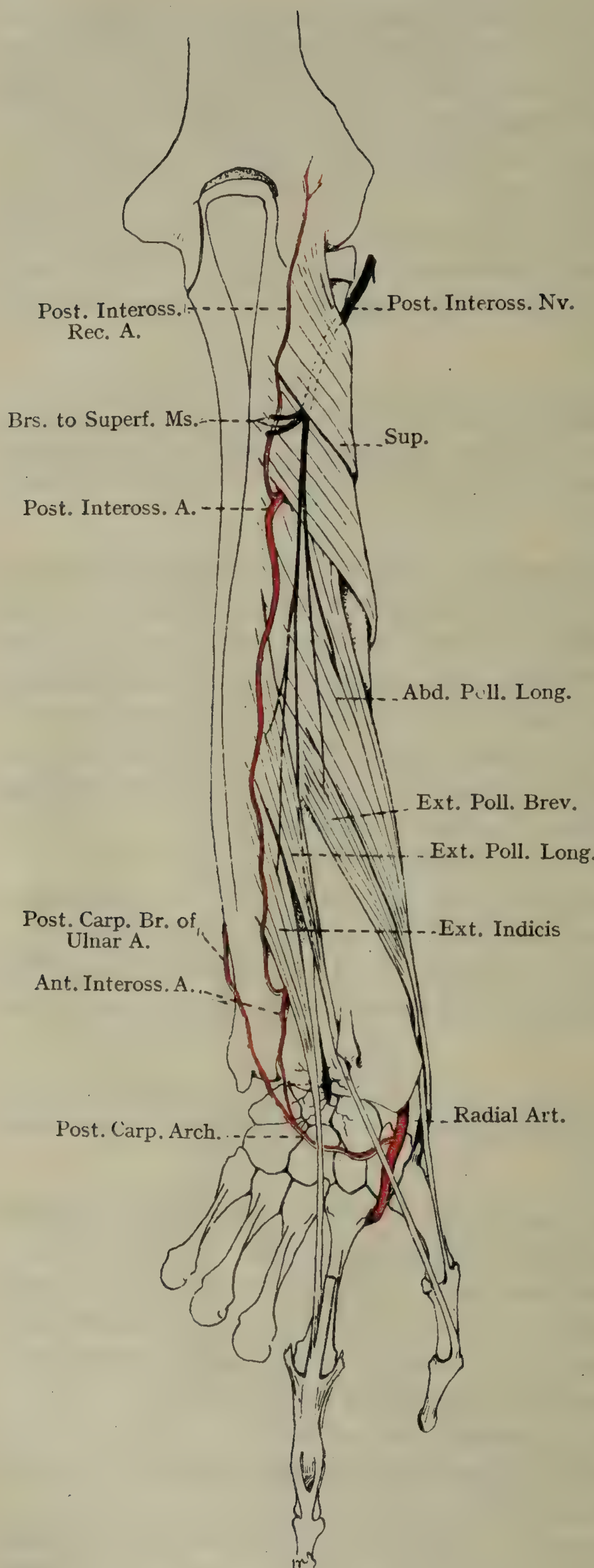


FIG. 313.—THE DEEP EXTENSOR MUSCLES.

Insertion.—The tuber on the inner side of the b of the fifth metacarpal bo

Nerve-supply.—The p terior interosseous nerve.

Action. — Extends wrist-joint, and assists adducting the hand.

The muscle rests upon inner half of the poster surface of the shaft of ulna, and its tendon pas deeply to the extensor ret aculum, where it occupies groove on the back of lower end of the ulna.

The Deep Muscles on the Back of the Forearm (F 313) are five in number. addition to the three thur muscles, which, in the low part of the forearm, outcr between the two chief sup ficial groups (p. 500), th include the supinator sit ated in the region of elbow above the thur muscles, and below them t extensor indicis occupyi the lower part of the fo arm, where it lies deeply the extensor digitorum. T five deep muscles have o feature in common, in th they all incline oblique downwards and outwar from their origins to the insertions.

Supinator (Fig. 313) *Origin.*—The muscle has long and continuous orig from the humerus abov where it arises from t lateral epicondyle, to the ul below, where it is attach to the supinator crest (a co spicuous ridge on the outer aspect of the bone, continuous abo with the hinder lip of the radial notch), and to some extent to t

epressed area of bone in front of it. Between the two bones the muscle rises from the lateral and orbicular ligaments occupying the outer spect of the elbow-joint. Some of its fibres are attached to a dense ascia covering its posterior surface.

Insertion.—The upper part of the shaft of the radius on its anterior, uter, and posterior aspects, occupying an area on the bone limited elow by the anterior and posterior oblique lines.

Nerve-supply.—The posterior interosseous nerve.

Action.—Supinates the radius upon the ulna.

The fibres of the muscle are, for the most part, spirally disposed, nd wind round the outer side of the radius from its posterior to its nterior aspect. The muscle almost completely surrounds the upper nd of the radius and consists of two laminæ, superficial and deep, the osterior interosseous nerve lying between them.

Abductor Pollicis Longus (Fig. 313)—*Origin.*—The posterior surface f the shaft of the radius for fully 2 inches below the posterior oblique ne; the adjacent portion of the interosseous membrane; and the outer art of the posterior surface of the shaft of the ulna for a short distance elow the oblique line which marks the lower limit of the insertion of he anconeus.

Insertion.—The outer side of the base of the metacarpal bone of he thumb.

The muscle passes obliquely downwards and outwards; its well-iarked tendon crosses the insertion of the brachio-radialis, and is losely accompanied by that of the extensor pollicis brevis. Both endons cross those of the radial extensors of the wrist superficially, nd occupy the groove on the outer side of the lower end of the radius, here they lie deeply to the extensor retinaculum.

Nerve-supply.—The posterior interosseous nerve.

Action.—Extends and abducts the metacarpal bone of the thumb, nd abducts the wrist-joint.

The tendon of the abductor pollicis longus is rarely single, and is usually iultiple, when it may consist of two or three tendons. Of these, one may be ttached to the trapezium, where it is usually associated with the attachment f the abductor pollicis brevis, the fibres of which may arise from it. Occasion-lly the proximal end of the abductor pollicis brevis is not attached to bone, but directly continuous with the tendon of the abductor pollicis longus. This endency to complexity and subdivision is a human characteristic, and probably idicates an increasing specialization of the movements of the thumb. It may ortend a numerical increase of the thumb musculature.

Extensor Pollicis Brevis (Fig. 313)—*Origin.*—The posterior surface f the shaft of the radius for a short distance below the preceding iuscle, and the adjacent part of the interosseous membrane.

Insertion.—The back of the base of the proximal phalanx of the humb.

The muscle closely accompanies the abductor pollicis longus.

Nerve-supply.—The posterior interosseous nerve.

Action.—Extends the metacarpo-phalangeal joint of the thumb.

Extensor Pollicis Longus (Fig. 313)—*Origin.*—The outer part of

the posterior surface of the shaft of the ulna for about its middle thir immediately below the attachment of the abductor pollicis longus, ar the adjacent part of the interosseous membrane.

Insertion.—The back of the base of the distal phalanx of the thuml

The muscle is directed obliquely downwards and outwards; i tendon passes deeply to the extensor retinaculum, where it occupi the narrow oblique groove on the radius, medial to the dorsal tubercl

Nerve-supply.—The posterior interosseous nerve.

Action.—Extends the distal phalanx of the thumb. Further co traction assists in extending the proximal phalanx and also the met carpal bone.

Extensor Indicis (Fig. 313)—*Origin.*—The outer part of the posteric surface of the shaft of the ulna, below the attachment of the extenso pollicis longus, and the lower part of the interosseous membrane.

Insertion.—The inner side of the tendon of the common extenso to the index finger, which it joins at the level of the metacarpo-phalar geal joint.

The muscle is directed downwards and outwards, and its tendo lies deeply to the extensor retinaculum, where it occupies the innermos groove on the back of the radius, in company with the commo extensor tendons, under cover of which it lies.

Nerve-supply.—The posterior interosseous nerve.

Action.—The muscle is the special extensor of the index finger.

The Posterior Interosseous Nerve (Fig. 313) is a branch of the radia its fibres being derived from the sixth, seventh, and eighth cervic nerves. It descends for a short distance deeply to the brachio-radiali and then winds round the outer side of the upper end of the radiu As it does so, it passes through the supinator, occupying the plan between the two layers of the muscle. It appears on the back of th limb from under cover of the superficial layer of the supinator, an descends for a short distance, lying on the deep layer. At the lowe edge of the supinator it comes into relation with the posterior inte osseous artery, with which it descends, the artery lying to its inne side, between the superficial and deep muscles on the back of th forearm.

Branches.—Before traversing the supinator, it supplies branche to the extensor carpi radialis brevis and to the supinator. As it passe through the supinator, it supplies further branches to this muscl At its escape from the supinator three short branches are given of and are distributed to the extensor carpi ulnaris, extensor digi minimi, and extensor digitorum. At a little lower level it gives o two long branches: one from its outer side supplies the abductor pollic longus, and ends in the extensor pollicis brevis; the other from it inner side supplies the extensor pollicis longus, and ends in the extenso indicis. All these branches are given off in the upper part of th forearm. The nerve is now reduced to a very slender trunk, to whic the name posterior interosseous can be more properly applied. I descends between the superficial and deep extensor muscles, a mor

less close companion of the posterior interosseous artery. Reaching e upper border of the extensor pollicis longus, it descends deeply this muscle, and lies directly on the interosseous membrane. Finally, passes on to the back of the radius, and lies in the groove containing e tendons of the extensor digitorum and extensor indicis, together

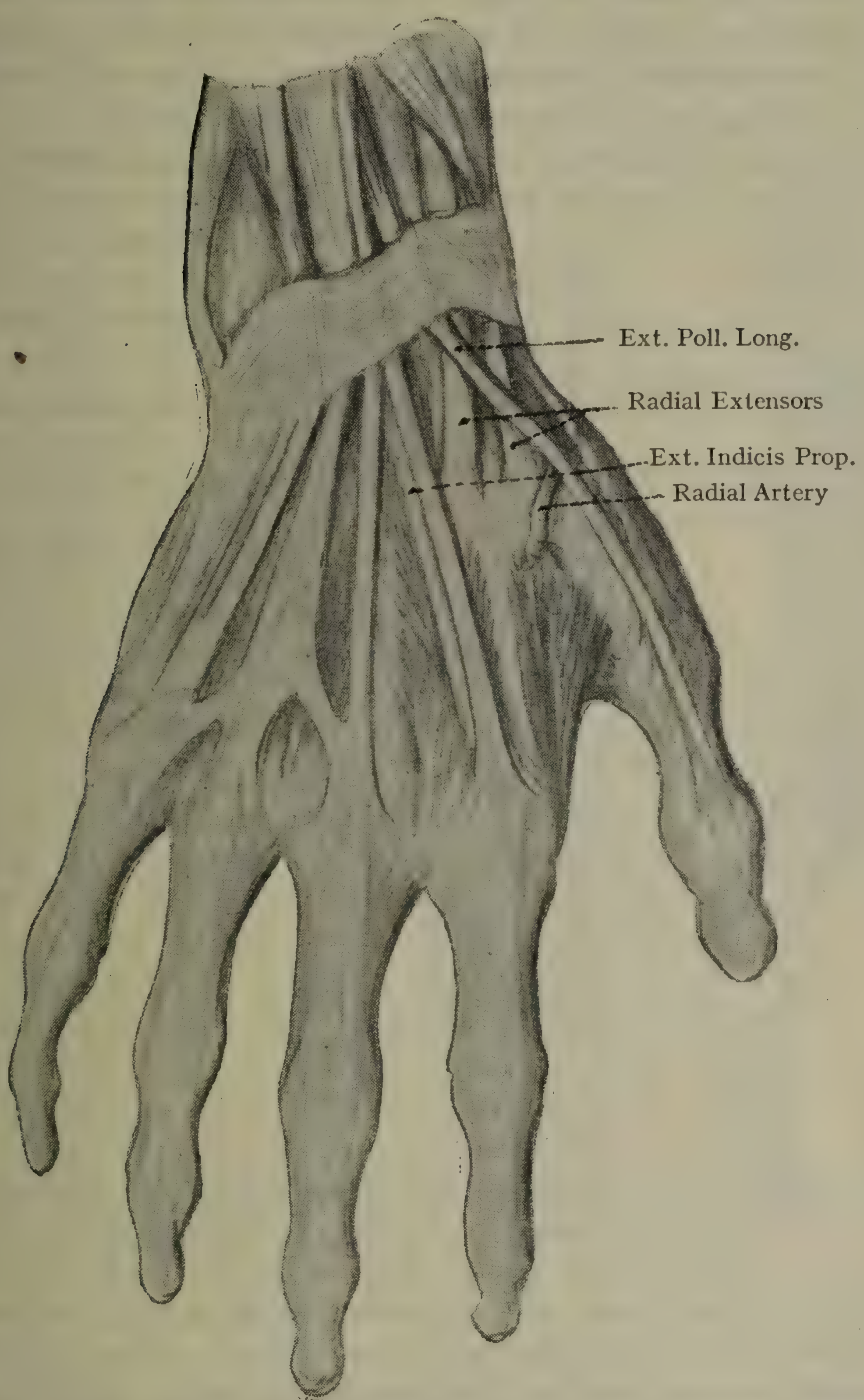


FIG. 314.—THE EXTENSOR TENDONS ON THE DORSUM OF THE HAND.

ith the terminal part of the anterior interosseous artery. It ends ere in a gangliform enlargement, which is prolonged downwards on to he back of the wrist, and from which branches are distributed to the rist and carpal joints.

The Posterior Interosseous Artery passes backwards through an terval between the upper border of the interosseous membrane and

the oblique cord. At the back of the forearm it appears between t
supinator and abductor pollicis longus, where it is joined by t
posterior interosseous nerve. The artery and nerve descend betwe
the superficial and deep extensor muscles to the upper border of t
extensor pollicis longus. Here the artery leaves the nerve, and pas
superficially to this muscle and to the extensor indicis. At the low
border of the latter muscle it anastomoses with the posterior termi
branch of the anterior interosseous, and usually ends by supplying t
wrist-joint. It may join the posterior carpal arch.

Branches.—The *posterior interosseous recurrent* arises at the low
border of the supinator, and passes upwards between this muscle a

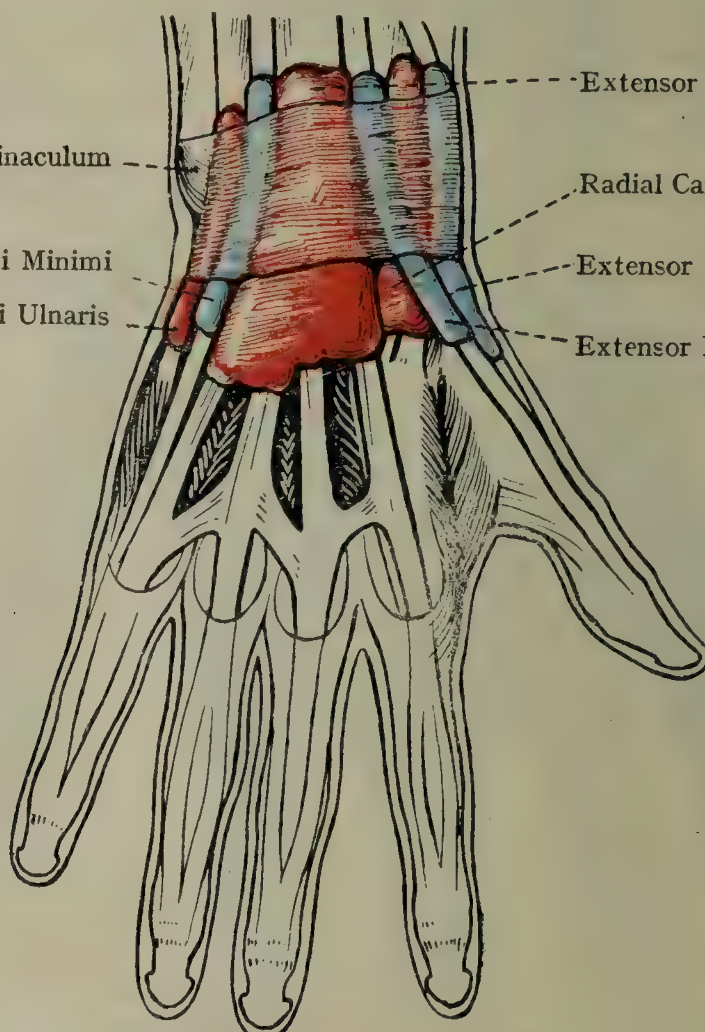


FIG. 315.—THE SYNOVIAL SHEATHS OF THE EXTENSOR TENDONS (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

the anconeus to the back of the lateral epicondyle, where it anasto
moses with the posterior branch of the profunda of the brachial. Sma
branches ramify on the back of the olecranon process and, anastomosin
with branches of the posterior ulnar recurrent, form the olecranon ret
In addition, it anastomoses with the muscular branches of the radi
recurrent. Muscular branches from the trunk of the posterior inte
osseous supply the extensor muscles on the back of the forearm
Articular branches supply the wrist-joint.

The Extensor Retinaculum is a thickened portion of the deep fasci
on the back of the forearm. It is attached *laterally* to a bony cres
at the lower end of the radius, marking the outer limit of the attach

ıent of the pronator quadratus, and *medially* to the inner and back ›art of the triquetral and pisiform bones; it is here continuous with he fibres of the flexor retinaculum. Its general direction is obliquely ownwards and inwards from the outer side of the lower end of the adius to the inner side of the carpus. It bridges over the various rooves on the dorsal aspects of the lower ends of the radius and ulna, nd being attached by deep processes to the ridges between them, con-erts them into fibro-osseous canals in which the extensor tendons are ontained. These canals are six in number and, rom without inwards, are disposed as follows: 'he **first** corresponds with the groove on the uter side of the lower end of the radius, and ontains the tendons of the abductor pollicis ɔngus and extensor pollicis brevis. The **second** orresponds with the broad groove to the inner ide of the styloid process, and contains the endons of the extensor carpi radialis longus nd extensor carpi radialis brevis. The **third** orresponds with the narrow, deep, oblique roove on the back of the radius medial to the lorsal tubercle, and contains the tendon of he extensor pollicis longus. The **fourth** corre-ponds with the broad, innermost groove on he back of the radius, and transmits the endons of the extensor digitorum and extensor ndicis, together with the posterior interosseous ıerve, which is here expanding into a pseudo-anglion, and the terminal branch of the nterior interosseous artery. The **fifth** corre-ponds with the groove between the radius nd ulna, and contains the tendon of the xtensor digiti minimi. The **sixth** corresponds vith the groove on the back of the ulna etween the styloid process and head of the one; it transmits the tendon of the extensor arpi ulnaris. Each canal is lined by a separate ynovial sheath, the sheaths extending for ome distance above and below the extensor etinaculum (Fig. 315).

FIG. 316.—LATERAL VIEW OF THE REGION OF THE WRIST.

The Deep Fascia of the Back of the Hand.—The deep fascia in this egion is continuous above with the extensor retinaculum, and at ither side with the thenar and hypothenar portions of the palmar ıscia. It covers the extensor tendons, with which it is intimately onnected. A deeper fascial layer lies under cover of the extensor endons; it invests the dorsal interosseous muscles, and is attached ɔ the metacarpal bones between them.

The Second Part of the Radial Artery (Fig. 317) winds backwards elow the styloid process of the radius to the back of the wrist. On

the back of the wrist it extends downwards to the proximal end of t
first intermetacarpal space, where it passes forwards between the tw
heads of the first dorsal interosseous muscle, and thus gains the paln

Relations—*Superficial.*—The skin, the commencement of the radi
vein, branches of the radial nerve, the tendons of the abductor pollic
longus, extensor pollicis brevis, and extensor pollicis longus; the la

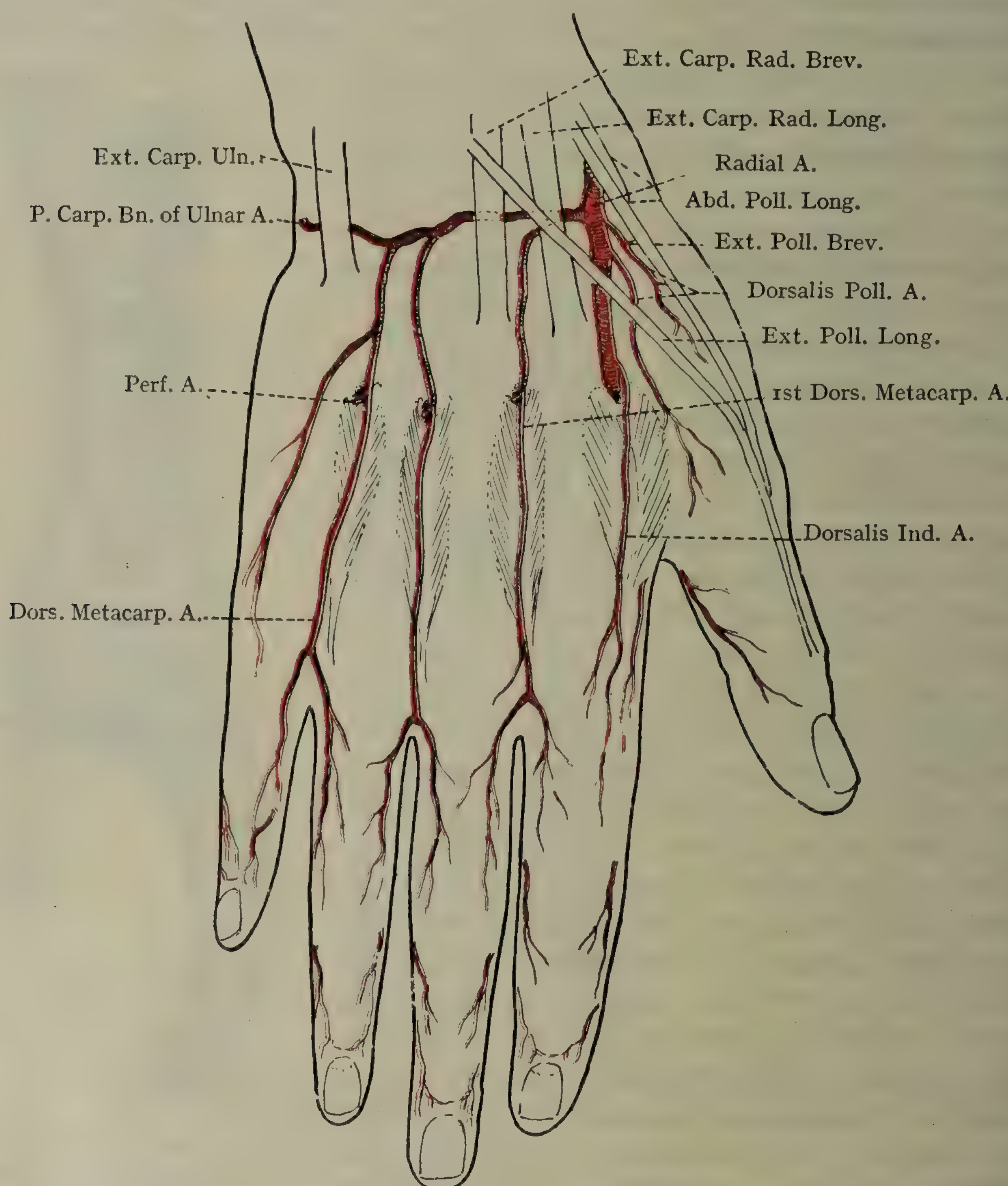


FIG. 317.—THE ARTERIES ON THE BACK OF THE HAND.

The small vessels supplying the dorsal segments of the digits are derived fro
the palmar digital arteries.

named crosses the vessel just before it disappears between the two head
of the first dorsal interosseous. At first it is deeply placed, but at th
back of the wrist it is comparatively superficial. In the living subje
its pulsation may be detected in a triangular depression bounded o
the outer side by the tendons of the abductor pollicis longus an
extensor pollicis brevis, on the inner side by the tendon of the extens

ollicis longus (p. 484). *Deep*.—The lateral ligament of the wrist-joint, he scaphoid and trapezium, and the ligaments connecting them ogether. The artery is accompanied by two venæ comites.

Branches.—The **posterior carpal branch** arises from the radial as it es upon the lateral ligament of the wrist-joint. It passes inwards on he back of the wrist deeply to the extensor tendons, and joins the posterior carpal branch of the ulnar artery to form the posterior carpal arch.

The **first dorsal metacarpal artery** is variable in origin, and arises ither directly from the radial or from the posterior carpal arch. It xtends downwards in he second intermetaarpal space, lying on, nd supplying, the econd dorsal interoseous muscle. At the roximal end of the pace it is joined by a erforating artery from he deep palmar arch. t ends by dividing into wo dorsal collateral igital arteries which upply the adjacent ides of the index and iddle fingers.

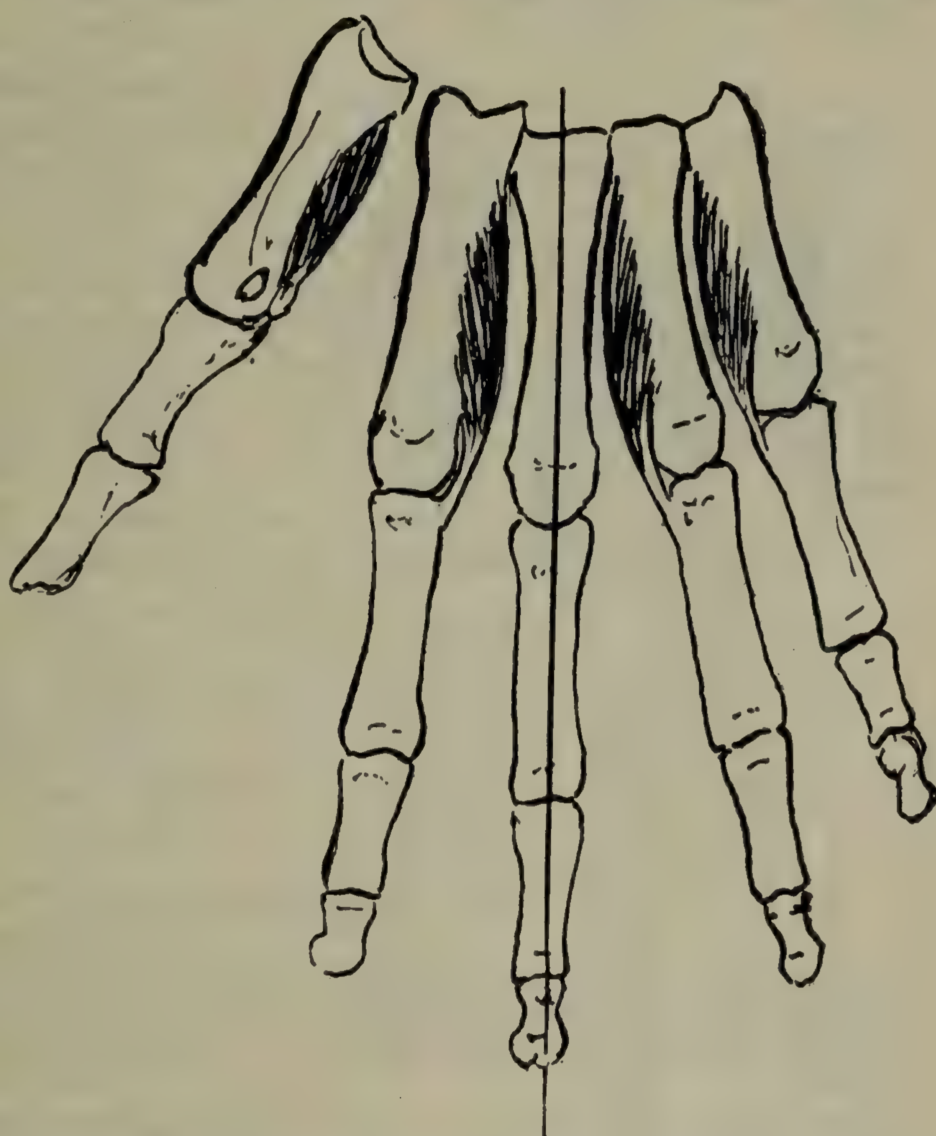


Fig. 318.—The Four Palmar Interosseous Muscles of the Right Hand.

The *second* and *third orsal metacarpal arteries* re branches of the osterior carpal arch, nd occupy the third nd fourth intermetaarpal spaces respecvely. Their course nd distribution are milar to that of the rst dorsal metacarpal; he second is distributed the adjoining sides of the middle and ring fingers; the third to the djoining sides of the ring and little fingers. A dorsal digital artery, upplying the inner side of the little finger, arises either from the third orsal metacarpal artery or from the posterior carpal arch.

The **dorsales pollicis** are two small arteries which arise independently r by a common trunk from the radial opposite the base of the first etacarpal bone, and are distributed to either side of the thumb.

The **dorsalis indicis artery** arises a short distance above the point t which the radial passes forwards between the two heads of the first orsal interosseous. It descends on the outer side of the second metaarpal bone, and supplies the outer side of the index finger.

The dorsal digital arteries do not extend, as a rule, beyond the le
of the proximal interphalangeal joint.

The Interosseous Muscles, eight in number, occupy the intermet
carpal spaces, and are arranged in two groups—four palmar and fo
dorsal.

The four **palmar interossei** (Fig. 318), termed numerically, fro
without inwards, the first, second, third, and fourth, occupy fo
intermetacarpal spaces, and are inserted into the thumb, index, rin
and little fingers. Each one of the four muscles arises from one met
carpal bone only, and that one the metacarpal bone of the digit in
which the muscle is inserted. T
first palmar interosseous has
ready been described with t
short muscles of the thumb (s
p. 494); the remaining three w
now be considered. The *seco*
arises from the inner aspect of t
shaft of the second metacarp
bone, and the *third* and *four*
from the outer aspects of t
shafts of the fourth and fif
metacarpals. The *second* is i
serted partly into the *inner* si
of the base of the proximal phala
of the index finger, and part
blends with the extensor expansi
on the dorsal aspect of the phalan
The *third* and *fourth* are insert
in a similar manner to the ri
and little fingers, but are attach
to the *outer* side of the base
the proximal phalanx.

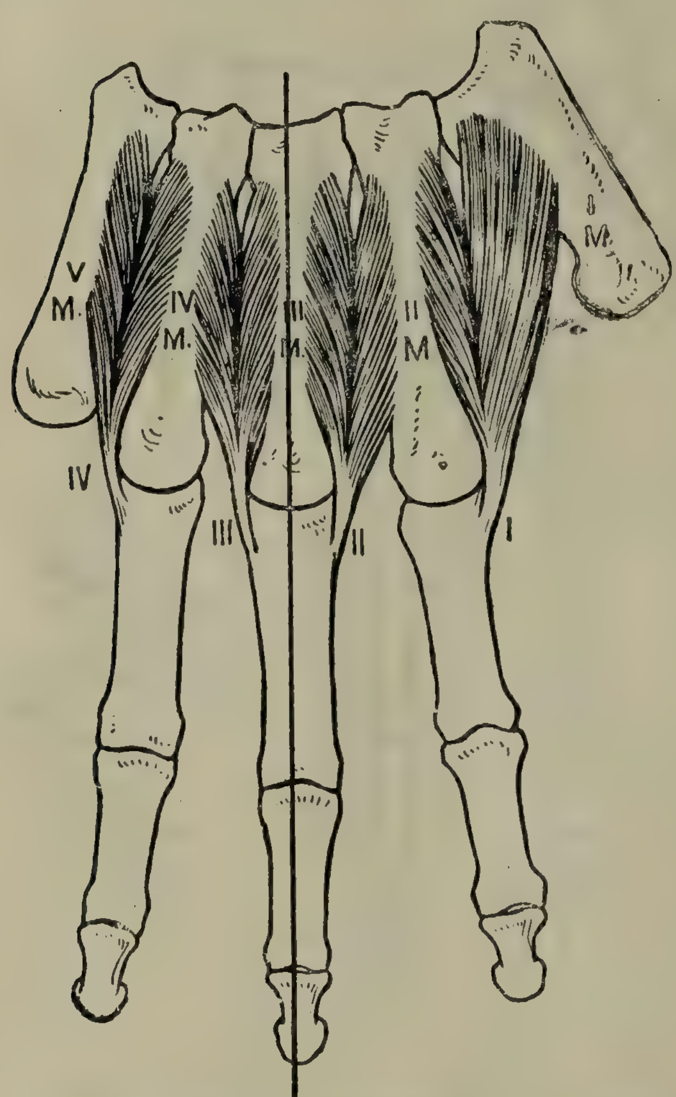


Fig. 319.—The Dorsal Interosseous Muscles of the Right Hand.

The four **dorsal interossei** (Fi
319), termed numerically, fro
without inwards, the first, secon
third, and fourth, occupy the fo
intermetacarpal spaces, and a
inserted into the index, middl
and ring fingers, the middle finger being provided with two. Ea
muscle arises by two heads from the adjoining sides of the shafts of t
two metacarpal bones between which it is placed, and always mo
extensively from the bone belonging to the digit into which the musc
is inserted. The fibres of each muscle end in a tendon, which
inserted partly into the side of the base of the proximal phalanx an
partly into the extensor expansion on the back of the phalanx. T
first is the largest of the series. Its outer larger head arises from t
proximal half of the first metacarpal bone, and its inner smaller hea
from the whole length of the outer aspect of the shaft of the secon

etacarpal. The first and second dorsal interosseous muscles are
serted into the *outer* sides of the bases of the proximal phalanges of
e index and middle fingers respectively, the third and fourth into the
ner sides of the bases of the proximal phalanges of the middle and
ng fingers.

Nerve-supply.—All the interossei are supplied by the deep division
the ulnar nerve.

Action.—The **palmar** interossei are *adductors* of the index, ring, and
tle fingers. The **dorsal** interossei are *abductors* of the index, middle,
d ring fingers.

The terms adduction and abduction are here used in reference to an imaginary
e, corresponding to the axis of the middle finger, and which may be regarded
the physiological axis of the hand. It is towards and away from this line
at the fingers are naturally drawn when closing and opening the hand, the
gers closing in the former case and separating in the latter. As the thumb
not only provided with its own special adductors, but with the first palmar
terosseous, and the middle or axial finger requires no muscle to draw it towards
own line, the three digits provided with the closing muscles or palmar inter-
sei are the index, ring, and little fingers. As the two marginal digits, the
umb and the little finger, are provided with special abducting muscles, the
ree digits provided with the separating muscles or dorsal interossei are the
dex, middle, and ring fingers, the middle being provided with two, whereby it
ay be made to diverge from its own axial line, either inwards or outwards.

Between the two heads of the first dorsal interosseous is an interval
r the passage of the radial vessels, and between the two heads of the
her three dorsal interossei is an interval for the passage of a perforating
tery connecting the deep palmar arch with a dorsal metacarpal
tery.

Lymphatic Vessels of the Upper Limb.

The lymphatic vessels of the upper limb are arranged in two groups—super-
ial and deep. The superficial lymphatics lie in the subcutaneous tissue, and
e main vessels accompany the superficial veins; the deep lymphatics accom-
ny the deep bloodvessels.

Superficial Lymphatics (Fig. 320)—*Digital.*—There are very rich networks of
mphatics in the fingers, especially over their palmar aspects. The *efferent*
mphatics from the digital networks are two digital vessels, one on either side
a finger, accompanying the corresponding digital artery. At the roots of the
gers these vessels pass to the dorsal aspect of the hand, and, communicating
th each other, form a dorsal network, which is prolonged upwards on to the
ck of the wrist.

Palmar.—There is a very rich network of lymphatics in the palm, from
ich the lymph is collected by several vessels passing in various directions—
twards, inwards, downwards, and upwards. The *lateral efferent* vessels pass
wards and outwards over the thenar eminence, and join the lymphatics from
e thumb. The *medial efferent* vessels pass inwards, and, winding round the
ier border of the hand, join the lymphatics from the little finger. The *inferior*
erent lymphatics pass downwards to the clefts between the fingers, where
ey turn backwards and join the digital efferent lymphatics. The *superior*
erent vessels ascend to the front of the wrist.

Carpal.—The carpal lymphatics are disposed in two groups—palmar and
rsal, the vessels of which are continuous with the palmar and dorsal networks
the hand.

Antibrachial.—The superficial lymphatics of the front of the forearm arranged in three groups—radial, median, and ulnar, which accompany corresponding veins. As the radial and ulnar lymphatics ascend they joined at intervals by efferent vessels from the dc plexus of the hand, which wind round the radial ulnar borders of the forearm from its dorsal asp The *radial lymphatics* in part ascend into the a and accompany the cephalic vein, and in part the median lymphatics. The *median lymphatics* terminate in the antecubital glands, should the present. When they are absent, they join the *u lymphatics*, which end in the supratrochlear g or glands.

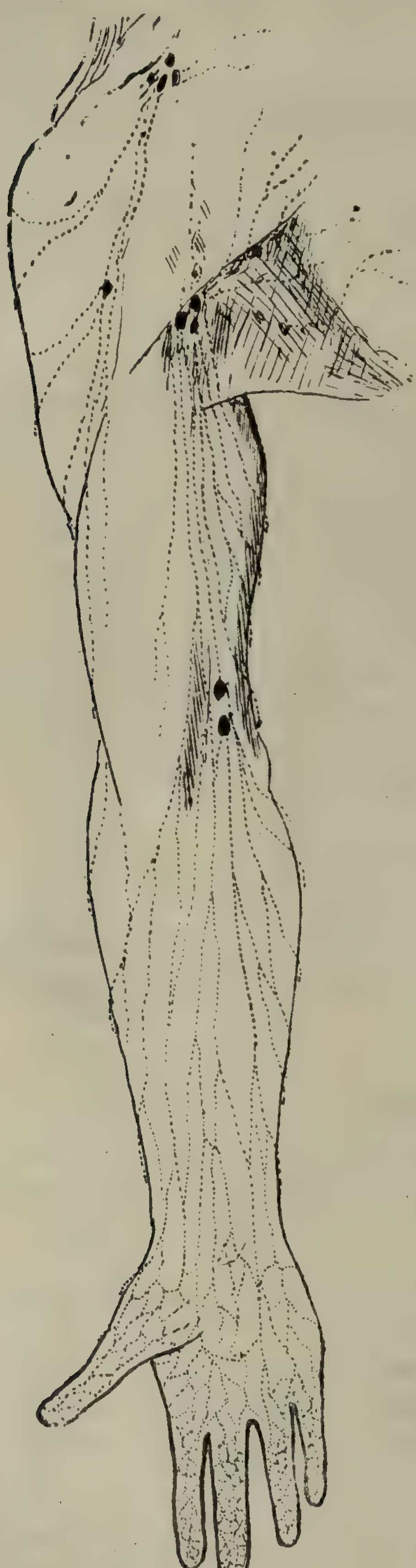


Fig. 320.—The Superficial Lymphatics of the Upper Limb (Anterior View).

Brachial.—The superficial lymphatics of brachial region are disposed in two groups—i and outer. The *inner lymphatics*, which are numerous, lie along the inner border of the bi brachii in more or less close association with basilic vein. They largely represent the effe vessels of the supratrochlear gland or glands, the antecubital glands, when they are present. the upper part of the arm they traverse the fascia, and join the lateral axillary glands, in a ciation with the deep brachial lymphatics. *outer lymphatics* are reinforced by some of the ra lymphatics, and lie on the outer side of the bi brachii, following the cephalic vein. They as in the groove between the deltoid and pecto major muscles, and join finally the infraclavic glands; one or two of them may ascend in fro the clavicle, and end in the supraclavicular glan

The Deep Lymphatics accompany the deep bl vessels, and are disposed in five groups—ra ulnar, anterior interosseous, posterior interosse and brachial. There are usually two lymp vessels in connection with each artery. Those companying the radial, ulnar, anterior interosse and brachial arteries occasionally traverse on two small deep lymphatic glands, which are s times met with along the course of these arte The *brachial lymphatics* are formed by the unic the radial, ulnar, anterior interosseous, and post interosseous lymphatic vessels. About the m of the arm they are joined by the efferent ve of the supratrochlear gland or glands, and higher level by lymphatic vessels accompanyin profunda artery. They end in the lateral axi glands.

Summary of the Lymphatic Glands of the U Limb.—The lymphatic glands of the upper form two groups—superficial and deep.

The **superficial glands** include the medial condylar or supratrochlear and possibly the a cubital glands, but these are inconstant.

The **deep glands** occupy the axillary space (p. 434). Minute lymp glands are occasionally found in association with the lymphatic vessels w accompany the arteries of the forearm and the brachial artery. One or lymphatic glands may occupy the groove between the deltoid and pecto major muscles in the course of the cephalic vein.

Morphology and Development of the Intrinsic Muscles of the Hand.

An account of the morphology and the developmental changes affecting the uscles of the hand can be equally applied to those of the foot, the only difference ·ing in the names of the individual muscles.

The lumbrical muscles are specialized parts of the muscle (flex. prof. dig). th which their origins are associated, and are consequently derived from the ep flexor sheet on the ventral aspect of the forearm.

The interossei, together with the short muscles of the thumb and little finger, e derived from a 'generalized type,' modifications of which are found in all imals possessing hands with four or five digits. In the early developmental ages of the human hand this generalized type is represented almost in its tirety, and the ontogenetic transformations which its musculature undergoes obably recapitulate its phylogeny.

The generalized mammalian hand has three planes of short digital muscles. (*a*) A deep set of **intermetacarpal** muscles which occupy the intermetacarpal aces, and are confined in their attachments to the metacarpal bones. (*b*) An termediate set of double-bellied **short flexors** which arise in each case from e proximal part of a metacarpal bone, the two bellies being inserted one on ther side of the base of the proximal phalanx of the corresponding digit. (*c*) A perficial set of **contrahentes** (muscles closing or bringing the fingers together wards the axial line of the middle digit) which arise from the front of the carpus, m which they diverge, and are inserted into the bases of the proximal phalanges. e deep vessels and nerve lie in a plane between the contrahentes superficially d the short flexors deeply.

A secondary modification affects the contrahentes muscles in that the con-ahens muscle of the middle finger, which can only act as a flexor, and is con-quently superfluous, loses its muscle fibres and becomes modified into a fibrous rd along which the origins of the remaining muscles spread, and their adducting ect on the more marginal digits is thereby increased.

The Intermetacarpal and Short Flexor Muscles.—The radial belly of the cond, both bellies of the third, and the ulnar belly of the fourth short flexor ık dorsalwards, and fuse with the intermetacarpal muscles, which thus condarily acquire an attachment to the proximal phalanges and form a group abducting muscles, the four dorsal interossei. The remaining bellies of the ort flexors, with the exception of the radial belly of the muscle of the thumb d the ulnar belly of that of the little finger, maintain their independence, d are represented by the four palmar interossei. They lose to a certain extent eir primary function as flexors, and serve as adductors (secondary contra-ntes).

The contrahentes are nearly complete in the early human fœtus, but to a ge extent disappear in the course of development, that of the thumb being e sole survivor. The proximal attachment of this muscle extends distally ng the fibrous cord representing the contrahens muscle of the middle digit. is fibrous cord becomes implanted deeply on to the shaft of the third meta-rpal, except in the situation where it is held off by the deep artery. Thus e muscle which is represented by the adductors of the thumb is, in descriptive atomy, said to consist of two parts—the transverse head of adductor pollicis tached to the third metacarpal distal to the artery, and the oblique head tached to the proximal end of the third metacarpal and to the carpus.

Thenar and Hypothenar Muscles.—For these muscles a marginal member of e intermetacarpal set of muscles occupying the free surface of each marginal tacarpal bone (thumb and little finger) must be postulated. The origin of e muscle extends proximally, and it forms a primary abductor. Later the ximal end of the muscle spreads towards the centre of the palm superficially the palmar vessels and on to the flexor sheath (of the long flexor tendons). rt of this muscle splits off and forms a short flexor (flex. poll. brev. or flex. . min.); the rest of the muscle maintains the original position, and persists the abductor proper (abd. poll. brev. or abd. dig. min.). From the marginal

belly of the short flexor (of the thumb or little finger), which took no part in the formation of the interosseous muscles (*vide supra*), the opponens muscle is derived by the migration of its insertion from the proximal phalanx to the shaft of the metacarpal bone, and the extension of its origin on to the flexor sheath.

The opponens of the little finger, as a part of the primitive short flexor of this digit, at first lies deeply to the deep artery and nerve. As its proximal end undergoes a secondary extension on to the ventral aspect of the limb, it grows round these structures, and its continuity is to some extent interrupted, the artery and nerve being said to pass through the muscle. Whether the primary part of the muscle persists or no, the position of the nerve always indicates the demarcation between the two parts of the muscle.

Development of Arteries of Upper Limbs.

The arterial stem of the *left* upper limb is developed entirely from the **seventh left cervical segmental artery** in association with the left vertebral artery. The component arteries of this stem, from above downwards, are as follows: (1) The subclavian artery; (2) the axillary artery; (3) the brachial artery; and (4) the anterior interosseous artery. The arterial stem of the *right* upper limb is developed from the **fourth right arterial arch,** a *portion* of the **right dorsal aorta,** and the **seventh right cervical segmental artery,** in association with the right vertebral artery. The component arteries of this stem are similar to those on the left side.

Before the adult condition of the arteries is reached, several stages of development have to be passed through.

(1) As the anterior interosseous artery becomes diminished, another artery springs from the brachial a short distance below the elbow-joint. This new vessel accompanies the median nerve, and is called the **median artery.**

(2) The median artery superiorly furnishes a branch, which becomes the **ulnar artery.**

(3) As the median artery becomes diminished, a vessel springs from the brachial artery about the centre of the brachial region. This vessel is called the **primary radial artery,** and it accompanies the radial nerve.

(4) As the upper part of the primary radial artery atrophies, the brachial artery gives off another branch just below the elbow-joint, which soon joins the primary radial, and so the **permanent radial artery** is formed.

Development of Veins of Upper Limbs.

The veins of each upper limb form two groups—superficial and deep. The superficial veins are developed prior to the deep, the latter accompanying the arteries.

The primitive vein is the **primary ulnar** or **postaxial vein,** which receives distally the digital veins, and opens proximally into the anterior cardinal vein. At a later period the **cephalic vein** is formed as an outgrowth from the external jugular vein, but it subsequently acquires its permanent connection with the upper part of the axillary vein.

The distal portion of the primary ulnar vein disappears. Its proximal portion persists and gives rise to the **basilic, axillary,** and **subclavian veins.**

From the distal end of the basilic vein the **anterior** and **posterior ulnar veins** and the **median basilic vein** are developed.

The **radial** and **median cephalic veins** grow distally from the cephalic vein.

The **median vein** is developed from the median basilic and median cephalic veins.

The Elbow-Joint.

The articular surfaces taking part in the formation of the joint are the trochlea and capitulum of the humerus above, and the trochlear notch of the ulna and the cup-shaped depression on the head of the

radius below. The trochlea articulates with the trochlear notch, the capitulum of the humerus with the head of the radius. The joint is surrounded by a capsule, in which four ligaments—anterior, posterior, lateral, and medial—may be recognized.

The **anterior ligament** is broad, thin, and weak, the central portion being the strongest. Its fibres are attached above to the front of the humerus above the coronoid and radial fossæ, and below to the coronoid process of the ulna and the annular ligament. Most of its fibres are vertical; some superficial fibres pass obliquely downwards

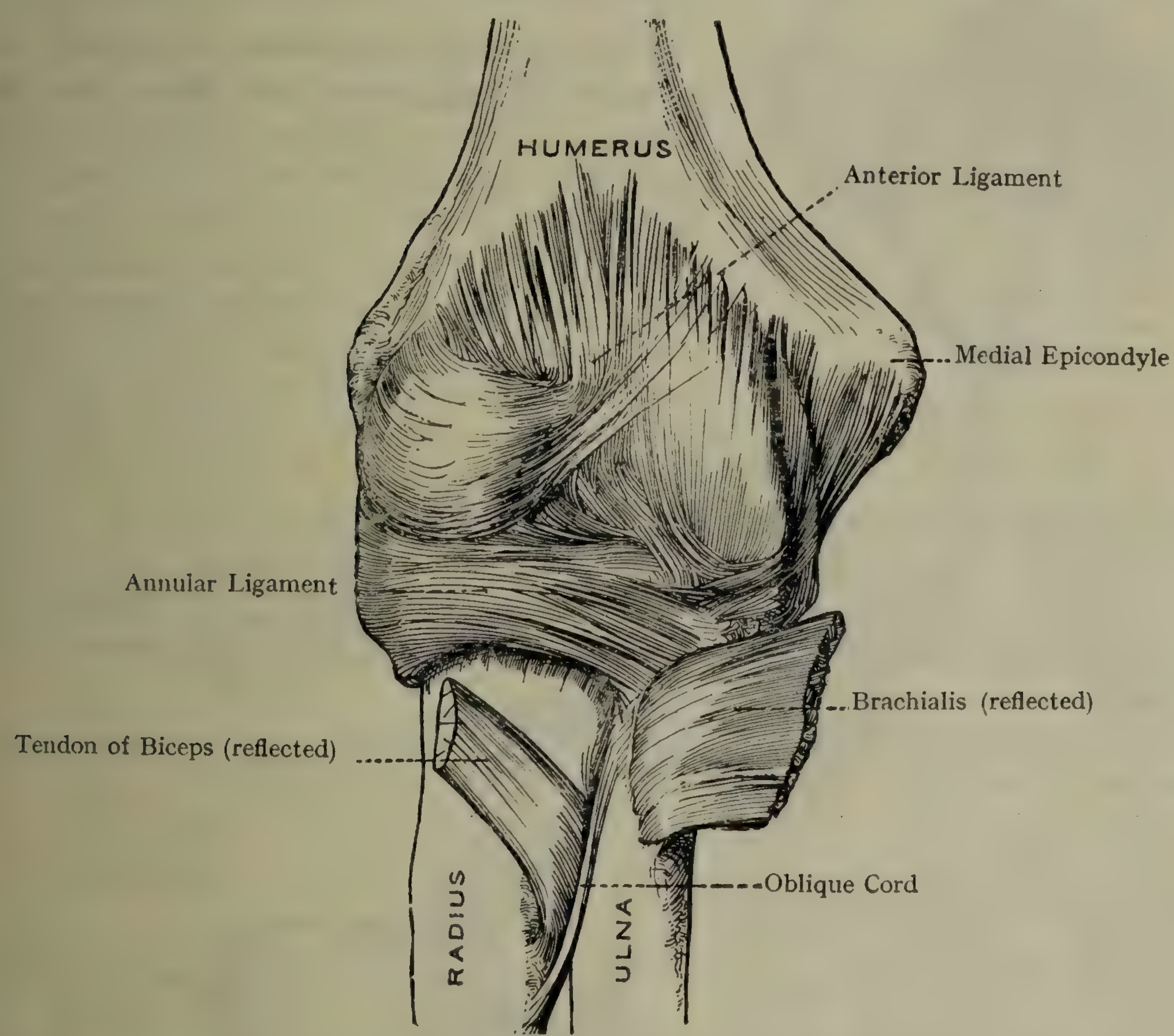


FIG. 321.—THE RIGHT ELBOW-JOINT (ANTERIOR VIEW).

and outwards. The ligament is closely covered in front by brachialis, which is, to a certain extent, adherent to it.

The **posterior ligament** is thin and membranous. Above it is attached to the margins of the olecranon fossa of the humerus, and below to the front part of the upper aspect of the olecranon process of the ulna and to the annular ligament of the radius. Most of its fibres are disposed vertically, but a few pass transversely between the margins of the olecranon fossa, especially in its upper part, where they are disposed as a band with an upper free edge, above which, between it and the upper part of the olecranon fossa, is a deficiency in the capsular ligament through which a pad of fat, invested by synovial membrane, protrudes when the elbow-joint is extended.

Attention may be drawn to the fact that the coronoid fossa of the humeru is completely roofed by the capsular ligament, while the upper part of th olecranon fossa is above the limits of the capsule.

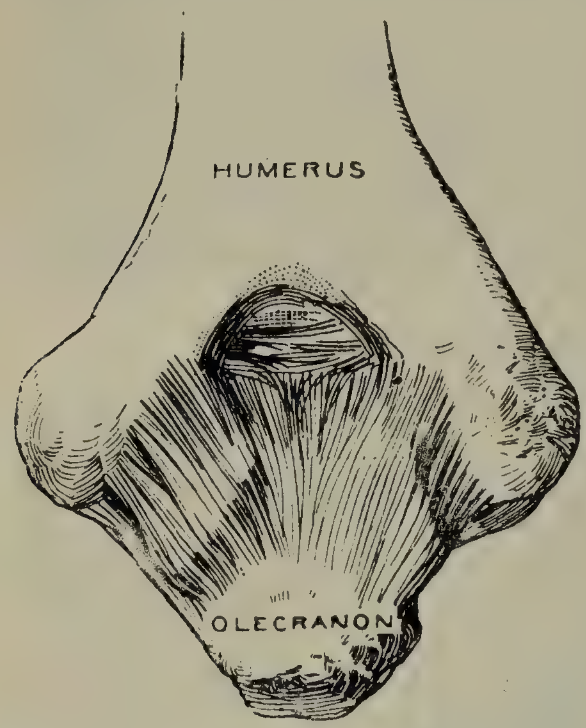


FIG. 322.—THE POSTERIOR LIGAMENT OF THE ELBOW-JOINT.

The ligament is covered behind by the tendon of insertion of the triceps and the anconeus.

A few of the deep fibres of the inner head of the triceps have been described (Theile) as being attached to the posterior ligament under the name of the subanconeus muscle.

The **lateral ligament** is a thick triangular band, attached above to the lower part of the lateral epicondyle of the humerus, and below to the annular ligament; some of its fibres may be traced to the bony ridges on the ulna, extending downwards from the anterior and posterior margins of the radial notch. The extensor carpi radialis brevis and supinator muscles are attached to it.

The **medial ligament** is triangular, with the apex upwards. It is attached above to the medial epicondyle of the humerus, and below to the inner margin of the trochlear notch of the ulna. It consists of three parts: An *anterior*, attached above to the front and lower part of the medial epicondyle, and below to the inner margin of the coronoid process. A *posterior*, attached above to the lower and back part of the medial epicondyle, and below to the inner margin of the olecranon process. A *middle*, a comparatively weak part of the ligament, consists of fibres which are mainly attached to a fibrous band (oblique ligament of Cooper), bridging over the notch on the inner margin of the trochlear notch, and stretching from the olecranon process to the coronoid process. The flexor digitorum sublimis muscle is attached to the ligament.

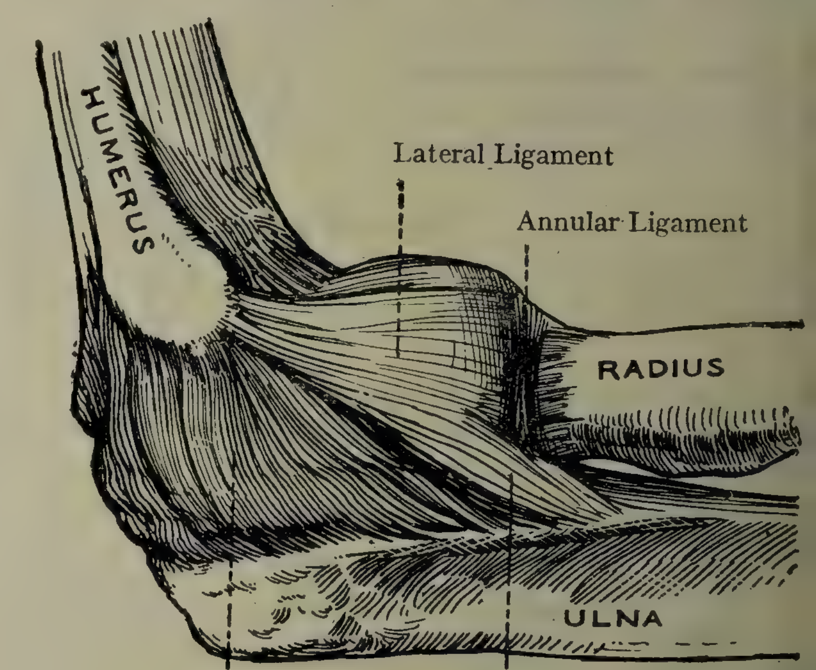


FIG. 323.—THE RIGHT ELBOW-JOINT (LATERAL ASPECT).

The notch on the inner margin of the trochlear notch of the ulna, together with the bridging ligament, completes a foramen or deficiency in the capsule through which the extra-articular fat on the inner aspect of the joint is con-

tinuous with an intra-articular pad of fat occupying a rough non-articular area crossing the trochlear notch. When a relatively larger amount of the trochlear of the humerus occupies the trochlear notch of the ulna, fat is extruded through this deficiency. On the other hand, when a lesser amount of the trochlea occupies the trochlear notch, fat is drawn into the joint. The former occurs in extension, the latter in flexion, of the joint.

The **synovial membrane** lines the deep aspect of the capsule, and below is continuous with that of the superior radio-ulnar joint, lining the deep surface of the orbicular ligament and the upper part of the neck of the radius. It also lines the coronoid, radial, and olecranon fossæ of the humerus.

Muscular Relations.—The capsule is closely related to the following muscles: *anteriorly*, brachialis; *posteriorly*, the triceps and the anconeus;

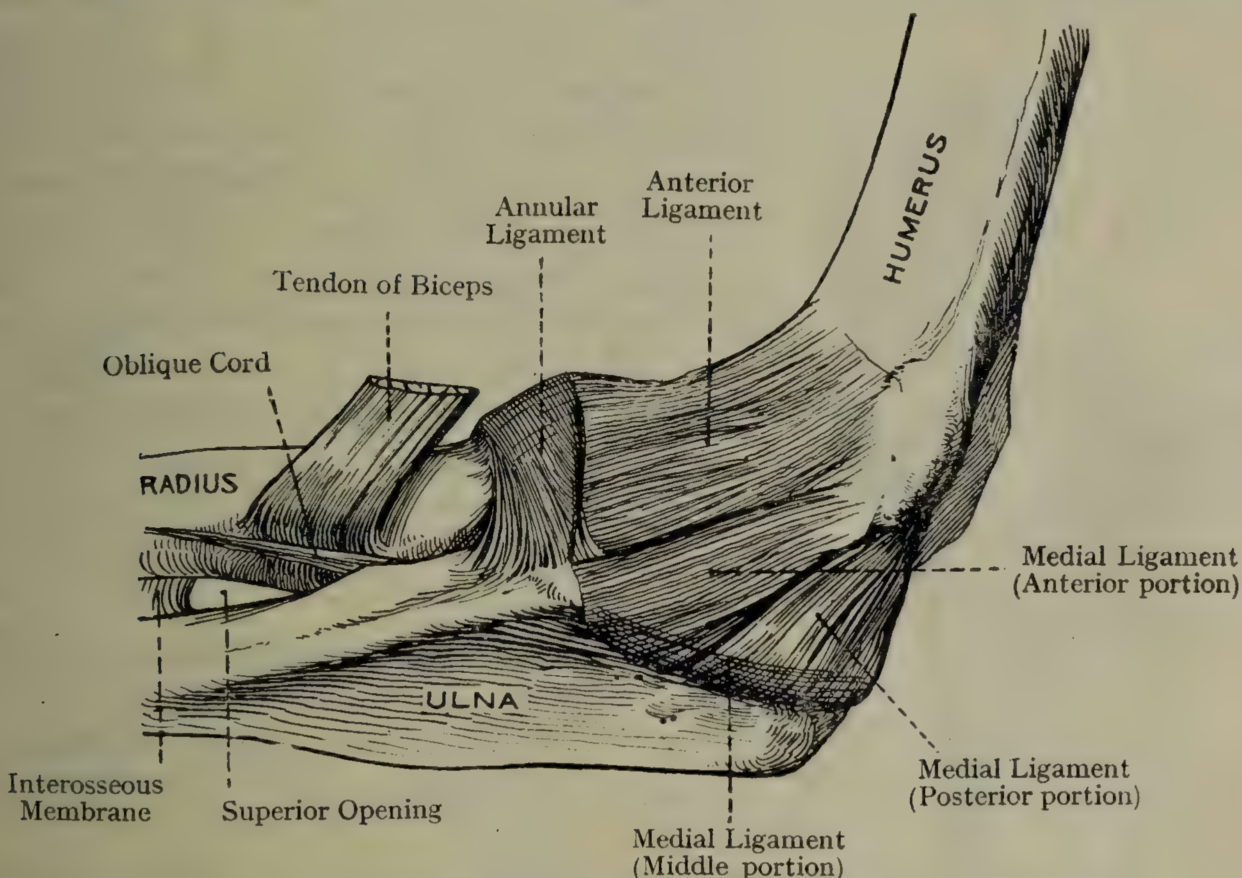


FIG. 324.—THE RIGHT ELBOW-JOINT (MEDIAL ASPECT).

laterally, the extensor carpi radialis brevis and supinator; and *medially*, the flexor digitorum sublimis.

Nerve-supply.—The radial musculo-cutaneous, median, and ulnar nerves.

Movements.—The chief movements are flexion and extension, extension being limited by the tension of the muscles on the front of the joint, and flexion by the approximation of the muscular prominences on the front of the forearm and of the arm respectively. Slight lateral movements can take place in all degrees of flexion. They are very limited when the joint is extended.

Muscles concerned in the Movements.—**Flexion** is produced by the biceps, brachialis, brachio-radialis, and, as auxiliaries, the muscles arising from the medial epicondyle of the humerus. **Extension** is produced by the triceps and anconeus, and, as auxiliaries, the muscles arising from the lateral epicondyle.

Bursæ at Elbow-Joint.—The bursæ in the neighbourhood of the joint are: a subcutaneous bursa between the skin and the triangular

surface on the back of the olecranon process; a small bursa between the tendon of the triceps and the posterior ligament of the joint; and one between the tendon of the biceps and the anterior smooth portion of the tuberosity of the radius. Small bursæ over the medial and lateral epicondyles of the humerus may be present, but they are inconstant.

The Radio-Ulnar Joints.

The joints between the radius and ulna are the superior and inferior radio-ulnar. Intermediately the two bones are connected together by the interosseous membrane.

Superior Radio-ulnar Joint.—The articular surfaces are the circumferential articular surface surrounding the head of the radius and the radial notch of the ulna. The **annular (orbicular) ligament** is a strong fibrous band which forms about four-fifths of a circle, and surrounds the circumference of the head of the radius, which it retains in contact with the radial notch. Its extremities are attached to the anterior and posterior margins of the radial notch. The ligament is smaller below than above, and thus maintains the head of the radius in position. It gives attachment to ligaments of the elbow-joint and to the supinator muscle.

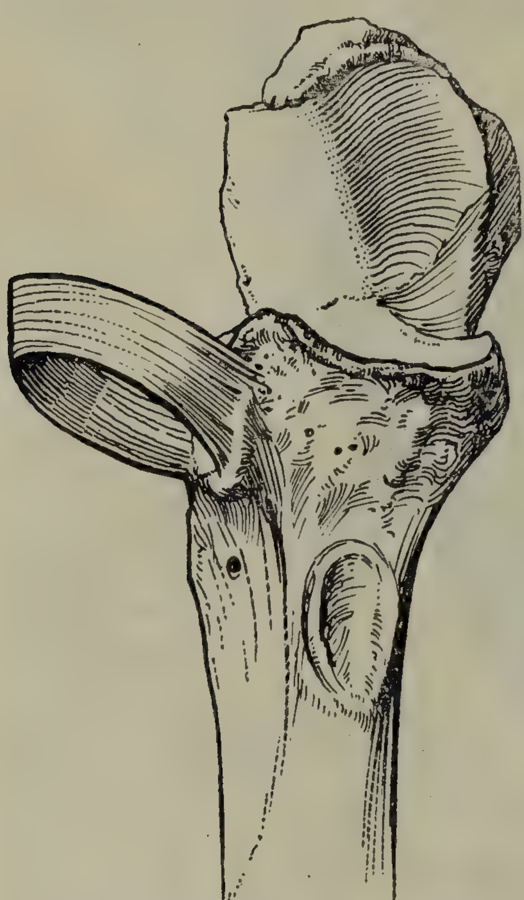


FIG. 325.—THE UPPER END OF THE ULNA, AND THE ANNULAR LIGAMENT.

The **synovial membrane** is continuous with that of the elbow-joint, and lines the inner surface of the annular ligament and upper part of the neck of the radius.

A loose fold of the synovial membrane, extending from the inner side of the neck of the radius to the lower lip of the radial notch of the ulna, is thickened by the presence of elastic fibres, and is sometimes termed the *quadrate ligament.*

Muscular Relations.—Extensor carpi radialis brevis and supinator.

Nerve-supply.—The radial nerve.

Inferior Radio-ulnar Joint.—The articular surfaces concerned are the ulnar notch of the radius, the outer side of the head of the ulna, and the upper surface of the articular disc.

The **anterior** and **posterior radio-ulnar ligaments** consist of loose and relatively weak fibres in front of and behind the joint, and are attached to the adjacent portions of the radius and ulna; the posterior ligament is thicker than the anterior. The **articular disc** is more or less triangular when viewed from above or below. Interposed between the ulna and the triquetral, its base is attached to the ridge on the

radius, intervening between the ulnar notch and the carpal articular surface, its apex to the pit at the lower end of the ulna on the deep aspect of the root of the styloid process. It is thicker in front and behind than it is centrally, and at its ulnar attachment than it is at its radial. Its anterior and posterior borders are adherent to the anterior and posterior ligaments. It is sometimes perforated, in which case the synovial cavities of the inferior radio-ulnar joint and of the wrist-joint are continuous with one another.

The **synovial membrane** of the joint is very loose, and is known as the *membrana sacciformis*. It consists of two parts, vertical and horizontal, the two being continuous with each other; the former is associated with the joint between the head of the ulna and the ulnar notch of the radius, the latter with that between the lower end of the ulna and the upper surface of the articular disc.

Nerve-supply.—The anterior and posterior interosseous nerves.

The Intermediate Joint between the Radius and Ulna is an extended **syndesmosis.** The shafts of the two bones do not come into close approximation, but are connected together by the interosseous membrane and the oblique ligament.

The **interosseous membrane** is a strong expansion which stretches between the interosseous borders of the shafts of the radius and ulna, and is deficient at the upper end of the interspace between the two bones. The direction of its fibres is obliquely downwards and outwards from the radius to the ulna; some fibres, however, are disposed in the opposite direction. The upper limit of its radial attachment is about 1 inch below the radial tuberosity. The terminal branch of the anterior interosseous artery traverses its lower part. In addition to connecting the shafts of the two bones together, the membrane gives attachment to the deep muscles on the front and back of the forearm.

Relations—*Anterior.*—The flexor digitorum profundus and flexor pollicis longus, with the anterior interosseous vessels and nerve lying deeply between the two. The pronator quadratus lies in front of its lower part. *Posterior.*—From above downwards the supinator, abductor pollicis longus, extensor pollicis brevis, extensor pollicis longus, extensor indicis, and, for a short distance below, the posterior interosseous nerve and posterior branch of the anterior interosseous artery. *Above.*—The posterior interosseous artery as it passes backwards to gain the back of the limb. *Below.*—The inferior radio-ulnar joint.

The **oblique cord** is a narrow band which extends obliquely upwards and inwards from the lower and back part of the tuberosity of the radius to the tuberosity of the ulna. Between it and the upper free edge of the interosseous membrane is a triangular interval bounded medially by the shaft of the ulna and occupied by the posterior interosseous artery.

The movements taking place at these joints are those of **pronation** and **supination,** the latter being the more forcible. In pronation the lower part of the radius, carrying the hand with it, crosses over the lower part of the ulna to such an extent as to lie on its inner side, the dorsum of the hand being directed

upwards. In supination the lower end of the radius and the hand move in the opposite direction, and when the movement is complete the lower part of the radius lies on the outer side of the ulna, the palm of the hand being directed upwards. At the superior radio-ulnar joint the head of the radius rotates axially upon the capitulum of the humerus within the ring provided by the radial notch of the ulna and the annular ligament. At the inferior radio-ulnar joint the radius rotates upon the head of the ulna, the movement being one of circumduction about an oblique axis passing through the centre of the head of the radius above to the styloid process of the ulna below. There is also limited movement of the ulna, the lower end of that bone moving outwards and backwards in pronation, and inwards and forwards in supination.

As the articular disc is attached to the styloid process of the ulna—*i.e.*, to a point on the imaginary axis, about which the rotation of the lower end of the radius takes place—it maintains apposition between the ulnar notch of the radius and the head of the ulna, and is equally tense in all positions of supination and pronation.

Muscles concerned in the Movements—(1) **Pronation.**—The principal pronating muscles are the pronator teres and pronator quadratus. (2) **Supination.**—The biceps is the chief supinating muscle, and is assisted by the supinator. The brachio-radialis is also a feeble supinator, but can only come into play when the hand is fully pronated.

The Radio-Carpal or Wrist Joint.

The articular surfaces concerned are the carpal surface of the radius and the articular disc above, and the upper facets of the scaphoid, lunate, and triquetral, with the interosseous ligaments between them below. The carpal surface of the radius together with the articular disc form an oval socket, into which an oval convexity provided by the proximal row of the carpal bones is received. The articular surface extends farther on to the dorsal aspect than on to the palmar aspect of the carpus. The ulna is excluded from the joint by the articular disc. The joint is surrounded by a capsule, in which anterior, posterior, lateral, and medial ligaments may be distinguished.

The **anterior ligament** (Fig. 326) consists of two parts: An outer broad, thick band of fibres which sweep obliquely downwards and inwards from the anterior aspect of the lower end of the radius, and its styloid process to the lunate, triquetral, and capitate. The inner band is narrower, weaker, and more vertically disposed; it extends downwards from the articular disc of the wrist to the triquetral and capitate.

The **posterior radio-carpal ligament** (Fig. 328) is broad and thick. It consists of fibres which sweep obliquely downwards and inwards from the posterior border of the radius to the scaphoid, lunate, and cuneiform bones.

It is to be noted that the general direction of the fibres of both the anterior and posterior radio-carpal ligaments is downwards and *inwards*. This feature is associated with the fact that adduction of the wrist-joint (inward bending of the hand) is a much more extensive movement than abduction.

The **lateral ligament** (Fig. 326) is a strong, flattened band which extends from the tip of the styloid process of the radius to the tubercle of the scaphoid.

The **medial ligament** (Fig. 326) is a rounded cord which extends from the tip of the styloid process of the ulna to the triquetral and pisiform bones.

The **synovial membrane** lines the deep surface of the capsule and the upper surfaces of the interosseous ligaments between the carpal bones. When the articular disc is perforated, as is sometimes the case, it is continuous with the synovial membrane of the inferior radio-ulnar joint.

Muscular Relations—*Anterior.*—From within outwards, the flexor carpi ulnaris, flexor digitorum profundus, flexor pollicis longus, and flexor carpi radialis. *Posterior.*—From within outwards, the extensor carpi ulnaris, extensor digiti minimi, extensor digitorum with the

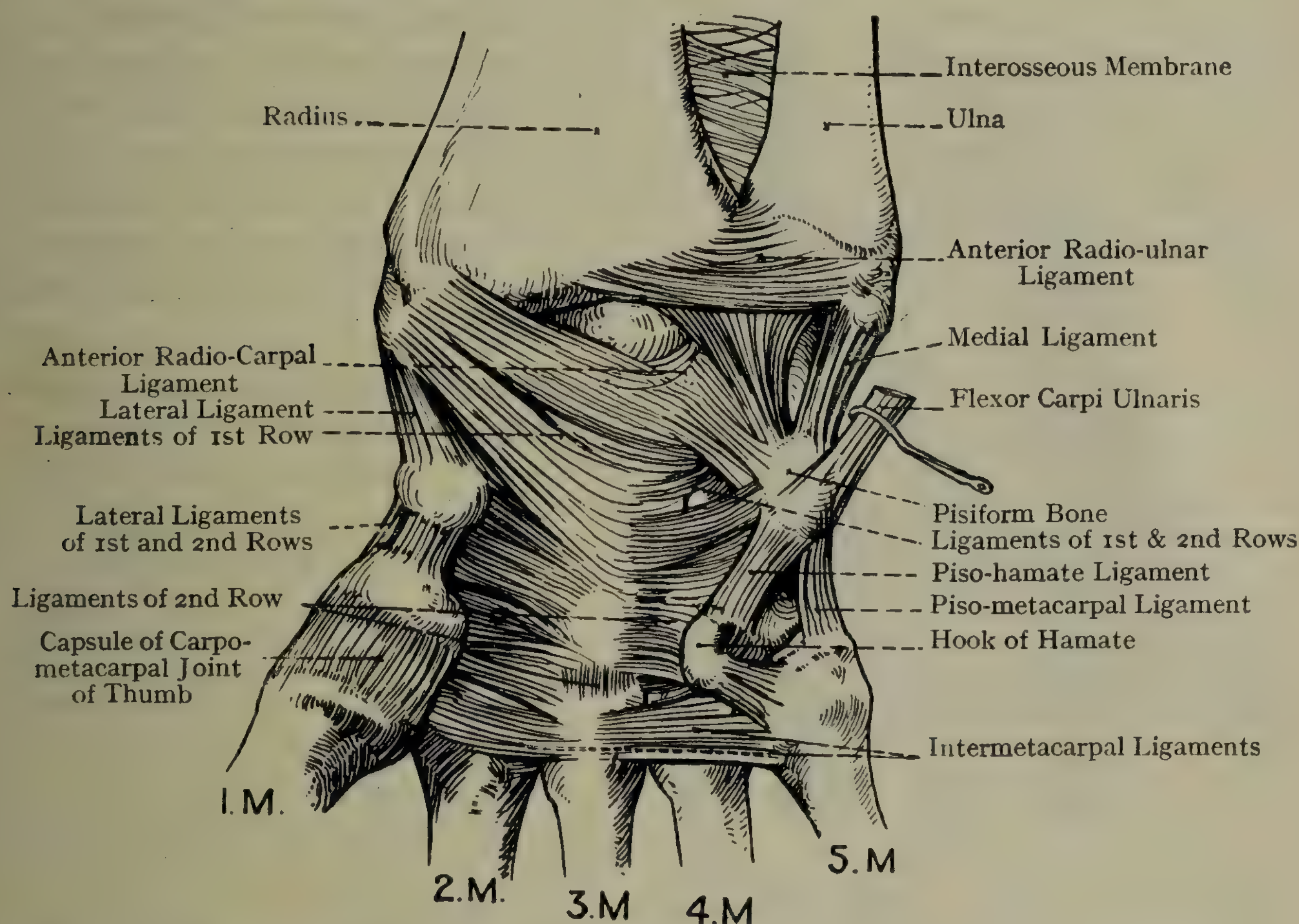


FIG. 326.—THE LIGAMENTS OF THE RADIO-CARPAL, CARPAL, CARPO-METACARPAL, AND INTERMETACARPAL JOINTS (ANTERIOR VIEW).

extensor indicis, extensor pollicis longus, extensor carpi radialis brevis, and extensor carpi radialis longus. *Lateral.*—The abductor pollicis longus and extensor pollicis brevis.

Nerve-supply.—The median, ulnar, and posterior interosseous nerves.

Movements.—The movements taking place in the joint are flexion, extension, adduction, and abduction. Adduction is much more extensive than abduction. When the hand is in line with the forearm, the scaphoid facet on the radius articulates with the scaphoid bone, and the lunate facet of the radius, together with the articular disc, articulate with the lunate bone, the proximal articular surface of the triquetral being in contact with the inner portion of the capsule. When the hand is adducted, the proximal articular surface of the triquetral articulates with the articular disc, the lunate partially articulates with the scaphoid facet of the radius, and the scaphoid bone is in partial contact with the outer portion of the capsule.

The Joints of the Hand.

The Intercarpal Joints.—The carpal joints are classified into those between the individual bones of the proximal row, those between the individual bones of the distal row, and the transverse carpal joint, or the joint between the proximal and distal rows.

Joints of the Proximal Row.—The bones, with the exception of the pisiform, are united together by dorsal, palmar, and interosseous ligaments. The dorsal and palmar ligaments are more or less transversely disposed, and join the corresponding surfaces of the three bones together. The interosseous ligaments (Fig. 327) are placed one on either side of the lunate, and connect it with the scaphoid and triquetral. They unite the upper or proximal parts of the bones together, and help to form the carpal articular surface of the radio-carpal joint.

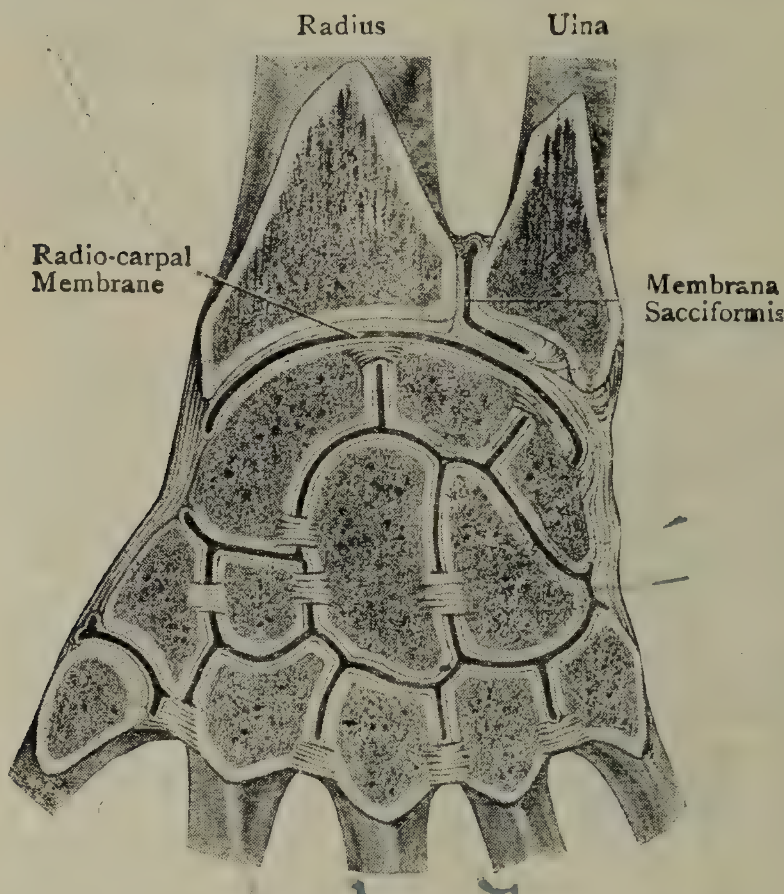


FIG. 327.—RADIO-CARPAL AND CARPAL SYNOVIAL CAVITIES.

The synovial cavities between the bones are continuous with that of the transverse carpal joint.

Pisiform Joint.—The pisiform bone is united to the front of the triquetral by a capsular ligament which surrounds the joint, and is attached to the circumferential edges of the opposed articular surfaces. Above the capsule is connected with the tendon of insertion of the flexor carpi ulnaris, and below with the *piso-hamate* and *piso-metacarpal* ligaments. The former is attached to the hook of the hamate bone, and the latter to the base of the fifth metacarpal. By means of these ligaments the contraction of the flexor carpi ulnaris is exerted upon the distal row of the carpus and the metacarpus.

The pisiform joint has an independent synovial cavity.

Joints of the Distal Row.—The four bones of the distal row are connected together by dorsal, palmar, and interosseous ligaments, which are disposed similarly to those of the first row.

The three interosseous ligaments present a contrast to those of the proximal row in that they connect the middle parts of the opposed surfaces of the four bones together. As they do not fill up the intervals between the dorsal and palmar surfaces of the bones completely, the synovial cavities extend across them, and the transverse carpal joint is thereby put into communication with the carpo-metacarpal joints.

Transverse Carpal Joint (Fig. 327).—The articular surface of the proximal row is convexo-concave, that of the distal row concavo-convex, in each case from without inwards. The convexity of the proximal row is formed by part of the scaphoid, and the concavity by part of the scaphoid and by the lunate and triquetral. The concavity of the second row is formed by the trapezium and trapezoid, and the convexity by the head of the capitate and part of the hamate. The two rows are connected by dorsal, palmar, and lateral ligaments. The dorsal and palmar ligaments are somewhat indefinite, but for the most part radiate from the capitate. The lateral ligament of the wrist-joint connects the scaphoid with the trapezium, and the medial the triquetral with the hamate.

The **Carpal Synovial Cavity** of the transverse carpal joint is continuous above with the two synovial cavities, one on either side of the lunate bone, these being limited proximally by the interosseous ligament. Below it is continuous with the three synovial cavities between the four bones of the distal row, and these, in their turn, are continuous with the synovial cavities of the four inner carpo-metacarpal joints.

Nerve-supply.—The median, ulnar, and posterior interosseous nerves.

Movements.—The gliding movements taking place between the individual bones of each row are extremely limited. The movements at the transverse carpal joint are less restricted, and render the flexion and extension movements of the radio-carpal joint more extensive. The numerous joints bestow considerable strength and elasticity to the wrist, and thereby enable it to minimize the effect of shock or jar which may be transmitted from the hand to the forearm.

Carpo-metacarpal Joints—*Inner Four Joints.*—The bones concerned are the trapezium, trapezoid, capitate, and hamate proximally, and the bases of the four inner metacarpal bones distally. The ligaments connecting the bones are dorsal, palmar, and interosseous. The second, third, and fourth metacarpal bones receive each two dorsal ligaments from two adjoining carpal bones; the fifth, as a rule, receives one from the hamate only. The palmar ligaments are usually one to each joint. There is one interosseous ligament, which connects the adjacent parts of the capitate and hamate with the inner aspect of the base of the third metacarpal bone.

These joints derive their arterial supply from the radial and ulnar arteries, and their nerve-supply from the deep division of the ulnar nerve and the posterior interosseous nerve.

Movements.—The movements are those of slight flexion and extension. Lateral movements also take place in varying degree, leading to separation and approximation of the distal ends of the metacarpal bones.

Carpo-metacarpal Joint of the Thumb.—The articular surfaces taking part in the joint between the trapezium and the base of the first metacarpal are reciprocally saddle-shaped. They are connected together by a capsular ligament, which is attached round the margins of the two articular surfaces, and is strongest on the dorsal and outer aspects. This ligament is sufficiently loose to allow of considerable movement.

The synovial cavity is independent of the other carpo-metacarpal joints.

Nerve-supply.—The median nerve.

Movements.—The movements allowed are flexion, extension, abduction, and adduction. At this joint the movements of **opposition,** whereby the tip of the thumb is brought in such position that it can be easily opposed in succession to the tip of each of the four fingers, take place.

Intermetacarpal Joints (Fig. 327).—The bones concerned are the bases of the four inner metacarpals, the first metacarpal bone not coming into approximation with the second. The ligaments are dorsal, palmar, and interosseous. The dorsal ligaments are composed of stout fibres transversely disposed. The palmar ligaments are

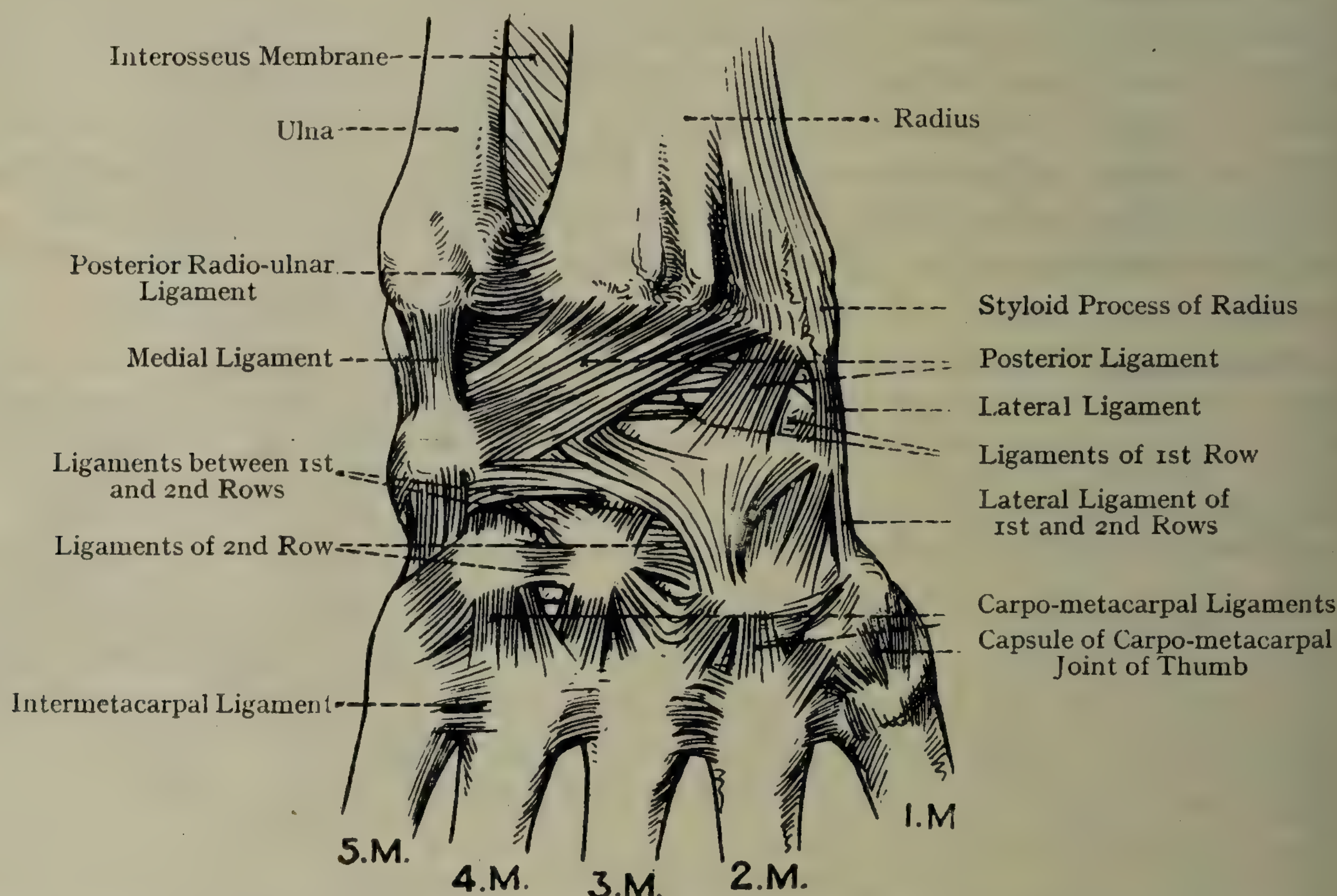


Fig. 328.—Ligaments of the Radio-carpal, Carpal, Carpo-metacarpal, and Intermetacarpal Joints (Posterior View).

similarly disposed in front. The interosseous ligaments are strong bundles which pass between the opposed surfaces of the bases; their attachments are distal to the articular facets.

Nerve-supply.—The deep division of the ulnar nerve.

The synovial cavities are continuous with those of the carpo-metacarpal joints.

The heads of the four inner metacarpal bones are connected by **deep transverse ligaments of palm.** They extend transversely across the palmar aspects of the heads, and their fibres are attached to the fibrous plates on the palmar surfaces of the metacarpo-phalangeal joints. They receive the deep lateral slips of the digital processes of the central part of the palmar aponeurosis, and in the intervals between

the bones the digital arteries and nerves pass in front of them and the interosseous muscles behind them.

Metacarpo-phalangeal Joints.—In each joint the rounded head of a metacarpal bone articulates with the cup-shaped depression on the adjoining surface of a proximal phalanx.

Inner Four Metacarpo-phalangeal Joints.—Each joint is provided with four ligaments—capsular, palmar, and two collateral. The collateral ligaments are strong bands attached proximally to the dorsal tubercle and palmar depression on either side of the head of a metacarpal bone, and distally to the side of the base of a proximal phalanx; it is also attached to the lateral margin of the palmar ligament. Each collateral ligament is connected with a deep lateral slip from a digital process of the central part of the palmar aponeurosis. The palmar ligament, the thickened palmar part of the capsular ligament, is in the form of a *fibro-cartilaginous plate.* It is closely attached on either side to the collateral ligaments, distally to the palmar aspect of the base of the proximal phalanx, and proximally it is connected with the deep transverse ligaments of palm, and also has a slight attachment to the palmar aspect of the head of a metacarpal bone, close to the edge of the articular cartilage. On its deep aspect is a fibro-cartilaginous lip which projects backwards and occupies to some extent an interval between the articular surfaces; it increases the extent of the phalangeal socket for the reception of the head of a metacarpal bone. Its anterior or superficial surface is grooved, and forms the floor of the tunnel for the passage of the flexor tendons. The posterior part of the capsular ligaments is exceedingly thin, and is with difficulty separable from the extensor tendon, which is closely applied to the dorsal aspect of the joint, and is adherent to the ligament.

Nerve-supply.—The deep division of the ulnar nerve.

Movements.—The movements are chiefly flexion and extension. Lateral movements are also possible, these lateral movements occurring when the fingers close and separate during flexion and extension respectively.

Metacarpo-phalangeal Joint of the Thumb.—The collateral ligaments of this joint are similar to those of the other joints, but there is no palmar fibro-cartilaginous plate. The two common tendons of the short muscles of the thumb (Fig. 309) attached to the base of the proximal phalanx blend with the capsular ligament on the front of the joint, and two sesamoid bones, comparable in size and form to split peas, are present where the blending occurs. The palmar surface of each sesamoid bone is convex; the deep surface is almost flat, covered by cartilage, and plays upon a groove on the palmar surface of the head of the first metacarpal bone. The two bones are united by fibres which pass between their adjacent surfaces and are related superficially to the tendon of the flexor pollicis longus. Distally they are connected by fibres with the palmar aspect of the base of the proximal phalanx. At either side they are connected with the collateral ligaments, and proximally the connection with the head of the first metacarpal close

to the edge of the articular cartilage is a weak one. The posterior part of the capsular ligament is very thin, and closely associated with the extensor tendons.

Nerve-supply.—The median nerve.

Movements.—Flexion, extension, and slight lateral movements.

Interphalangeal Joints.—These joints are similar to the metacarpo-phalangeal joints, each joint being provided with a capsular ligament and two collateral ligaments—a palmar ligament with a fibro-cartilaginous lip projecting backwards into the joint cavity, and a very thin dorsal ligament adherent to the extensor tendon. The nerve-supply is derived from the digital nerves.

The **movements** are limited to flexion and extension, the former being very free but the latter limited.

CHAPTER X

THE LOWER LIMB

THE GLUTEAL REGION.

Landmarks.—The crest of the ilium is almost entirely obscured by the prominence of the abdominal muscles above it and the gluteus medius below it, its position being usually indicated by a depression. By following this depression backwards, the posterior superior iliac spine, which is on a level with the second sacral spine and the centre of the sacro-iliac joint, may be found. In the mid-dorsal line the spinous processes of the sacral vertebræ, usually four in number, may be distinguished as separate projections, or they may be fused together into a median ridge which, as the fifth sacral spine is undeveloped, terminates abruptly below. At a slightly lower level and on either side of the middle line the sacral cornua may be detected. The coccyx can be felt in the **natal cleft** between the buttocks. The **ischial tuberosity** is under cover of the gluteus maximus when the hip-joint is extended, but when that joint is flexed, its prominence can be easily distinguished. The **greater trochanter** can be felt at the lower and outer part of the gluteal region; its situation corresponds to a surface depression. The prominence of the buttock is due to the gluteus maximus, and a thick mass of fatty tissue covering it superficially. The **gluteal fold** is a skin fold limiting the buttock prominence below; it is very obvious when the hip-joint is extended, but disappears when the joint is flexed. It is horizontally disposed, and practically bisects the obliquely disposed lower edge of the gluteus maximus. In a thin subject it is sometimes possible to feel the sciatic nerve in this fold, as that nerve lies deeply at a point very nearly midway between the greater trochanter and ischial tuberosity, being rather nearer the latter than the former.

The Cutaneous Nerves (Fig. 329) are met with in the following situations: (1) Along the line of origin of the gluteus maximus; (2) crossing the iliac crest; (3) on the outer and lower part of the gluteus maximus; and (4) crossing the lower border of the gluteus maximus.

1. **Along the Line of Origin of Gluteus Maximus.**—The nerves are disposed in three sets:

(*a*) Two or three twigs from the lateral branches of the posterior primary divisions of the first three sacral nerves. From communications between these lateral branches two sets of loops are derived, one set being situated deeply on the back of the sacrum, and the other set more superficially on the posterior surface of the sacro-tuberous

ligament. From the latter set of loops two or three cutaneous twigs are derived, and pass outwards through the substance of the gluteus maximus.

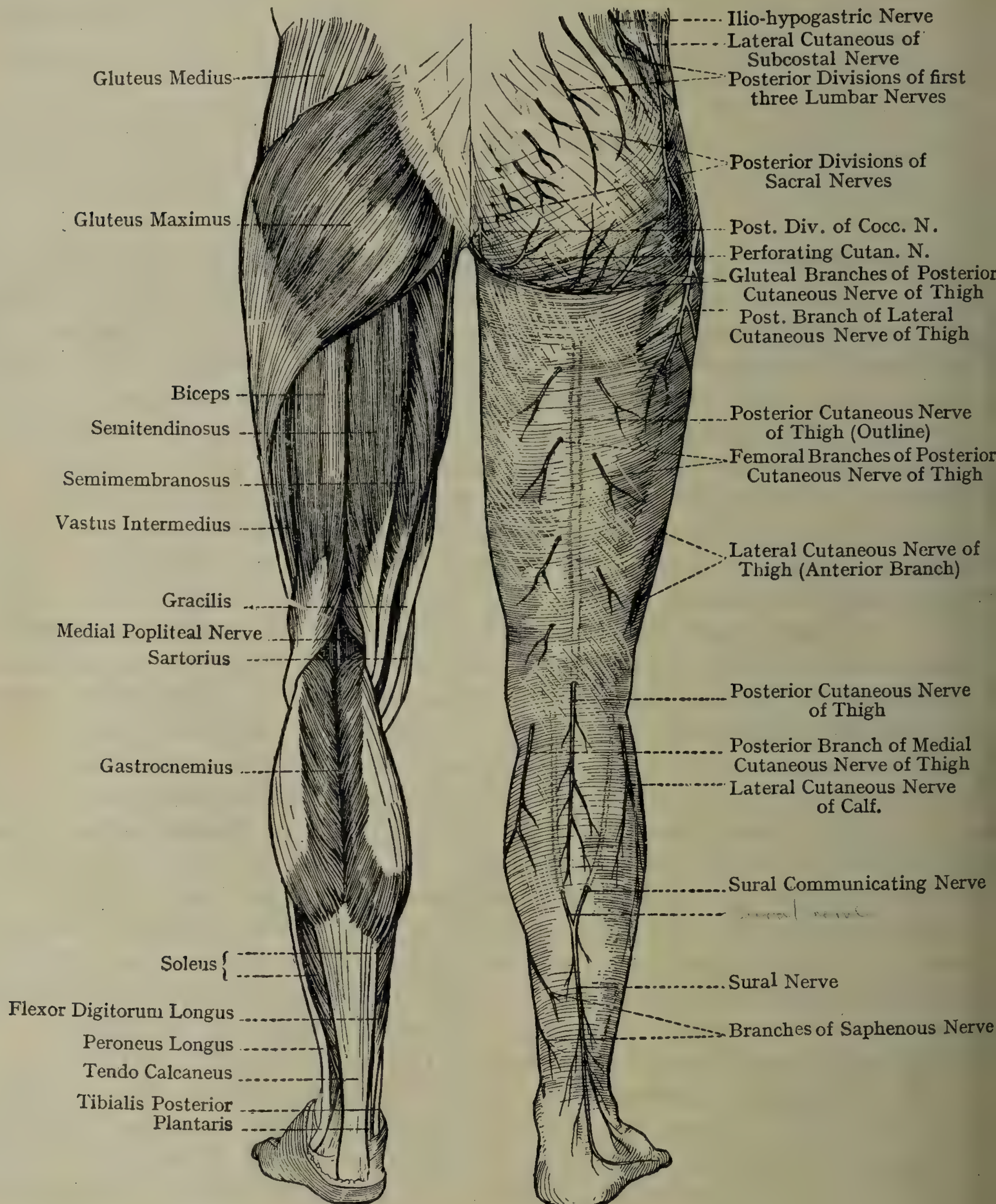


FIG. 329.—MUSCLES AND CUTANEOUS NERVES OF THE LOWER LIMB (POSTERIOR ASPECT).

(*b*) The posterior primary divisions of the last two sacral nerves and the coccygeal nerve form a loop on the back of the sacrum, from which cutaneous twigs are given off and are distributed to the skin on the back of the coccyx.

(*c*) Branches from the coccygeal plexus, which is situated on the pelvic surface of the coccygeus muscle, traverse the coccygeus muscle, the sacro-spinous and sacro-tuberous ligaments, and the gluteus maximus successively, and are distributed to the skin on the back of the coccyx.

2. **Crossing the Iliac Crest.**—The lateral branches of the posterior primary divisions of the first three lumbar nerves descend over the iliac crest in front of the outer border of the sacro-spinalis muscle. The lateral cutaneous branch of the ilio-hypogastric nerve crosses the iliac crest at the junction of the middle and anterior thirds, the most prominent point of the tubercle of the crest being a guide to its position.

The lateral cutaneous branch of the subcostal nerve descends over the anterior part of the iliac crest 1 inch behind the anterior superior iliac spine, and is distributed to the skin of the anterior part of the gluteal region as low as the greater trochanter.

3. **Outer and Lower Part of Gluteus Maximus.**—Branches of the posterior division of the lateral cutaneous nerve of the thigh.

4. **Crossing the Lower Border of Gluteus Maximus.**—Three or four recurrent branches from the posterior cutaneous nerve of thigh supply the skin over the lower and outer part of the gluteus maximus. The perforating cutaneous branch of the sacral plexus, usually derived from the second and third sacral nerves, traverses the sacro-tuberous ligament, winds round the lower edge of the gluteus maximus, and supplies the skin over the lower and inner part of the muscle.

Fasciæ.—The **superficial fascia** is loaded with fat. It is continuous over the iliac crest with the superficial fascia of the back of the trunk, and largely contributes to the prominence of the buttock. Between the iliac crest and the upper border of the gluteus maximus a considerable amount of fatty tissue occupies a depression in this situation. The **deep fascia** investing the gluteus maximus is thin, but at the insertion of the muscle and over the anterior two-thirds of the gluteus medius it is thick and dense. In these latter situations it gives insertion to a considerable part of the gluteus maximus, and the superficial fibres of the gluteus medius arise from its deep aspect. As it passes from the gluteus maximus on to the gluteus medius it straps down the upper border of the former muscle.

Muscles—Gluteus Maximus (Fig. 329)—*Origin.*—The posterior 2 inches of the outer lip of the iliac crest; the upper part of the rough surface on the gluteal surface between the crest and the posterior gluteal line; the posterior layer of the lumbar fascia; the dorsal aspects of the fourth and fifth sacral vertebræ and of the upper three coccygeal vertebræ; and the sacro-tuberous ligament.

Insertion.—The upper part and the superficial fibres of the lower part of the muscle are inserted into the ilio-tibial tract, a thickened band of the fascia lata on the outer side of the thigh, attached above to the tubercle of the iliac crest and below to the lateral condyle of the tibia and the head of the fibula. The deep fibres of the lower part of the muscle are inserted into the gluteal tuberosity of the femur.

Nerve-supply.—The inferior gluteal nerve, a branch of the sacral plexus, enters the deep surface of the muscle.

The muscle is very coarsely fasciculated. Its general direction is downwards and outwards.

Action.—Acting from its origin, the muscle extends the thigh upon the trunk. The upper part abducts the thigh, and the lower part adducts it and rotates it outwards. By means of the ilio-tibial tract the muscle also takes part in completing and maintaining extension of the knee-joint. Acting from its insertion, the muscle extends the trunk upon the thigh.

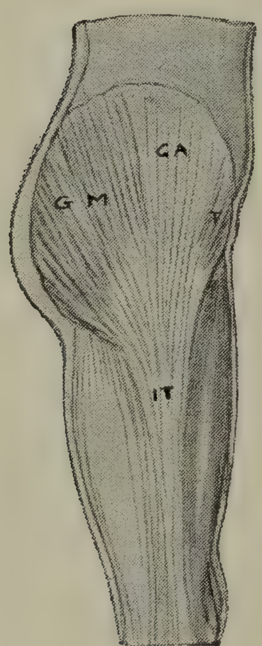


FIG. 330.—SHOWING THE ARRANGEMENT OF GLUTEUS MAXIMUS (GM), TENSOR FASCIÆ LATÆ (T), AND GLUTEAL APONEUROSIS (GA), ALL CONVERGING ON AN APONEUROTIC BAND, THE ILIO-TIBIAL TRACT (IT).

The gluteus maximus is quadrilateral; it has a short upper border bound down to the gluteus medius by the fascia lata, and a longer lower border.

Deep Relations.—The back of the sacrum and coccyx, the hinder part of the ilium, the ischial tuberosity when the hip-joint is extended, the hinder aspect of the greater trochanter, and the upper end of the shaft of the femur; the posterior sacro-iliac ligaments and the sacro-tuberous and sacro-spinous ligaments; the following muscles from above downwards: gluteus medius, pyriformis, obturator internus and the two gemelli, quadratus femoris and upper part of the adductor magnus, lateral to the two latter muscles the upper part of the vastus lateralis, and medial to them the origins of the hamstrings; above the pyriformis the superior gluteal vessels and superior gluteal nerve, and below that muscle the sciatic, posterior cutaneous of thigh, inferior gluteal, and pudendal nerves, the nerves to quadratus and obturator internus, the inferior gluteal and internal pudendal vessels, between the quadratus femoris and adductor magnus the transverse branch of the medial femoral circumflex artery.

Three synovial bursæ may be found on the deep aspect of the muscle. An inconstant one is situated between the lower border of the muscle and the ischial tuberosity. Another lying between the muscle and the greater trochanter is occasionally present. The third is large and constant, and is found between the muscle and the upper part of the vastus lateralis, just below the greater trochanter.

The gluteus maximus is relatively a larger muscle in man than in any other animal. Its extensive attachment to the deep fascia is also a human peculiarity. It is essentially a muscle of the erect attitude, in which it plays an important part by its actions on the hip and knee joints.

Gluteus Medius (Fig. 331)—*Origin.*—An area on the gluteal surface of the ilium bounded by the crest, posterior gluteal line, and middle

gluteal line; and the fascia lata covering the anterior two-thirds of the muscle.

Insertion.—The oblique impression on the outer surface of the greater trochanter, extending from the postero-superior angle downwards and forwards to the antero-inferior angle.

Nerve-supply.—The superior gluteal nerve.

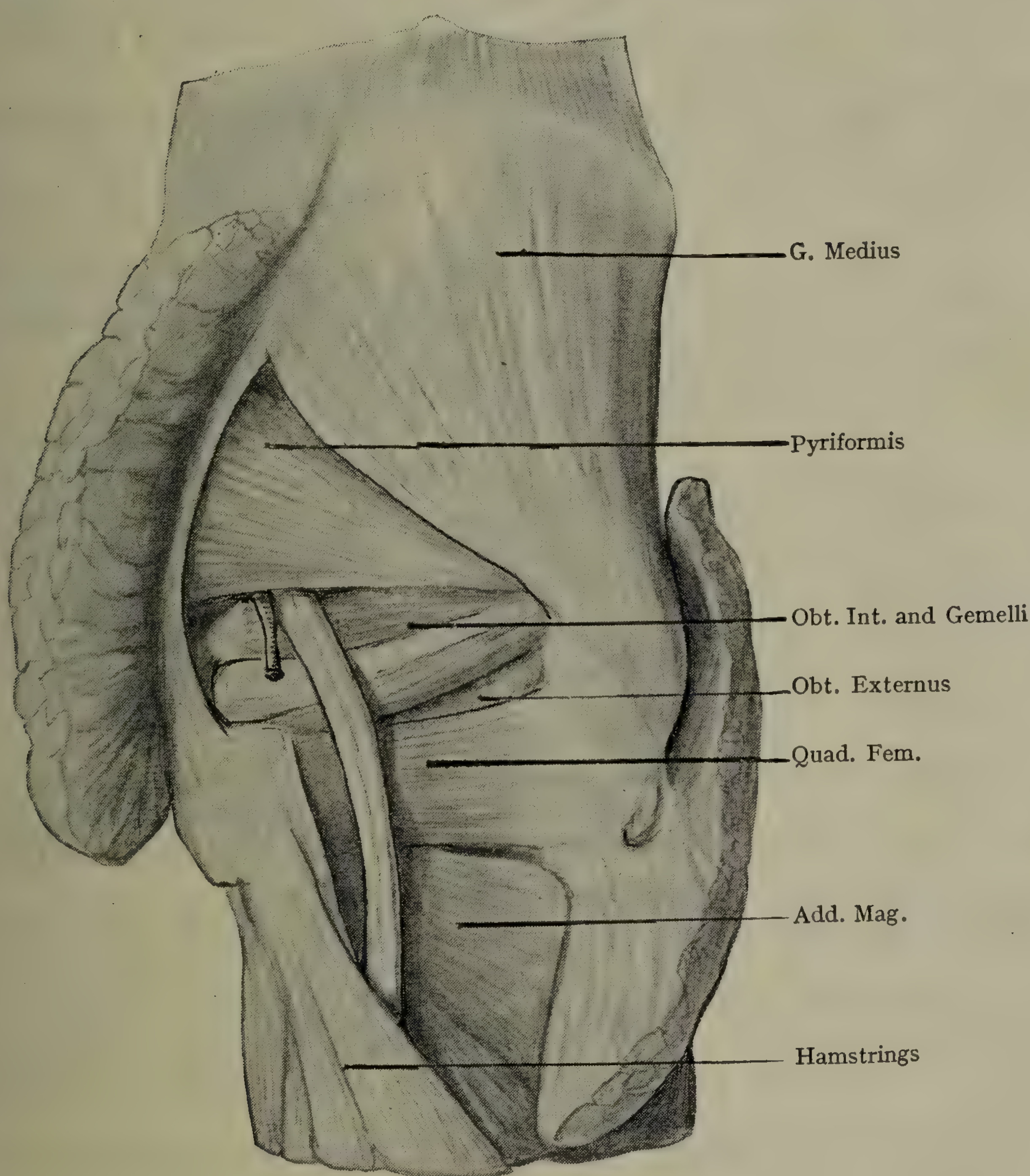


FIG. 331.—MUSCLES OF THE GLUTEAL REGION.

Gluteus maximus divided and turned back. Sciatic nerve and inferior gluteal artery introduced to show their position.

The direction of the anterior fibres of the muscle is downwards and slightly backwards, and of the posterior fibres downwards and forwards. The fibres of the muscle converge from their origin to the fan-shaped tendon of insertion; they correspond in direction with those of the gluteus minimus.

Action.—Acting from its origin, the muscle abducts the thigh. The anterior fibres, contracting independently, rotate the thigh inwards,

while the posterior fibres rotate it outwards. Acting from its insertion, it rotates and bends the trunk to the same side; it is an important balancing muscle.

The muscle is triangular. The posterior fleshy third is covered by the gluteus maximus, and the anterior two-thirds by the fascia lata. The muscle lies superficially to the gluteus minimus, the deep division of the superior gluteal artery and the superior gluteal nerve lying between them. A synovial bursa intervenes between it and the upper part of the greater trochanter.

Gluteus Minimus—*Origin.*—The gluteal surface of ilium between the middle and inferior gluteal lines.

Insertion.—A depression on the anterior aspect of the greater trochanter.

Nerve-supply.—The lower division of the superior gluteal nerve.

The fibres of the muscle correspond in direction, for the most part, with those of the gluteus medius.

The Action is similar to that of the gluteus medius (*q.v.*).

The muscle is fan-shaped, and the tendon of insertion spreads out into an aponeurotic expansion over its lower part. It is covered superficially by the gluteus medius. Its deep surface is related to the capsular ligament of the hip-joint and the reflected head of the rectus femoris. The tendon of insertion of the muscle is separated from the greater trochanter by a synovial bursa, and is connected with the upper part of the capsular ligament of the hip-joint by a strong arched band of fibres.

The anterior portion of the gluteus minimus is sometimes detached from the rest of the muscle, and when this occurs, the separated part represents the *gluteus quartus* or *musculus scansorius* (climbing muscle) of certain animals.

Pyriformis (Fig. 331)—*Origin.*—By three fleshy slips from the anterior surfaces of the second, third, and fourth sacral vertebræ, the slips lie between and lateral to the anterior sacral foramina; the deep surface of the sacro-tuberous ligament; and the posterior border of the ilium immediately below the posterior inferior iliac spine.

Insertion.—A flattened area on the upper border of the greater trochanter.

Nerve-supply.—Branches from the first and second sacral nerves enter the intrapelvic part of the muscle.

Action.—A lateral rotator of the thigh.

As the pyriformis emerges from the pelvic cavity through the greater sciatic foramen it divides the latter into a smaller upper and a larger lower compartment. In the *upper compartment* are the superior gluteal vessels and superior gluteal nerve. In the *lower compartment* the inferior gluteal and internal pudendal vessels, sciatic and posterior cutaneous nerves, inferior gluteal nerve, pudendal nerve, nerve to obturator internus, and common nerve to gemellus inferior and quadratus femoris.

Gemellus Superior (Fig. 331)—*Origin.*—The outer and lower part of the spine of the ischium.

Insertion.—The upper border of the tendon of the obturator internus, with which it is inserted.

Nerve-supply.—A branch from the nerve to the obturator internus, which enters the muscle on its deep surface and close to its origin.

The gemellus superior is often very small and is sometimes absent.

Obturator Internus (Fig. 331)—*Origin.*—The deep surface of the obturator membrane except in its lower part; the pelvic aspect of the bone both above and medial to the obturator foramen, and between the foramen and the greater sciatic notch; and slightly from the obturator fascia covering the muscle.

Insertion.—To a depression on the inner surface of the greater trochanter, above and in front of the trochanteric fossa.

Nerve-supply.—The nerve to the obturator internus derived from the fifth lumbar and the first and second sacral nerves.

Action.—A lateral rotator of the thigh.

The intrapelvic and extrapelvic parts of the muscle are disposed at very nearly a right angle to each other, the tuberosity of the ischium playing the part of a pulley for the muscle. It emerges from the pelvic cavity through the lesser sciatic foramen, and in this situation the deep surface of its tendon is subdivided into from three to five bands, with linear grooves between them. The bone upon which these tendons lie is covered by cartilage, which presents as many grooves as there are tendons. A bursa intervenes between the tendons and the cartilage covering the bone.

Gemellus Inferior (Fig. 331)—*Origin.*—The part of the ischial tuberosity forming the lower margin of the lesser sciatic notch.

Insertion.—The lower border of the tendon of the obturator internus, with which it is inserted.

Nerve-supply.—A branch from the nerve to the quadratus femoris, which enters the muscle on its deep surface near its origin.

The gemelli are extrapelvic parts of the obturator internus. The two muscles are not only attached to the upper and lower borders of the obturator tendon, but also overlap and partially conceal the tendon on its superficial aspect.

Lesser Sciatic Foramen.—The structures occupying this foramen are the obturator internus muscle; the pudendal nerve and the nerve to the obturator internus; and the internal pudendal vessels.

Quadratus Femoris (Fig. 331)—*Origin.*—The outer border of the ischial tuberosity.

Insertion.—The quadrate eminence and the quadrate line of the femur.

Nerve-supply.—The nerve to the quadratus femoris, derived from the fourth and fifth lumbar and the first sacral nerves.

Action.—A lateral rotator of the thigh.

The muscle lies superficially to a part of the obturator externus and the lesser trochanter of the femur, being separated from the latter by a small bursa. If the gemellus inferior and quadratus femoris are separated, the obturator externus comes into view. Between the lower border of the muscle and the upper border of the adductor magnus is the transverse branch of the medial femoral circumflex artery. If the lower border of the muscle is raised, the lesser trochanter with the tendon of insertion of the ilio-psoas come into view.

Arteries.—The chief arteries of the gluteal region are the superior and inferior gluteal and the internal pudendal.

The Superior Gluteal Artery (Fig. 332) arises from the posterior division of the internal iliac artery. Traversing the parietal pelvic fascia, it passes between the lumbo-sacral trunk and the anterior primary division of the first sacral nerve, and emerges from the pelvic cavity through the upper compartment of the greater sciatic foramen above the pyriformis, where it divides into two divisions—superficial and deep. From the trunk of the artery the chief nutrient artery to the ilium is given off. The **superficial division** passes backwards between the posterior border of the gluteus medius and the pyriformis, and enters the deep or anterior surface of the gluteus maximus near its origin. Some of its branches become cutaneous by piercing the muscle, and anastomose with the posterior branches of the lateral sacral arteries derived from the posterior division of the internal iliac.

The **deep division** lies deeply to the gluteus medius, where it subdivides into two branches, an upper and a lower. The *superior branch* courses along the upper border of the gluteus minimus, following the middle curved line of the ilium in company with the upper division of the superior gluteal nerve. It supplies the ilium and adjacent muscles, and terminates in the region of the anterior superior iliac spine, where it anastomoses with the deep circumflex iliac of the external iliac and the ascending branch of the lateral femoral circumflex of the arteria profunda femoris. The *inferior branch* crosses the middle of the gluteus minimus in company with the lower division of the superior gluteal nerve. It supplies the gluteus medius and gluteus minimus, the muscles between which it lies. It gives an articular branch to the hip-joint, and a branch to the trochanteric fossa which anastomoses with the inferior gluteal, an ascending branch of the medial femoral circumflex, and a branch of the first perforating artery. It also anastomoses with the ascending branch of the lateral femoral circumflex.

The place of emergence of the superior gluteal artery from the pelvis is indicated as follows: the thigh being rotated inwards, draw a line from the top of the greater trochanter to the posterior superior iliac spine, and take a point in this line at the junction of the inner third and outer two-thirds.

The Superior Gluteal Vein.—As the artery occupies the upper part of the greater sciatic notch it is surrounded by a dense plexus of veins, which join the internal iliac vein.

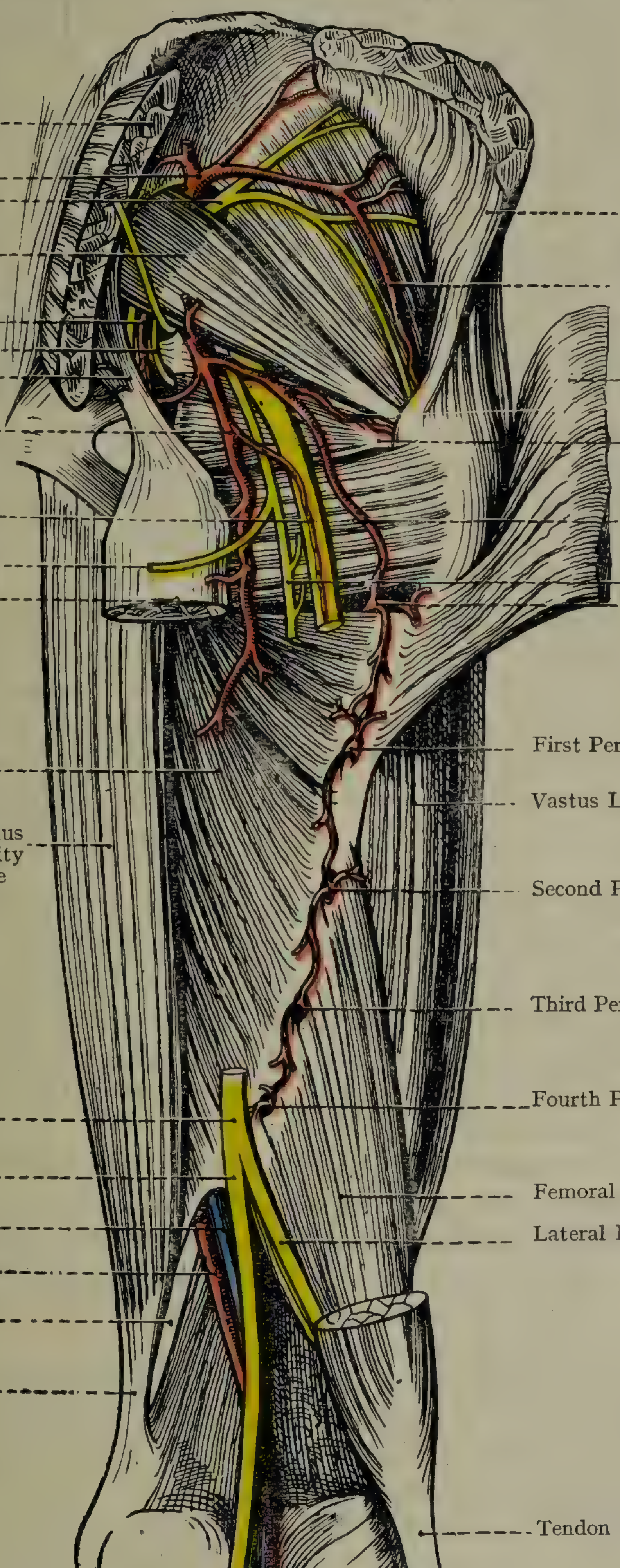


FIG. 332.—THE GLUTEAL REGION AND BACK OF THE THIGH (DEEP DISSECTION).

The Inferior Gluteal Artery arises from the anterior division of the internal iliac artery. In the pelvis it descends behind the internal pudendal, lying in front of the pyriformis and sacral nerves, and emerges through the lower compartment of the greater sacro-sciatic foramen below the pyriformis. It passes downwards between the greater trochanter and ischial tuberosity to the inner side of the sciatic nerve, lying deeply to the gluteus maximus, and superficially to the gemelli, obturator internus, and quadratus femoris.

Branches.—The extrapelvic branches are as follows:

The **coccygeal branch** traverses the sacro-tuberous ligament and gluteus maximus, and is distributed over the back of the coccyx. **One branch** enters the deep surface of the gluteus maximus with the inferior gluteal nerve, and anastomoses in the substance of the muscle with the superficial division of the superior gluteal artery. The **muscular branches** are distributed to the adjacent lateral rotator muscles and the origins of the hamstrings.

The **anastomotic branches** are two in number. One passes to the trochanteric fossa, where it anastomoses with the superior gluteal, ascending branch of the medial femoral circumflex, and first perforating arteries. The other passes to the interval between the quadratus femoris and adductor magnus, where it anastomoses with the transverse branch of the medial femoral circumflex, the transverse branch of the lateral femoral circumflex, and the first perforating artery. This fourfold anastomosis is called the *crucial anastomosis*, but cannot always be recognized.

The **articular branches** are two or three in number. They pass deeply to the gemelli and obturator internus with the nerve to the quadratus femoris, and supply the hip-joint from behind.

The **gluteal cutaneous branches** wind round the lower border of the gluteus maximus with the gluteal cutaneous branches of the posterior cutaneous nerve of the thigh, and are distributed to the skin covering the lower part of the muscle.

The **femoral cutaneous branch** descends with the posterior cutaneous nerve of the thigh, and supplies the skin on the back of the thigh.

The **companion artery of sciatic nerve** is a long branch which descends for some distance with the sciatic nerve, to which it is distributed, and in which it anastomoses with the perforating branches of the arteria profunda femoris.

The place of emergence of the inferior gluteal artery from the pelvic cavity is indicated by a point at the junction of the middle and lower thirds of a line drawn from the posterior superior iliac spine to the outer border of the ischial tuberosity.

The **inferior gluteal vein** terminates in the internal iliac vein.

The inferior gluteal artery in the early embryo is the main arterial trunk supplying the lower limb. As the femoral artery is developed it effects a junction with the inferior gluteal in the neighbourhood of the knee, and by transmitting blood to the distal part of the limb eventually becomes the chief artery. The trunk of the primitive sciatic between the knee and the gluteal region for the most part disappears.

The **internal pudendal artery** (Fig. 332) arises from the anterior division of the internal iliac, and at first lies within the pelvic cavity. The second part of the vessel appears in the gluteal region, and will be described here. It emerges from the pelvic cavity through the lower compartment of the greater sacro-sciatic foramen below the pyriformis, and, passing downwards for a short distance, crosses the back of the spine of the ischium. It leaves the gluteal region by passing through the lesser sacro-sciatic foramen.

Relations.—*Superficial or Posterior.*—Gluteus maximus. *Deep or Anterior.*—The spine of the ischium.

The artery is accompanied by two venæ comites. The pudendal nerve lies on its inner side, and the nerve to the obturator internus on its outer side.

Branches.—**Muscular,** to gluteus maximus.

The position of the second part of the internal pudendal artery, as it lies upon the back of the spine of the ischium, is about 4 inches below the posterior superior iliac spine, and is indicated on the surface by rotating the thigh inwards, and taking a point at the junction of the inner third and outer two-thirds of a line drawn from the upper border of the greater trochanter to the junction of the sacrum with the coccyx.

Deep Nerves.—The **superior gluteal nerve** (Fig. 332) arises from the fourth and fifth lumbar and the first sacral nerves. It passes through the upper compartment of the greater sacro-sciatic foramen, above the pyriformis, in company with the superior gluteal artery, and passes outwards between the gluteus medius superficially and the gluteus minimus deeply, where it divides into a smaller upper and a larger lower branch. The **upper branch** accompanies the upper deep branch of the superior gluteal artery, and supplies the gluteus medius. The **lower branch** crosses the middle of the gluteus minimus, and accompanies the lower deep branch of the superior gluteal artery. It supplies the gluteus medius and gluteus minimus, and ends by supplying the tensor fasciæ latæ.

It may be noticed that the three muscles supplied by the superior gluteal nerve are all concerned in rotating the thigh inwards, a movement brought about by, amongst other muscles, the anterior fibres of the gluteus medius and minimus and the tensor fasciæ latæ.

The **inferior gluteal nerve** (Fig. 332) arises from the fifth lumbar and first and second sacral nerves. It passes through the lower compartment of the greater sacro-sciatic foramen, below the pyriformis, and in close contact with the sciatic nerve. It divides into several branches which enter the deep surface of the gluteus maximus.

The **nerve to obturator internus** arises from the fifth lumbar and first and second sacral nerves. It passes through the lower compartment of the greater sacro-sciatic foramen, below the pyriformis, and medial to the sciatic nerve and posterior cutaneous nerve of the thigh. It winds round the spine of the ischium, where it lies to the outer side

of the internal pudendal vessels, and, passing through the lesser sacro-sciatic foramen, is finally distributed to the intrapelvic part of the obturator internus. At the lower border of the pyriformis it gives a branch to the gemellus superior, which enters the deep surface of the muscle close to its origin.

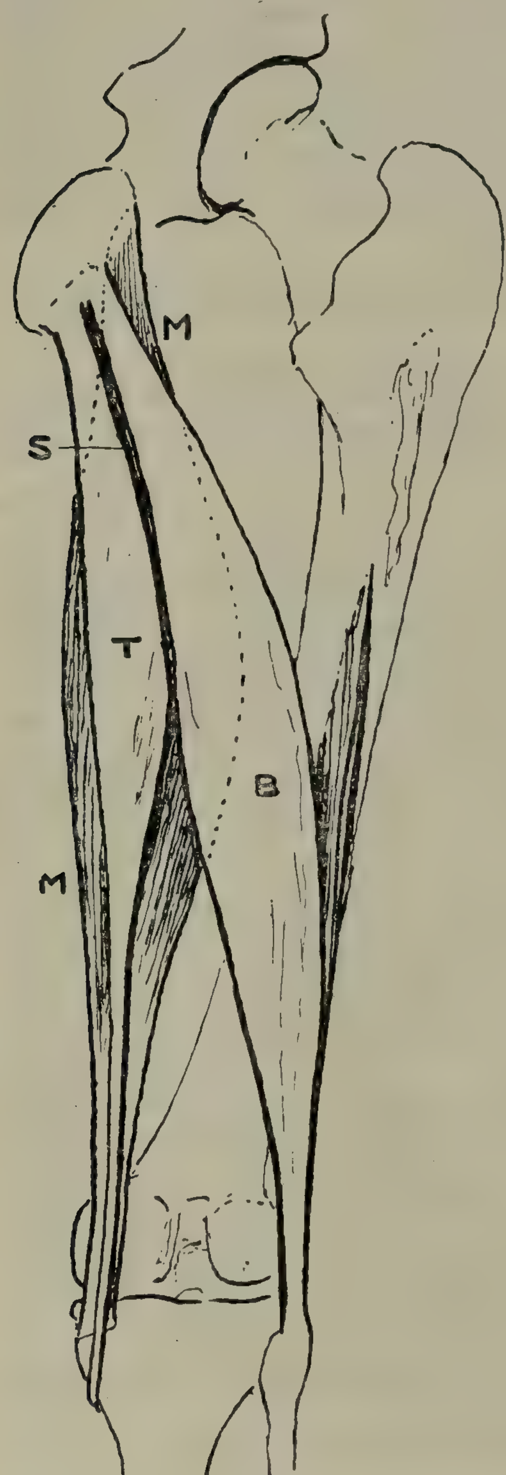


FIG. 333.—SHOWING THE COMPOSITION OF THE GROUP OF HAMSTRING MUSCLES.

Biceps (B) and semitendinosus (T) have a common origin from ischial tuberosity and from septum (S). The femoral head of biceps is seen lower down. M, semimembranosus.

The **nerve to quadratus femoris** arises from the fourth and fifth lumbar and the first sacral nerves. It passes through the lower compartment of the greater sacro-sciatic foramen, below the pyriformis, where it lies in close contact with the deep surface of the sciatic nerve. It passes downwards, lying directly on the bone, and covered on its superficial or posterior aspect by the gemellus superior, obturator internus, gemellus inferior, and quadratus femoris. It enters the deep surface of the quadratus femoris near its upper border and close to its origin. It gives a branch to the gemellus inferior, which enters its deep surface near its upper border and close to its origin.

The nerve to the quadratus femoris usually supplies an articular branch to the back of the hip-joint.

Lymphatics.—The **superficial lymphatics** of the gluteal region terminate in the superficial inguinal glands. The **deep lymphatics** enter the pelvic cavity and terminate in the internal iliac glands.

THE THIGH.

Back of the Thigh and Popliteal Space.

Landmarks.—The hamstring muscles are responsible for the prominence on the back of the thigh, but can only be recognized individually in the region of the knee. The **sciatic nerve** is deeply placed, being under cover of the long or ischial head of the biceps femoris; its course may be indicated by drawing a line from the centre of the back of the knee-joint to a point between the greater trochanter and the ischial tuberosity, rather nearer the latter than the former. The upper two-thirds of this line corresponds with the sciatic nerve, and the lower third with the medial popliteal nerve.

The situation of the **popliteal fossa** behind the knee-joint is in-

dicated by a depression when the joint is flexed. The strong tendon of the biceps femoris descending to the head of the fibula can be felt on the outer side and in front of it; the lateral ligament of the knee-joint can be distinguished as a tense rounded cord on the outer side of the knee. Anterior to this ligament the lower part of the ilio-tibial tract, which may easily be mistaken for a tendon, can be felt. The **lateral popliteal nerve** is close to the inner side of the biceps tendon. Lower down it winds round to the front of the limb just below the head of the fibula. On the inner side of the popliteal fossa, over the back of the inner medial, three tendons may be felt. The most superficial is that of the semitendinosus, which is narrow and resistant; it is traceable for some distance above the knee-joint. Deeply to it is the tendon of the semimembranosus, and medial to this is the slender tendon of the gracilis. The course of the **popliteal artery** coincides with the middle line of the popliteal fossa, but the vessel can only be felt when the joint is well flexed. In this position of the joint the popliteal lymphatic glands, if enlarged, may be detected.

Back of the Thigh.—The **posterior cutaneous nerve of the thigh** (Fig. 334) arises from the first, second, and third sacral nerves. It escapes from the pelvic cavity through the lower compartment of the greater sacro-sciatic foramen, below the pyriformis. Passing downwards between the greater trochanter and ischial tuberosity, and under cover of the lower part of the gluteus maximus, it is at first a close companion of the sciatic nerve. After escaping from under cover of the gluteus maximus, it descends in the middle line of the back of the thigh superficial to the hamstring

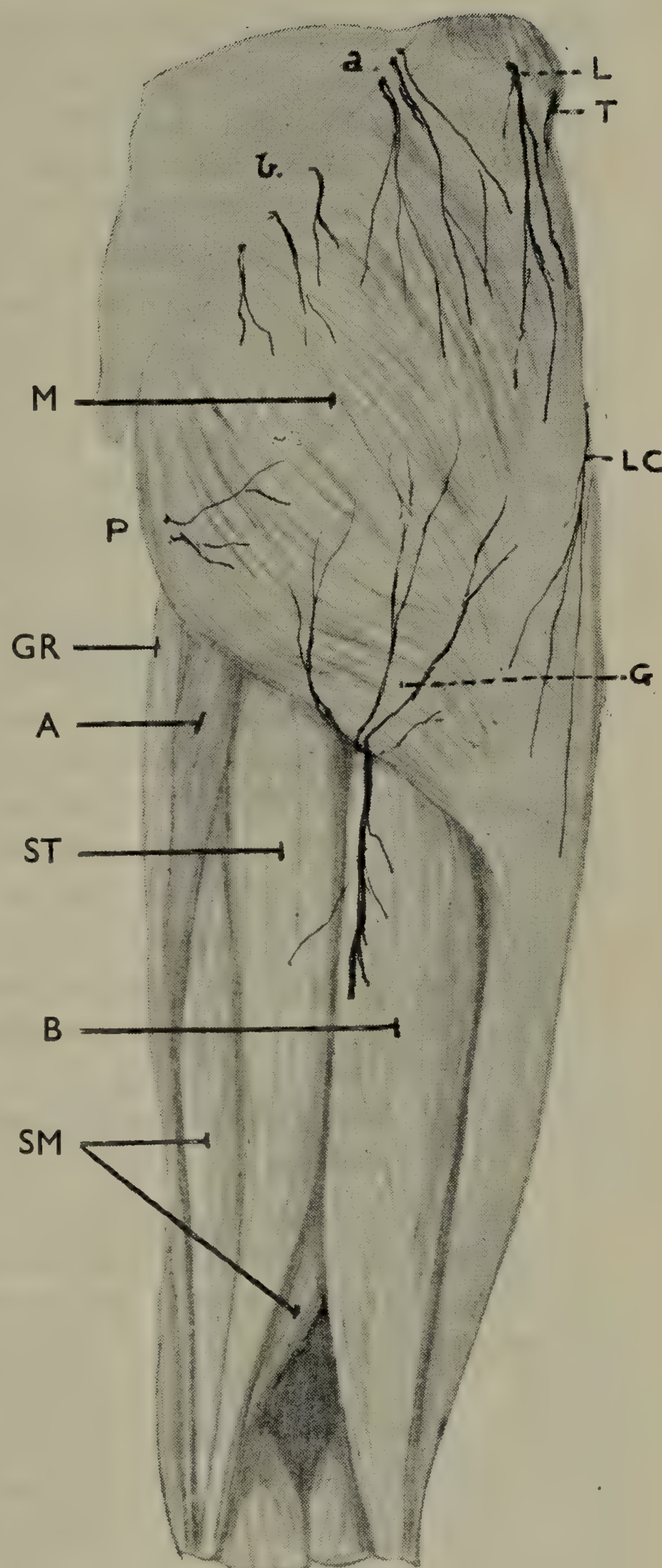


FIG. 334.—DISSECTION SHOWING CUTANEOUS GLUTEAL NERVES.

a, b, Lumbar and sacral, post. primary; T, Last thoracic; L, Ilio-hypogast.; M, Glut. max.; LC, Lat. cutan.; GR. Gracilis; P, Perforating; A, Add. magn.; G, Recurr. gluteal (of post fem. cut.); ST, Semitend.; SM, Semi-memb.; B, Biceps.

The posterior cutaneous nerve of the thigh is shown for some distance running down superficial to muscles; it is immediately under deep fascia.

muscles and deep to the fascia lata covering them. Extending downwards to the popliteal space, it traverses the deep fascia at the back of the knee. Thence it descends on to the back of the leg in company with the short saphenous vein, and terminates on the back of the calf. The nerve is entirely cutaneous in its distribution.

Branches.—The **gluteal cutaneous branches,** three or four in number, take a recurrent course, wind round the lower border of the gluteus maximus, and supply the skin covering the lower and outer part of the muscle. The **perineal branch** arises under cover of the gluteus maximus, and winds inwards towards the anterior part of the perineum; it lies some little distance below the ischial tuberosity, and crosses the origins of the hamstring muscles. It pierces the fascia lata fully 1 inch in front of the ischial tuberosity, and, passing over the ischio-pubic ramus through the deeper layer of the superficial perineal fascia, it courses forwards and inwards in company with the two superficial perineal nerves and the superficial perineal artery, being finally distributed to the scrotum in the male and the labium majus in the female. In the anterior part of the perineum it communicates with the two superficial perineal nerves, and with them forming one of the three posterior scrotal (or labial) nerves. Its branches are *femoral cutaneous,* to the upper and inner part of the thigh on its posterior aspect; and *scrotal* or *labial,* to the scrotum or labium majus, according to sex. The **femoral cutaneous** are a series of branches supplying the skin of the back of the thigh as low as the knee. The **sural cutaneous** are the terminal branches of the nerve. They supply the skin of the upper part of the back of the leg, and communicate with the sural nerve, a branch of the internal popliteal nerve.

Muscles.—The muscles of the back of the thigh are usually termed the **hamstring** muscles, and are three in number.

Biceps Femoris (Figs. 333, 334)—*Origin.*—The muscle arises by two heads—the long or ischial, and the short or femoral. (1) The **long or ischial head** arises, in common with the semitendinosus, from the lower and inner impression on the posterior surface of the ischial tuberosity; some of the fibres of the tendon of origin are continuous with the sacro-tuberous ligament.

In many animals the biceps femoris is a vertebro-crural muscle extending from the caudal end of the vertebral column to the leg. The sacro-tuberous ligament represents, partially at all events, the proximal end of the muscle, which has acquired a secondary attachment to the tuberosity of the ischium.

(2) The **short or femoral head** arises from the outer lip of the linea aspera, the upper two-thirds of the lateral supracondylar line, and the lateral intermuscular septum.

Insertion.—The tendon descends on the outer side of the knee-joint superficial to the upper part of the lateral ligament of the knee-joint, a bursa being interposed between the two. Some little way above the upper end of the fibula the tendon splits into two parts, anterior and posterior, which embrace the lower end of the lateral ligament. The anterior part is attached to the head of the fibula,

and is prolonged forwards on to the lateral condyle of the tibia; the posterior is also attached to the head of the fibula; an expansion from it passes downwards and blends with the deep fascia on the outer side of the leg.

Nerve-supply.—The sciatic nerve. The long or ischial head receives branches from the *medial* popliteal part of the nerve, and the short or femoral head from the *lateral* popliteal part.

It is to be noted that the short head of the muscle receives its supply from a nerve (the *lateral* popliteal part of the sciatic) which is exclusively concerned in supplying extensor muscles. The short head is undoubtedly a derivative from the extensor musculature which has been displaced to the opposite side of the limb, and has there become associated with the flexor muscles anatomically and functionally.

Action.—Acting from its origin, the ischial head of the muscle extends the hip-joint; the two heads flex the leg upon the thigh. Acting from its insertion, the ischial head extends the trunk upon the thigh.

Semitendinosus (Fig. 333)—*Origin.*—The lower and inner impression on the posterior surface of the ischial tuberosity, in common with the long or ischial head of the biceps femoris.

Insertion.—The upper part of the medial surface of the shaft of the tibia, behind and below the sartorius and below the gracilis. From the tendon of insertion an expansion is given to the deep fascia of the leg.

Nerve-supply.—Sciatic nerve. The branches come from the medial popliteal part of the nerve.

Action.—Acting from its origin, the muscle extends the hip-joint, and flexes the leg upon the thigh; it also acts as a medial rotator of the leg. Acting from its insertion, it extends the trunk upon the thigh. The semitendinosus is inseparable from the long head of the biceps in the upper part of the thigh; its belly is interrupted about its middle by an oblique tendinous intersection. In the lower third of the thigh the muscle has a long, narrow, round tendon, which crosses the medial ligament of the knee-joint superficially, and broadens out at its insertion. A bursa intervenes between it and the ligament, and also between it and the tendon of the sartorius.

Semimembranosus (Fig. 333)—*Origin.*—By means of a broad, flat tendon from the upper and outer impression on the posterior surface of the ischial tuberosity.

Insertion.—By means of a strong tendon into a horizontal groove on the medial condyle of the tibia. At its insertion the tendon is at right angles to the rest of the muscle. From its tendon an expansion passes obliquely upwards and outwards to the upper and back part of the lateral condyle of the femur, and forms an accessory ligament on the back of the knee-joint, known as the *oblique posterior ligament.* Another expansion passes downwards and outwards to the soleal or popliteal line on the posterior surface of the shaft of the tibia and covers the popliteus muscle.

Nerve-supply.—Sciatic nerve. The branches come from the medial popliteal part of the nerve.

Action.—Acting from its origin, the muscle extends the hip-joint and flexes the leg upon the thigh. Acting from its insertion, it extends the trunk upon the thigh.

The tendon of origin is prolonged downwards for some distance on the outer side of the muscle, and the tendon of insertion is prolonged upwards for some distance on its inner side. The muscle fibres are short, and pass obliquely from the tendon of origin to the tendon of insertion. This arrangement increases its power, but limits its range of movement. A large bursa, common to it and the medial head of the gastrocnemius, and usually continuous with the synovial membrane through a deficiency in the posterior ligament, underlies the tendon at the back of the knee-joint. The tendon of insertion lies deeply to the medial ligament of the knee-joint, and is separated by a bursa from the upper lip of the groove on the medial condyle of the tibia.

The hamstring muscles descend in close contact with one another in the upper part of the thigh, being held together by the fascia lata. In the lower part of the thigh they part company, the biceps femoris passing downwards and outwards, and the semitendinosus and semimembranosus downwards and inwards; as the muscles diverge from one another the popliteal fossa opens out between them.

The **sciatic nerve** arises from the fourth and fifth lumbar, and the first, second, and third sacral nerves. It escapes from the pelvic cavity through the lower compartment of the greater sacro-sciatic foramen, below the pyriformis, and passes downwards between the greater trochanter and ischial tuberosity, being somewhat nearer the latter than the former. It descends in the middle line of the back of the thigh, deeply to the long head of the biceps, and ends, about the junction of the middle and lower thirds of the thigh, by dividing into the medial and lateral popliteal nerves. The sciatic is the largest nerve in the body, and is about $\frac{3}{4}$ inch broad.

Chief Relations—*Superficial or Posterior.*—Gluteus maximus, and the long head of the biceps femoris. *Deep or Anterior.*—From above downwards the nerve is in contact with the following structures: the ischium, with the nerve to the quadratus femoris intervening between them, gemellus superior, obturator internus, gemellus inferior, quadratus femoris, and the posterior surface of the adductor magnus. *Medially.*—Semimembranosus.

Branches.—The **muscular branches** arise in the upper part of the thigh, with the exception of the branch to the short head of the biceps femoris, which arises at a lower level. They supply the hamstring muscles, and also that part of the adductor magnus which descends from the ischial tuberosity to the adductor tubercle of the femur. The branch to this part of the adductor magnus arises in common with the nerve to the semimembranosus. The branch to the short head of the biceps femoris is derived from the *lateral* popliteal part of the

nerve; all the other muscular branches come from the *lateral* popliteal part.

The **terminal branches** are the medial and lateral popliteal nerves. They arise at about the junction of the middle and lower thirds of the thigh.

The sciatic nerve supplies the hip-joint when the articular branch of the nerve to the quadratus femoris is absent.

The sciatic nerve may divide into the lateral and medial popliteal trunks at a higher level than is usually the case, and in some instances before it leaves the pelvic cavity. In the latter case the lateral popliteal nerve often traverses the pyriformis.

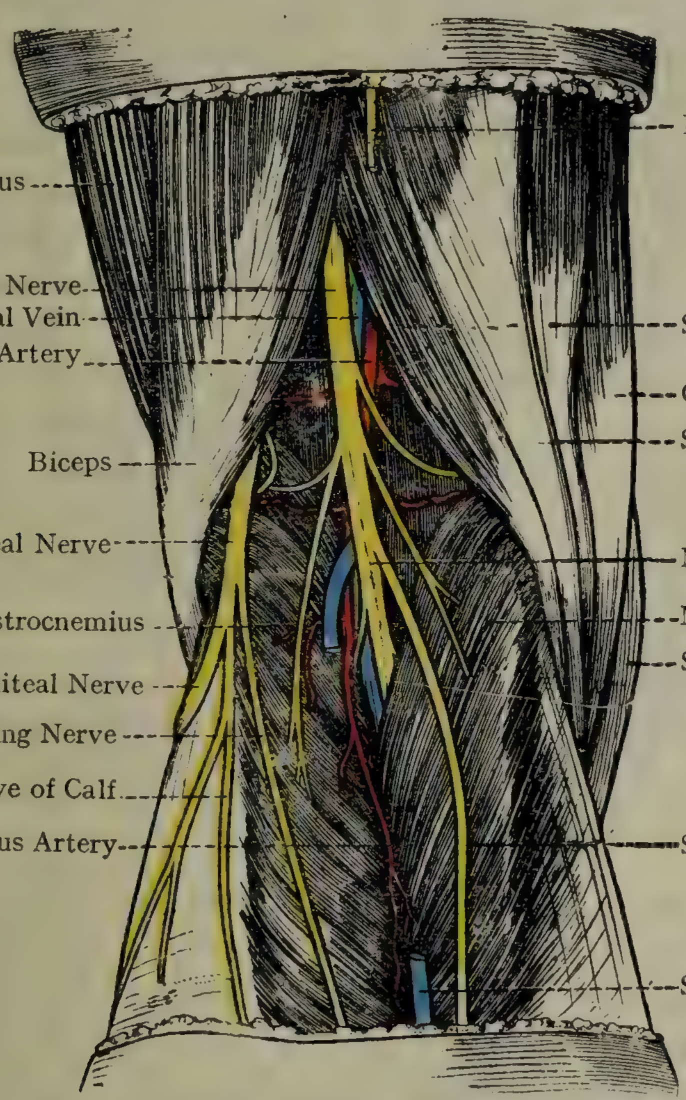


FIG. 335.—THE POPLITEAL SPACE (SUPERFICIAL DISSECTION).

The **popliteal fossa** (Fig. 335) is situated behind the knee-joint, whence it extends upwards on to the back of the thigh, and downwards to the upper part of the back of the leg. In outline the space resembles a diamond.

Boundaries—Lateral—*Above the Knee-joint.*—Biceps femoris. *Below the Knee-joint.*—The outer head of the gastrocnemius, and the plantaris.

Medial—*Above the Knee-joint.*—Semitendinosus and semimembranosus. *Below the Knee-joint.*—The inner head of the gastrocnemius.

The upper angle of the space corresponds with the point of di-

vergence of the hamstring muscles; the lower angle to the approximation of the outer and inner heads of the gastrocnemius; the outer angle to the meeting between the biceps femoris and lateral head of the gastrocnemius; and the medial angle by the meeting between the semimembranosus and medial head of the gastrocnemius.

The **roof** is formed by the skin, subcutaneous tissue, and popliteal fascia. It contains the posterior cutaneous nerve of the thigh.

The **floor** is formed, from above downwards, by the popliteal surface of the femur, the posterior ligament of the knee-joint, and the popliteus muscle.

Contents.—The contents are the popliteal artery and its branches, the popliteal vein and its tributaries, the medial and lateral popliteal nerves and their branches, the genicular branch of the obturator nerve (inconstant), lymphatic glands, and a large amount of fat.

The **popliteal artery** (Fig. 336) is the continuation of the femoral artery, and extends from the femoral opening in the adductor magnus to the lower border of the popliteus muscle, where it divides into anterior and posterior tibial arteries. The division takes place on a level with the lower border of the tubercle of the tibia, and fully $1\frac{3}{4}$ inches below the level of the upper surface of the bone. It first passes downwards and outwards until it reaches the middle line of the limb. It then takes a straight course downwards between the condyles of the femur, and finally disappears from view under cover of the gastrocnemius muscle.

In the popliteal fossa the popliteal artery is comparatively superficial, and can be easily approached from the surface. As the lower edge of the popliteus muscle is considerably below the level of the lower angle of the fossa the lower end of the vessel is deeply placed, being covered by the thick mass of the gastrocnemius muscle.

General Relations—*Superficial or Posterior.*—Skin, superficial and deep fasciæ, posterior cutaneous nerve of the thigh, terminal part of the short saphenous vein, the semimembranosus muscle for a short distance below the level at which the artery passes through the adductor magnus; the gastrocnemius and the plantaris lie superficially to the artery below the lower angle of the fossa. *Deep or Anterior.*—The popliteal surface of the femur, posterior ligament of the knee-joint and popliteus muscle.

In the *upper part* of the space the popliteal vein is superficial to, and on the outer side of, the artery, the medial popliteal nerve being superficial to, and on the outer side of, the vein. In the *middle* of the space the medial popliteal nerve is directly behind the artery, the popliteal vein intervening between them. In the *lower part* of the space the popliteal vein is behind and on the inner side of the artery, the medial popliteal nerve is behind and on the inner side of the vein, a relationship which is the reverse of that in the upper part of the space. The genicular branch of the obturator nerve (when present) traverses the adductor magnus, usually above, but sometimes through

the femoral opening, and descends behind and somewhat to the inner side of the popliteal artery; finally, the nerve leaves the main vessel

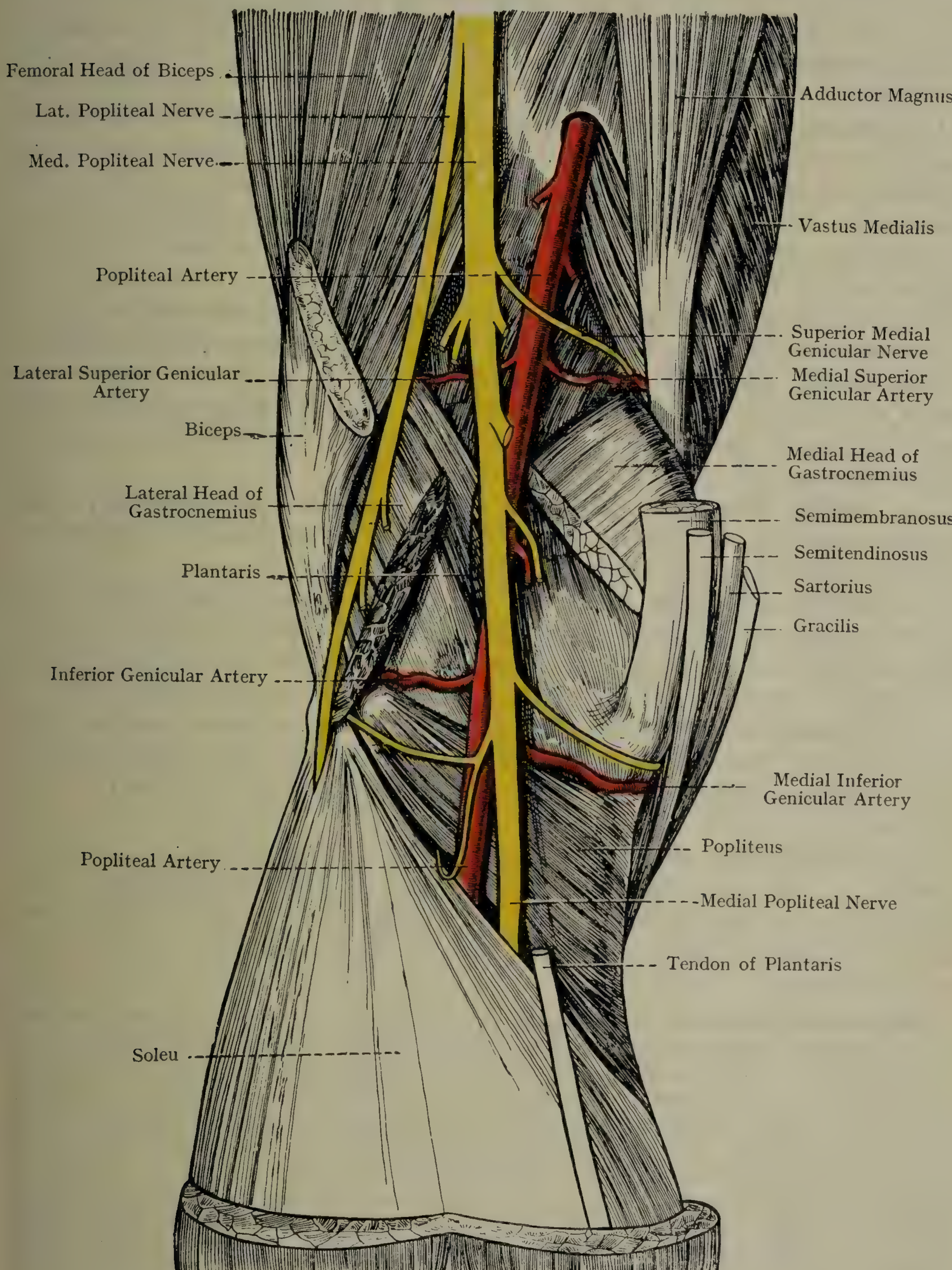


FIG. 336.—THE POPLITEAL SPACE (DEEP DISSECTION).

and passes into the knee-joint from behind, traversing the posterior ligament in company with the middle genicular artery.

Branches.—The branches are muscular, cutaneous, and genicular.

The **muscular branches** may be subdivided into two sets, superior and inferior. The *superior* are distributed to the lower parts of the hamstring muscles, and anastomose with the lower perforating branches of the profunda femoral artery. The *inferior* or *sural* supply the gastrocnemius, the plantaris, and the soleus.

The **cutaneous branches** supply the skin covering the popliteal fossa, and the upper part of the back of the leg. The largest and most constant, sometimes called the *sural cutaneous* artery, is given off close to the lower angle of the fossa, descends in the groove marking the junction of the two heads of the gastrocnemius, and is there a companion of the short saphenous vein.

The **genicular branches** (Fig. 336) are five in number—two superior, lateral and medial; one middle; and two inferior, lateral and medial.

The **lateral superior genicular artery** courses outwards above the lateral condyle of the femur, lies deeply to the biceps femoris, and passes through the lateral intermuscular septum into the vastus intermedius muscle.

The **medial superior genicular artery** courses inwards above the medial condyle of the femur, lies deeply to the tendon of the adductor magnus, and enters the vastus medialis.

The **middle genicular artery** is sometimes an independent branch, but often arises in common with the lateral superior genicular branch. It passes forwards through the posterior ligament of the knee-joint, and supplies the synovial membrane and ligaments within the joint.

The **lateral inferior genicular artery** at first courses horizontally outwards, and then forwards above the head of the fibula; it lies deeply to the tendon of the biceps and the lateral ligament of the knee-joint.

The **medial inferior genicular artery** is distinguished by its comparatively large size and oblique course. It passes downwards and inwards to gain the inferior aspect of the medial condyle of the tibia, whence it passes forwards, lying deeply to the medial ligament of the knee-joint.

Anastomosis about the Knee-Joint (Fig. 337).—The two superior and two inferior genicular arteries are given off above and below the joint respectively. Clinging closely to the bone in each instance, they all gain the front of the limb, and take part in an anastomosis about the patella; the two superior arteries communicate with one another above this bone, the two inferior below it. The anastomoses between these arteries are both superficial and deep. The superficial anastomosis between the two superior arteries lies in front of the tendon of the quadriceps femoris, that between the two inferior in front of the ligamentum patellæ. Small branches derived from these superficial anastomoses supply a fine network of vessels in front of the patella, 'the pre-patellar rete.' The deep anastomosis between the two superior arteries is on the deep aspect of the tendon of the quadriceps extensor, while that between the two inferior lies deeply to the ligamentum patellæ.

In addition, there are vertical anastomoses, either on the lateral aspects of the joint or close to the margins of the patella, whereby the two lateral genicular arteries on the one hand, and two medial on the other, communicate with each other. These extensive anastomoses between the articular arteries are supple-

mented by other arteries. The musculo-articular branch of the descending genicular (femoral) descends from above the joint, and joins the anastomosis above the patella; the descending branch of this artery joins the vertical anastomosis on the inner aspect of the knee. The descending branch of the lateral femoral circumflex usually ends by communicating with the lateral superior genicular. The anterior tibial recurrent artery ascends from below, and joins the anastomosis below the patella; on the back of the joint the posterior tibial recurrent artery joins the two inferior genicular arteries.

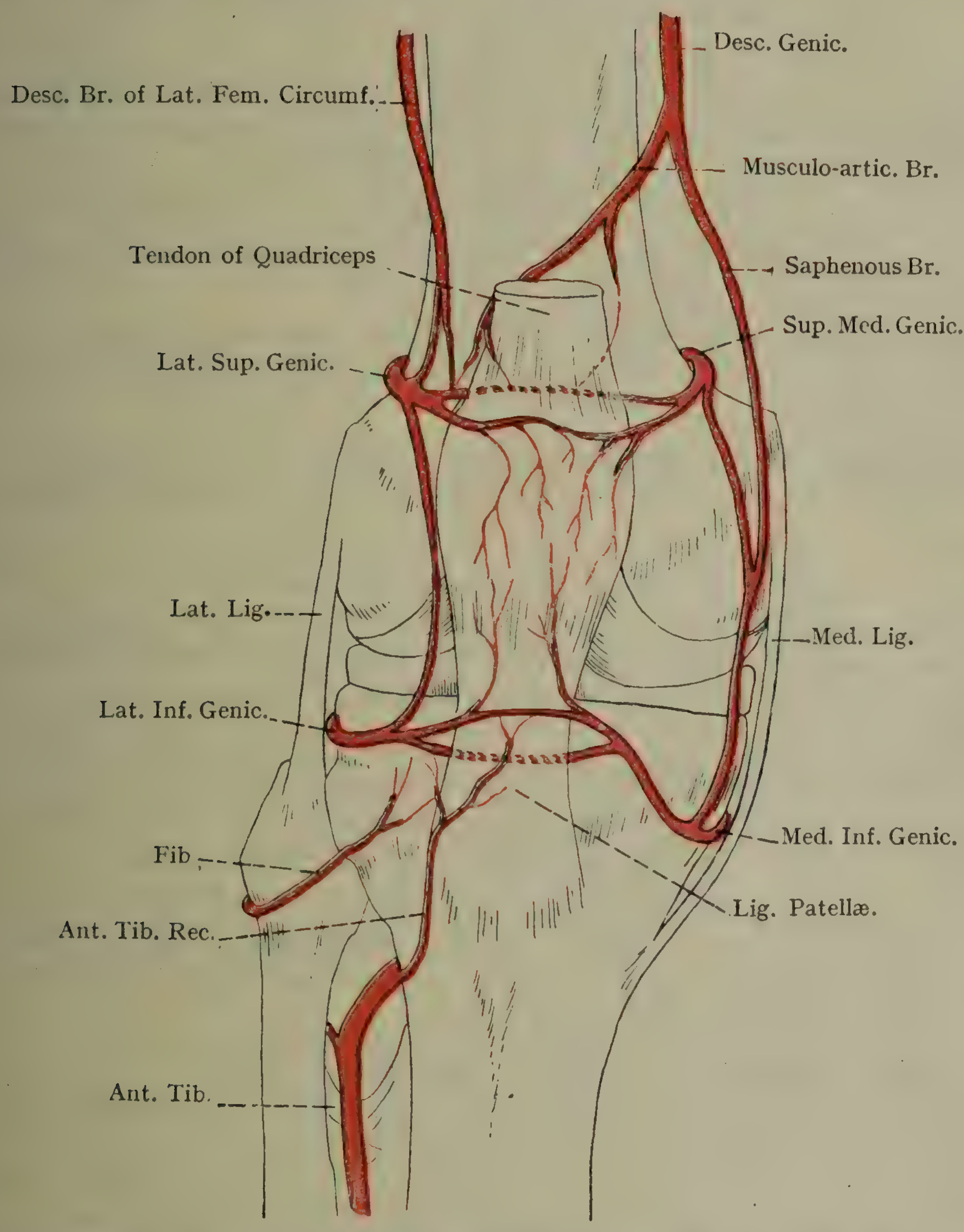


FIG. 337.—THE ANASTOMOSIS ABOUT THE KNEE-JOINT AS VIEWED FROM IN FRONT.

Varieties of Popliteal Artery.—The vessel may divide into the anterior and posterior tibial arteries at the upper border of the popliteus muscle.

The terminal branches may be three in number, the additional branch being the peroneal artery.

In very rare cases the popliteal artery divides high up into two trunks of equal size; the two re-unite prior to the normal termination of the vessel.

The **popliteal vein** commences at the lower border of the popliteus muscle, where it results from the junction of the venæ comites of the

anterior and posterior tibial arteries. It terminates at the femor opening in the adductor magnus, where it is continuous with tl femoral vein. Its tributaries correspond with the branches of tl popliteal artery, with, in addition, the short saphenous vein.

The **medial popliteal (tibial) nerve** (Fig. 336) is one of the termin branches of the sciatic; its fibres are derived from the fourth and fift lumbar, the first, second, and third sacral nerves. It extends fro the upper angle of the popliteal space to the lower border of the po liteus muscle, where it is continuous with the posterior tibial nerve.

Branches.—The branches are genicular, cutaneous, and muscular

The **genicular branches** are two or three in number: a *superi medial genicular* branch (inconstant) accompanies the medial superi genicular artery; a *middle genicular* (azygos) is a companion of tl corresponding artery; a *medial inferior genicular* accompanies tl medial inferior genicular artery.

The **sural nerve** descends in the middle line of the calf, and, aft traversing the deep fascia, is joined by the sural communicating ner from the lateral popliteal.

The **muscular (sural) branches** are usually five in number: one the outer head of the gastrocnemius, one to the plantaris (often comir off in common with the preceding), one to the inner head of the gastro nemius, one to the soleus which descends between the outer hea of the gastrocnemius and plantaris, and one to the popliteus. Tl **nerve to the popliteus** is deeply placed, and lies in close contact wit the muscle to the outer side of the popliteal vessels. It winds roun the lower border of the popliteus, and, taking a recurrent course, ente the deep surface of the muscle. In addition to supplying the popliteu it furnishes the following branches: *articular* to the superior tibi fibular joint; *vascular* to the anterior and posterior tibial arteries; ar *interosseous*, a long slender branch which, given off from the nerve it winds round the lower border of the popliteus muscle, descends c the interosseous membrane, supplies a *nutrient* twig to the tibia, ar ends in the inferior tibio-fibular joint.

The **lateral popliteal (common peroneal) nerve** (Fig. 336) is tl other terminal branch of the sciatic; its fibres are derived from tl fourth and fifth lumbar, and the first and second sacral nerves. commences at the upper angle of the popliteal space, and, descendir obliquely downwards and outwards, follows the tendon of the bicep It crosses the outer head of the gastrocnemius, and eventually, windir round the neck of the fibula under cover of the peroneus longus muscl gains the front of the limb, where it ends by dividing into the anteri tibial and musculo-cutaneous nerves.

Branches.—The branches are genicular, cutaneous, and termina

The **genicular branches** are three in number: a *superior lateral gen cular* branch accompanies the lateral superior genicular artery; a *inferior lateral genicular* branch accompanies the lateral inferior genicul artery; and a *recurrent genicular*, which, given off close to its terminatio accompanies the anterior tibial recurrent artery.

The **cutaneous branches** are two in number: the **lateral cutaneous nerve of calf,** given off at a higher level, supplies the skin on the outer side of the calf, and may descend as low as the lateral malleolus; the **sural communicating nerve,** given off at a lower level, varies very much in size, and, passing downwards and inwards over the outer head of the gastrocnemius, supplies branches to the skin of the calf, and, after traversing the deep fascia, joins the sural nerve.

The **terminal branches** are the **anterior tibial** (*q.v.*) and the **musculo-cutaneous** (*q.v.*).

The **popliteal lymphatic glands,** usually four in number, lie in close proximity to the popliteal artery, one being superficial to the vessel, one deeply to it, and the others being disposed one on either side of it. They receive afferent lymphatics from the following sources: the sole of the foot; the deep parts of the back of the leg; superficial lymphatics accompanying the short saphenous vein, and draining the outer side of the foot and the outer side and back of the leg; and two efferent lymphatics from the anterior tibial lymphatic gland, which lies on the front of the upper part of the interosseous membrane.

The efferent lymphatics of the popliteal glands accompany the main bloodvessels and end in the deep inguinal glands.

Front and Inner Side of the Thigh.

Landmarks—*Thigh.*—The **anterior superior spine of the ilium** is situated at the anterior extremity of the iliac crest, and can readily be felt. It is the point from which the length measurement of the lower limb is usually taken. The **inguinal (Poupart's) ligament** extends between the anterior superior iliac spine and the pubic tubercle. When the thigh is extended, abducted, and rotated outwards, it can be felt as a tense and somewhat curved band. Immediately below it the inguinal lymphatic glands may sometimes be felt. The inner end of the inguinal ligament marks the position of the **pubic tubercle,** which is situated at the lower and inner part of the anterior abdominal wall about $1\frac{1}{4}$ inches lateral to the upper limit of the symphysis pubis. If, as is sometimes the case, it is a sharp-pointed process, it can readily be felt beneath the skin. In most bodies, however, it is a more or less indistinct tubercle, and, especially in corpulent bodies, cannot be felt. In such cases the skin of the scrotum may be invaginated with the finger, whereby the fatty tissue is displaced from over the tubercle. If the pubic tubercle cannot be distinguished by this method, the thigh should be well abducted to render the adductor longus muscle prominent; the upper limit of the tendon of this muscle serves as a guide to its position, as it lies above and to its outer side. The pubic tubercle is the guide to the following openings: the **superficial inguinal ring** lies immediately above and to its outer side; the **femoral ring** is situated fully 1 inch lateral to the spine; situated on a line drawn horizontally outwards from the spine across the front of the thigh is the **saphenous opening,** which is below and slightly lateral to it.

The **pubic crest** extends inwards from the pubic spine for a distanc of about 1 inch, and ends in the **pubic angle.** The crest may be fe in the male if the skin of the back wall of the scrotum is invaginate and the little finger passed into the superficial abdominal ring, of whic the crest forms the lower limit. The spermatic cord may be fe descending over the pubic crest, and sometimes lies in front of th pubic tubercle. The pubic angle cannot usually be felt. The ischi pubic ramus can be felt as a bony ridge extending from the ischi tuberosity to the lower part of the symphysis pubis. The saphenou opening is situated below and lateral to the pubic tubercle, and extend downwards for about $1\frac{1}{2}$ inches below the inner part of the inguin ligament. At the lower extremity of the opening the superficial sul inguinal lymphatic glands may sometimes be felt. One inch belo the inguinal ligament, and a little to the outer side of its mid-poin the head of the femur may be felt.

The **greater trochanter** is situated about 4 inches below the anteri superior iliac spine, and about 4 inches behind a line let fall verticall from it. Its outline is more or less obscured by the muscles whic cover it, but the following guides may serve to localize it:

Holden's Guide.—In the recumbent position the top of the great trochanter is very nearly at the same level as the pubic tubercle.

Nélaton's Line.—This is a line drawn by stretching a tape fro the anterior superior iliac spine to the most prominent part of th ischial tuberosity. It passes over the top of the greater trochanter, an crosses the centre of the acetabulum.

Bryant's triangle is constructed as follows: A line is drawn horizontally bac wards from the anterior superior iliac spine and another vertically upwar from the top of the greater trochanter. These two lines are the sides of a triang of which the base is a line drawn from the anterior superior iliac spine to th top of the greater trochanter. The base line is used for estimating shorte ing of the neck of the femur. Should it be shorter than the correspondin line on the opposite side of the body, shortening of the femoral neck is i dicated.

The centre of the acetabulum is at the same horizontal level as th top of the greater trochanter.

The position of the **femoral (Scarpa's) triangle** is indicated by a sligh depression below the inguinal ligament. If the limb is forcibly at ducted, the outline of the adductor longus on the inner side of th thigh is made prominent, and its narrow rounded tendon of origin i readily felt at a point on the body of the pubis below and medial t the pubic tubercle. The rectus femoris is responsible for an elongate vertical prominence on the front of the thigh. The well-marke prominence over the lower fourth of the thigh on its inner aspect i caused by the vastus medialis muscle. When the knee is flexed, th narrow round **tendon of the adductor magnus** can be felt as it descends posterior to the vastus medialis, to reach the adductor tubercle on th upper aspect of the medial condyle of the femur.

Knee.—The outline of the **patella** and the ligamentum patellæ

›assing from the lower pointed end of the patella to the tubercle of :he tibia, can be easily identified.

The medial condyle of the femur is a large prominence projecting nwards. On its inner surface the blunt medial epicondyle is easily 'elt. When the knee-joint is flexed, the **adductor tubercle,** with the ıarrow round tendon of the adductor magnus inserted into it, can be 'elt at the upper and back part of the medial condyle. The upper ›order of the patellar surface of the femur may be felt when the knee-oint is flexed, but it is somewhat obscured by the tendon of the quadriceps femoris. It is obliquely disposed, being at a higher level laterally :han medially. The adductor tubercle is on the same level as the ›uter part of the upper border of the patellar surface. A line conıecting these two points indicates the line of junction of the lower ›piphysis of the femur with the shaft, the junction occurring at the :wentieth year. The lateral condyle of the femur is much less ›rominent than the medial. Below the lateral femoral condyle the ateral epicondyle of the tibia is a marked prominence at the outer ınd anterior part of the knee-joint, and presents a ridge to which the lio-tibial tract of the fascia lata is attached. The head of the fibula is ›asily felt below and behind the lateral condyle of the tibia. The **tubercle of the tibia** can be felt at the upper end of the sharp anterior border or crest of the bone. Its upper border is on the same level as the upper part of the head of the fibula. It is to be noted that the medial condyle of the tibia has a slight inclination backwards as well as inwards.

The lower limit of the **synovial membrane** of the knee-joint corresponds with the level of the ridge on the anterior and outer part of the lateral condyle of the tibia; this ridge serves for the attachment of the ilio-tibial tract of the fascia lata. If this ridge cannot be identified, a transverse line just above the head of the fibula indicates the lower limit of the membrane. The synovial membrane clothes the upper half of the posterior surface of the ligamentum patellæ. Behind the lower end of this ligament a bursa intervenes between it and the upper smooth part of the tubercle of the tibia. Superiorly the synovial membrane extends upwards above the patella in the form of a large pouch upon the front of the femur for about 2 inches above the upper border of the patellar surface of the bone. This pouch lies deeply to the tendon of the quadriceps femoris, and communicates with a bursa situated immediately above it, this bursa extending upwards for about another inch.

In extension of the knee-joint the patella is situated above the level of the condyles of the femur. In flexion it lies over the intercondylar notch. In extreme flexion the patella articulates chiefly with the semilunar impression on the outer part of the tibial surface of the medial condyle of the femur, close to the intercondylar notch. The particular part of the patella which thus articulates is the inner vertical zone on its posterior surface immediately adjoining the medial border. In flexion of the joint there is a depression on either side of the ligamentum

patellæ, and also on either side of the patella itself, the latter depressio being deeper on the inner than on the outer side. In this position the joint the anterior margin of each tibial condyle is readily felt, an above each is a hollow which separates it from the correspondi femoral condyle. In extension of the joint the depression on eith side of the patella is also manifest, being, as in flexion, deeper on i inner side. The depression on either side of the ligamentum patell however, is not present, this being due to the lateral dispersion of t fat, which is under cover of the ligamentum patellæ in extension.

The **superficial fascia** is, for about 3 inches below the inguinal lig ment, artificially divisible into two layers—subcutaneous and dee The subcutaneous layer is fatty, and, when traced upwards, is co tinuous with the superficial fascia on the anterior abdominal wa The deep layer is a very delicate membrane, best seen on the inn side of and deep to the long saphenous vein, this vessel lying betwee it and the subcutaneous layer. When traced upwards, it is found blend with the fascia lata a short distance below the inguinal ligamen

The **prepatellar subcutaneous bursa** is a large bursa in the su cutaneous tissue covering the front of the patella.

Cutaneous Nerves (Fig. 338)—**The Femoral Branch of the Genit femoral Nerve.**—The genito-femoral nerve is a branch of the lumb plexus, its fibres being derived from the first and second lumbar nerve Its **femoral branch** passes downwards to the thigh, behind the inguin ligament, superficial to the femoral artery, and embedded in the femor sheath. It supplies a twig to the artery, and, traversing the femor sheath and the fascia lata, is distributed to the skin covering th femoral triangle.

The **ilio-inguinal nerve** is a branch of the lumbar plexus, its fibre being derived from the first lumbar nerve. It escapes from the inguin canal through the superficial inguinal ring, where it lies directly t the outer side of the spermatic cord or round ligament of the uteru according to the sex. Having traversed the intercolumnar fascia, i descends, and is distributed to the skin on the upper part of the inne side of the thigh, and to the adjacent skin of the scrotum in the mal and of the labium majus in the female.

The **lateral cutaneous nerve of thigh** is a branch of the lumbar plexu being derived from the second and third lumbar nerves. It descend into the thigh behind the outer end of the inguinal ligament, and divide into two branches, a small posterior and a large anterior. The *posterio* branch is distributed to the skin of the upper part of the outer side o the thigh, and also to the skin of the outer and lower part of the glutea region. The *anterior* branch traverses the fascia lata at a lower level and supplies the skin on the outer side of the thigh, extending down wards as low as the knee. It occasionally sends a twig to the patella plexus.

The position of the lateral cutaneous nerve as it passes into the thigh is ver inconstant. It may be close to the anterior superior iliac spine or at a variabl distance to its inner side.

The **intermediate cutaneous nerve** is represented by two or three branches of the femoral nerve, which pierce the fascia lata about

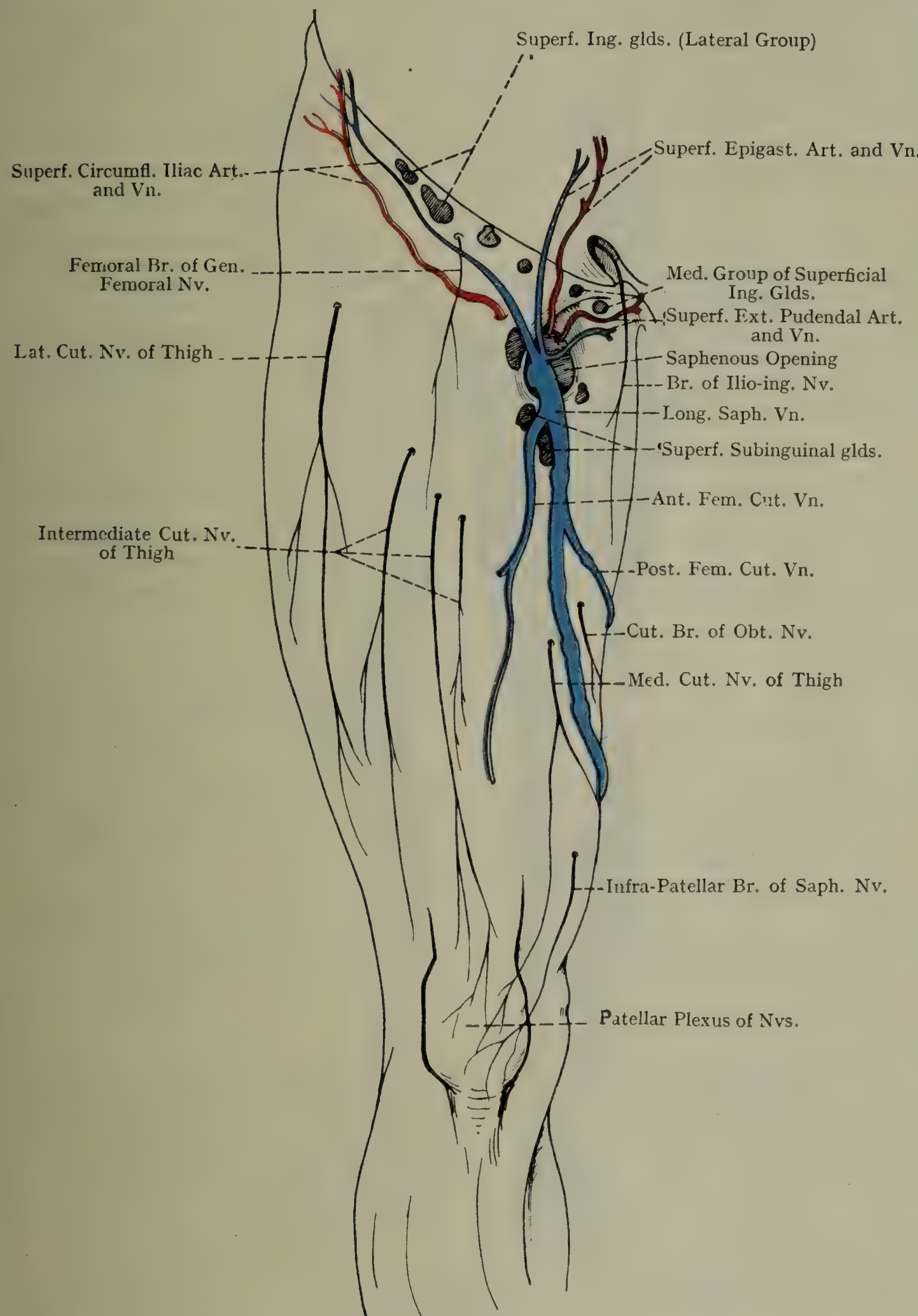


Fig. 338.—The Subcutaneous Vessels, Nerves, and Lymphatic Glands on the Front of the Thigh.

4 inches below the inguinal ligament. One and sometimes two branches pass through the upper part of the sartorius. They supply the skin of

the front of the thigh in the lower two-thirds, extend downwards t the knee, and end by taking part in the formation of the patella plexus.

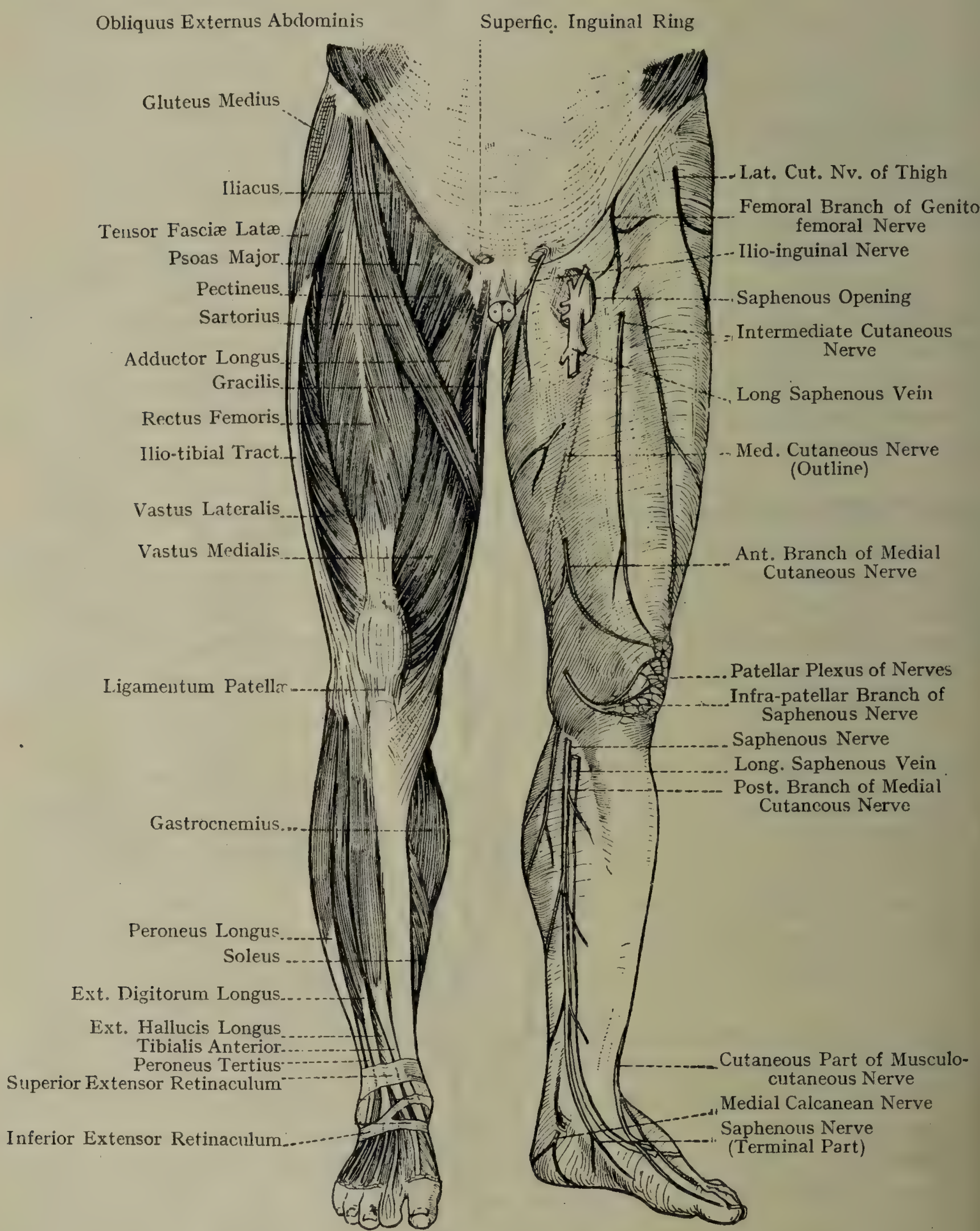


FIG. 339.—MUSCLES AND CUTANEOUS NERVES OF THE LOWER LIMB (ANTERIOR ASPECT).

The **medial cutaneous nerve** is also a branch of the anterior femoral It crosses the femoral artery superficially, and from without inwards near the apex of the femoral triangle. It usually divides into two

anches, anterior and posterior. The two branches descend on the ıer side of the thigh deep to the fascia lata, and correspond in position the long saphenous vein. At the junction of the middle and lower irds of the thigh the *anterior* branch traverses the fascia lata, and, scending to the inner side of the knee-joint, supplies the skin of the ıer side of the thigh in its lower third. It finally passes outwards to the patella, and ends in the patellar plexus. The *posterior* branch lows the posterior border of the sartorius, and traverses the fascia :a at the level of the medial condyle of the femur. It descends on e inner side of the knee, lies behind the long saphenous nerve, and pplies the skin of the inner side of the leg. The medial cutaneous rve gives off two or three cutaneous branches in the femoral triangle. ıese branches cross the femoral artery superficially, and are disibuted to the skin of the inner side of the thigh in its middle third. ıe posterior branch of the nerve gives a branch to the subsartorial exus.

The **saphenous nerve** (Fig. 349) is a branch of the femoral nerve. ı the lower part of the femoral triangle it lies close to the outer side the femoral artery, and thence descends into the subsartorial Iunter's) canal with the artery, which it crosses superficially and from ithout inwards. It escapes from the lower end of the subsartorial ınal by traversing its roof in company with the saphenous branch of ıe descending genicular artery, with which it descends at the hinder lge of the sartorius to the inner side of the knee. From the knee it ısses downwards to the inner side of the leg, and divides into two :anches, which accompany the long saphenous vein, the larger branch ing behind the vein and the smaller in front. At the ankle the larger ranch passes downwards in front of the medial malleolus, and gains ıe inner side of the foot, along which it courses as far as the metatarsoıalangeal joint of the great toe. In the subsartorial canal the saphe- ɔus nerve gives a branch to the subsartorial plexus. In the lower ırt of the thigh it gives off an *infrapatellar branch*, which traverses the ırtorius, supplies the skin on the front of the knee, and ends by joining ıe patellar plexus.

Below the knee-joint the nerve distributes branches to the skin f the inner side of the leg and of the inner side of the foot. In the pper part of the leg it communicates with the posterior branch of ıe medial cutaneous nerve, and on the inner side of the foot with the ıusculo-cutaneous.

Obturator Nerve.—The anterior division of the obturator nerve sually furnishes a branch, which, becoming superficial about the ıiddle of the thigh, between the posterior border of the sartorius and ıe anterior border of the gracilis, is distributed to the skin on the ıner aspect of the thigh for a variable extent.

The **patellar plexus** (Fig. 338) is a network of fine nerves on the :ont of the patella. The nerves which contribute branches to it are he infrapatellar branch of the saphenous; branches of the intermediate utaneous; the anterior branch of the medial cutaneous; and occasion-

ally the lateral cutaneous. Branches from the patellar plexus pas downwards, and supply the skin below the patella.

The **subsartorial plexus** (Fig. 349) is situated about the middle thir of the thigh, and lies deeply to the sartorius as this muscle forms th roof of the subsartorial canal. The nerves contributing branches t it are the saphenous; the posterior division of the medial cutaneous and the superficial or anterior division of the obturator. The branche of the plexus are distributed to the skin on the inner side of the thig for a variable distance.

The branches of the subsartorial plexus distributed to the skin are mainl derived from the obturator nerve. These branches may extend downward below the knee, and supply the skin on the inner aspect of the leg.

Lymphatic Glands.—The largest, the most important, and the mos numerous lymphatic glands of the lower limb occupy the upper end o the front of the thigh, and are known as the **inguinal glands.** The are arranged in two groups, superficial and deep. The superficia glands are embedded in the superficial fascia; the deep are dispose about the femoral vessels, and are therefore situated deeply to th plane of the deep fascia.

The **superficial inguinal glands** (Fig. 338) vary in number fron twelve to twenty. They are arranged in two sets. A *lateral* set sometimes known as the *superficial inguinal glands proper*, are paralle to and slightly below the inguinal ligament. The lowest or mos medial of these glands are disposed about the superficial externa pudendal artery, and are known as the *pubic glands*. The *lower* set the *superficial subinguinal glands*, are found in the region of the cribriform fascia and on either side of the upper end of the long saphenou vein. The largest and most constant of these glands occupies the angl of junction between the anterior femoral cutaneous vein and the long saphenous vein.

The *afferent vessels* to the superficial inguinal glands are the superficia lymphatics draining the greater part of the lower limb, the anterior abdomina wall below the level of the umbilicus, the gluteal region, the perineum and th anus, the scrotum and penis in the male, the labium majus and prepuce of th clitoris in the female. The chief superficial lymphatics of the lower limb follow the long saphenous vein. They receive tributaries draining the outer part o the foot, the front and inner side of the leg, and the front and back of the thigh. They join the subinguinal glands. Some of the superficial lymphatics draining the outer side of the thigh join the upper lateral group of superficial inguinal. The superficial lymphatics of the buttock wind round the outer side of the hip, and join the upper glands of the lateral group. The superficial lymphatics draining the anterior abdominal wall course downwards to the lateral group o superficial inguinal; many of them follow the superficial epigastric vessels. The superficial lymphatics of the genital organs, the perineum, and the anus mostly join the medial group of superficial inguinal glands.

The *efferent vessels* converge to the saphenous opening, where they traverse the cribriform fascia. Some of them join the deep inguinal glands, others pass upwards through the femoral canal and join the external iliac glands.

The **deep inguinal glands**, much less umerous than the superficial, are two or hree in number. They lie to the inner ide of the upper end of the femoral vein.)ne of them (Cloquet's gland) usually ccupies the femoral canal.

Their *afferent vessels* drain the deep parts of he lower limbs, the deep lymphatics of which ccompany the main arteries. They are also oined by the lymphatics of the glans penis in he male and of the clitoris in the female, and eceive some of the efferent vessels of the uperficial inguinal glands.

The **efferent vessels** pass upwards hrough the femoral canal and join the xternal iliac glands.

The **long saphenous vein** (Fig. 340) rises from the inner end of the venous rch on the dorsum of the foot. It passes ipwards in front of the medial malleolus ınd on the inner side of the leg, where it ies about a finger's breadth behind the nedial border of the tibia. From the leg t passes to the inner side of the knee, vhere it lies behind the most prominent art of the medial condyle of the femur. From the knee it ascends to the inner side of the thigh, following the hinder edge of the sartorius more or less closely. Towards the upper end of the thigh it nclines to the front of the limb, and at a oint about $1\frac{1}{2}$ inches below the inguinal igament it passes backwards, traverses he cribriform fascia occupying the saphe-ıous opening and the anterior wall of the emoral sheath; it finally ends by joining he femoral vein. The vein is contained n the superficial fascia for its whole xtent, and receives many tributaries rom the front and inner side of the leg ınd from the thigh; it has numerous ommunications with the deep veins of he leg. Two large tributaries joining its ıpper end are fairly constant. One, the *anterior femoral cutaneous*, collects the blood from the front of the thigh; the other, the *posterior femoral cutaneous*, drains the inner and back parts of the thigh.

FIG. 340.—THE LONG SAPHENOUS VEIN AND ITS TRIBUTARIES.

The anterior femoral cutaneous vein is of particular importance, as it cross the apex of the femoral triangle, where it lies directly in front of the femor artery, and is liable to be cut when this vessel is exposed.

As it traverses the cribriform fascia the long saphenous vein receiv the superficial circumflex iliac, the superficial epigastric, and the supe ficial external pudendal veins; these three superficial veins often joi together to form a common trunk. The long saphenous vein is sai to have about fifteen valves; but in most cases they are much le numerous. One valve is found in the vein just before it traverses th cribriform fascia, and another at its opening into the femoral vein.

The vein is occasionally double in the femoral part of its course. This due to the vein dividing into two trunks shortly after it enters the thigh. Th two ascend close together and unite to form one trunk close to the saphenou opening.

The **deep fascia** or **fascia lata** is a dense fibrous membrane ensheath ing the muscles of the thigh like a stocking. *Above* it is attached behind to the sacrum and coccyx; laterally to the outer lip of the ilia crest, and between them is continuous with the lumbar fascia; in fron to the inguinal ligament and the pubic crest; and medially to the bod of the pubis, the ischio-pubic ramus, the ischial tuberosity, and th sacro-tuberous ligament. *Below* it is attached, on the outer side of th knee, to the head of the fibula and lateral condyle of the tibia; in fron to the lateral borders of the patella, and here takes part in formin the lateral patellar ligaments; it clothes the front of the patella, an between it and the bone is a subfascial prepatellar bursa; behind i helps to form the roof of the popliteal fossa, being continuous belov this space with the deep fascia investing the calf; on the inner side o the knee it is attached to the medial condyle of the tibia.

Some of the fibres of the fascia lata have a circular disposition, other are directed longitudinally. It is interrupted by a large number o minute holes giving passage to bloodvessels and nerves. The fascia i stronger and thicker on the outer side of the thigh, where it give attachment to a large part of the gluteus maximus and to the tenso fasciæ latæ. It is also strong on the front of the knee on either side of the patella, where it blends with tendinous expansions from the quadriceps femoris muscle to form the lateral patellar ligaments.

A band-like thickening on the outer side of the thigh, extending between the tuberosity of the iliac crest above and the lateral tibial condyle and the head of the fibula below, is known as the **ilio-tibial tract.** At the attachment of the tensor fasciæ latæ, it is continuous with a deep fascial layer, which passes upwards on the deep surface of the muscle, and is attached above to the floor of a groove on the gluteal surface of ilium immediately above the margin of the acetabulum. To this groove the reflected head of the rectus femoris muscle is attached. This deep fascial layer is intimately connected with the capsular ligament of the hip-joint and the tendon of the gluteus minimus.

Cribriform Fascia.—On the front of the upper part of the thigh, a ittle way below the inner part of the inguinal ligament, is a some-vhat oval area, where the character of the fascia lata is profoundly nodified. Instead of being dense and membranous it is loose and atty, presenting the characteristics of the superficial fascia rather han those of the deep. Further, it is interrupted by numerous holes or passages for the transmission of vessels, and on this account is known is the cribriform fascia. The vessels traversing the cribriform fascia ire the long saphenous vein, the superficial branches of the femoral irtery with the exception of the superficial circumflex iliac, which isually passes through the fascia lata above and to its outer side, the veins accompanying these arteries, and the efferent vessels of the super-icial inguinal glands.

The cribriform fascia being relatively loose and non-resistant, the vessels raversing it are not pressed up, and the flow of fluid through them hindered or stopped, as would be the case were the fascia lata in this situation dense and esistant. This resistance is increased when the fascia lata is put on the stretch oy the contraction of the thigh muscles.

Saphenous Opening (Fig. 341).—If the cribriform fascia be removed, a deficiency or opening in the fascia lata, the saphenous opening, is artificially defined and the femoral sheath containing the femoral vessels is exposed. The opening is oval in outline, and although the upper, outer, and lower margins are well defined, the inner margin is indistinct. The part of the fascia lata lying to the outer side of the saphenous opening is known as the *iliac portion*, while that on the inner side is distinguished as the *pubic portion*. The iliac portion is attached above to the whole length of the inguinal ligament, and at the outer limit of the saphenous opening has a well-defined free edge, the *falciform border*. The falciform border arches upwards and inwards to the pubic tubercle as the *superior cornu*, which forms the upper margin of the opening, while its lower end is continuous with a crescentic edge, the *inferior cornu*, which forms the lower limit of the opening, occupies the angle of junction between the long saphenous vein and the femoral vein, and merges medially with the pubic portion. The pubic portion is continuous with the iliac portion below the saphenous opening, but when traced upwards is found to cling to the pectineus muscle, and with that muscle lies deeply to the femoral sheath containing the femoral vessels. Above it is attached

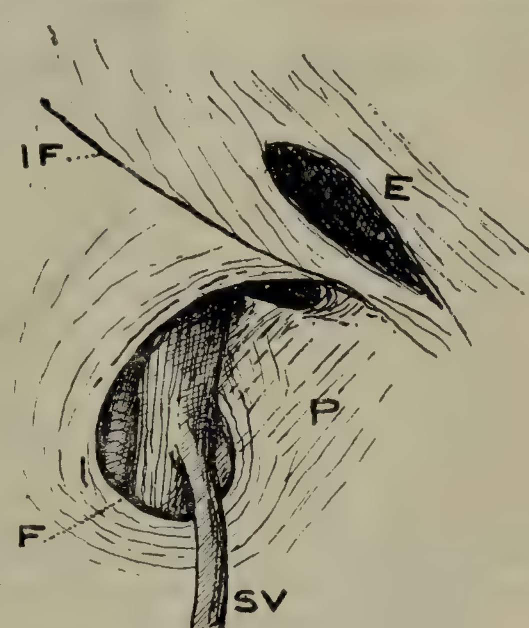


Fig. 341.—Diagram to show Formation of Saphenous Opening.

IF, medial part of inguinal ligament; E, external inguinal ring; P, fascia over pectineus; F, falciform edge; SV, saphenous vein opening into femoral vein. Femoral sheath not shown.

to the pectineal line, which marks the upper limit of the origin of t pectineus.

From the foregoing description it will be realized that, although the ili and pubic portions of the fascia lata are continuous with one another, and a disposed in the same plane below the saphenous opening, yet when trac upwards they occupy different planes. The iliac portion as it arches inwar above the saphenous opening lies in front of the femoral sheath containing t femoral vessels, while the pubic portion clinging to the pectineus lies behind t femoral sheath.

Intermuscular Septa (Fig. 342).—Adherent to or continuous wi the deep surface of the fascia lata ensheathing the thigh are thr

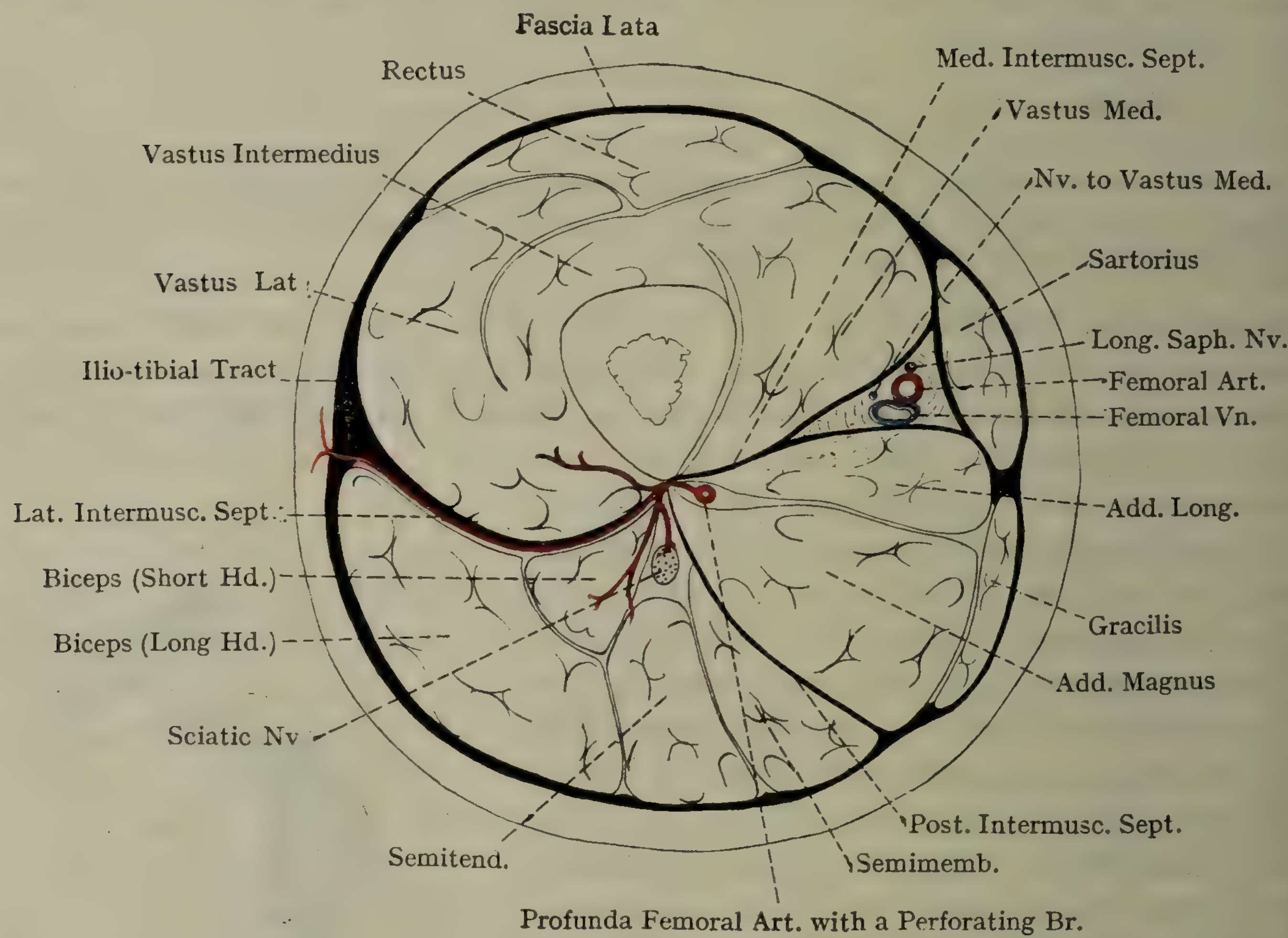


FIG. 342.—A SEMIDIAGRAMMATIC SECTION THROUGH THE MIDDLE OF THE THIGI ILLUSTRATING THE DISPOSITION OF THE THREE INTERMUSCULAR SEPT THE BOUNDARIES AND CONTENTS OF THE SUBSARTORIAL CANAL, AND TH COURSE AND DISTRIBUTION OF A PERFORATING ARTERY.

intermuscular septa, which occupy the intervals between the chie muscle groups and are attached deeply to the linea aspera of th femur. The three septa, together with the fascia lata, form the wall of three compartments containing the three muscle groups of the thigh the extensors, the adductors, and the flexors respectively. A *latera septum*, strong and well marked, intervenes between the extensor and flexors. A *medial septum*, relatively weak, separates the extensor from the adductors. A *posterior* or *postero-medial*, the weakest an least distinct of the three, lies between the adductors and flexors.

It is convenient to remember that the three muscle groups occupying th three fascial compartments of the thigh have independent nerve-supplies, th

xtensors being supplied by the femoral, the adductors by the obturator, and ıe flexors by the sciatic.

The Femoral (Scarpa's) Triangle.—When the fascia lata is removed rom the front of the upper part of the thigh, a space known as the emoral triangle is exposed. This space is of great surgical importance, s the main vessels of the limb contained therein are very superficially isposed, and are easily approached from the surface.

Boundaries of the Femoral Triangle.—The base of the triangle is bove, and is formed by the inguinal ligament. Of the two sides of he triangle, the lateral one is formed by the medial edge of the sarorius. This muscle crosses the front of the thigh obliquely as it passes rom the anterior superior iliac spine, above and to the outer side, to he inner aspect of the thigh below. The medial side is formed by the dge of the adductor longus. This muscle is attached above to the ubis close to the extremity of the inguinal ligament, inclines obliquely lownwards and laterally, and finally disappears under cover of the artorius. The lower limit, or apex of the space, is the point where he sartorius, lying superficially, crosses the more deeply placed lateral dge of the adductor longus.

Floor of the Femoral Triangle.—The lateral part of the floor is occuɔied by the ilio-psoas, which results from the fusion of the iliacus and ɔsoas muscles; a groove indicates the junction of the broader muscular liacus with the narrower more tendinous psoas lying to its medial side. The medial part of the floor is formed by the pectineus muscle.

The femoral triangle, as originally defined by Scarpa, was the space bounded on either side by the sartorius and the adductor longus muscles. The inner ɔoundary of the space has been variously interpreted by anatomists as the 'most ɔrojecting part of the adductor longus,' or 'its inner margin.' The most proecting part of the adductor longus is very ill defined, especially in the dissected ubject; if the inner margin of the muscle is adopted, it carries the space downvards into the thigh for some considerable distance, and thus serves no useful ɔurpose; further, the level at which the inner margins of the sartorius and ıdductor longus meet is exceedingly variable. The outer margin of the adductor ongus has been adopted in this work as the inner boundary of the femoral triangle, ıs it more accurately delimits the space in which the main artery of the limb is uperficially disposed on the front of the thigh. The adductor brevis muscle is ometimes stated to be one of the muscles in the floor of the triangle. It is true hat in an ill-developed subject the adjoining edges of the pectineus and adductor ongus are not in direct approximation, and the adductor brevis may be seen in he narrow interval between the two. As the adductor brevis, however, is on ın altogether different and deeper plane to that of the other muscles forming the loor of the triangle, and does not come into direct relationship with any of its ɔccupants, it has been omitted in the foregoing description.

Contents of the Triangle—The Femoral Vessels.—The femoral artery nay be said to bisect the triangle. It extends vertically downwards rom behind the mid-point of the inguinal ligament above to the apex of the space below, where it disappears under cover of the sartorius. Several branches are given off from the artery, including the three superficial branches (Figs. 338, 343), and other branches which will be lescribed later. Immediately below the inguinal ligament the femoral

vein lies to the inner side of and on the same plane as the artery, bu it inclines outwards and occupies a deeper plane towards the lower en of the triangle, at the apex of which it lies behind the artery. *Lym phatic Glands.*—The deep inguinal glands, two or three in number, ar disposed to the inner side of the femoral vein. They receive the dee lymphatic vessels of the limb coursing upwards with the femoral arter and efferent vessels from the superficial inguinal glands. Their efferen vessels, together with some of the efferent vessels from the superficia

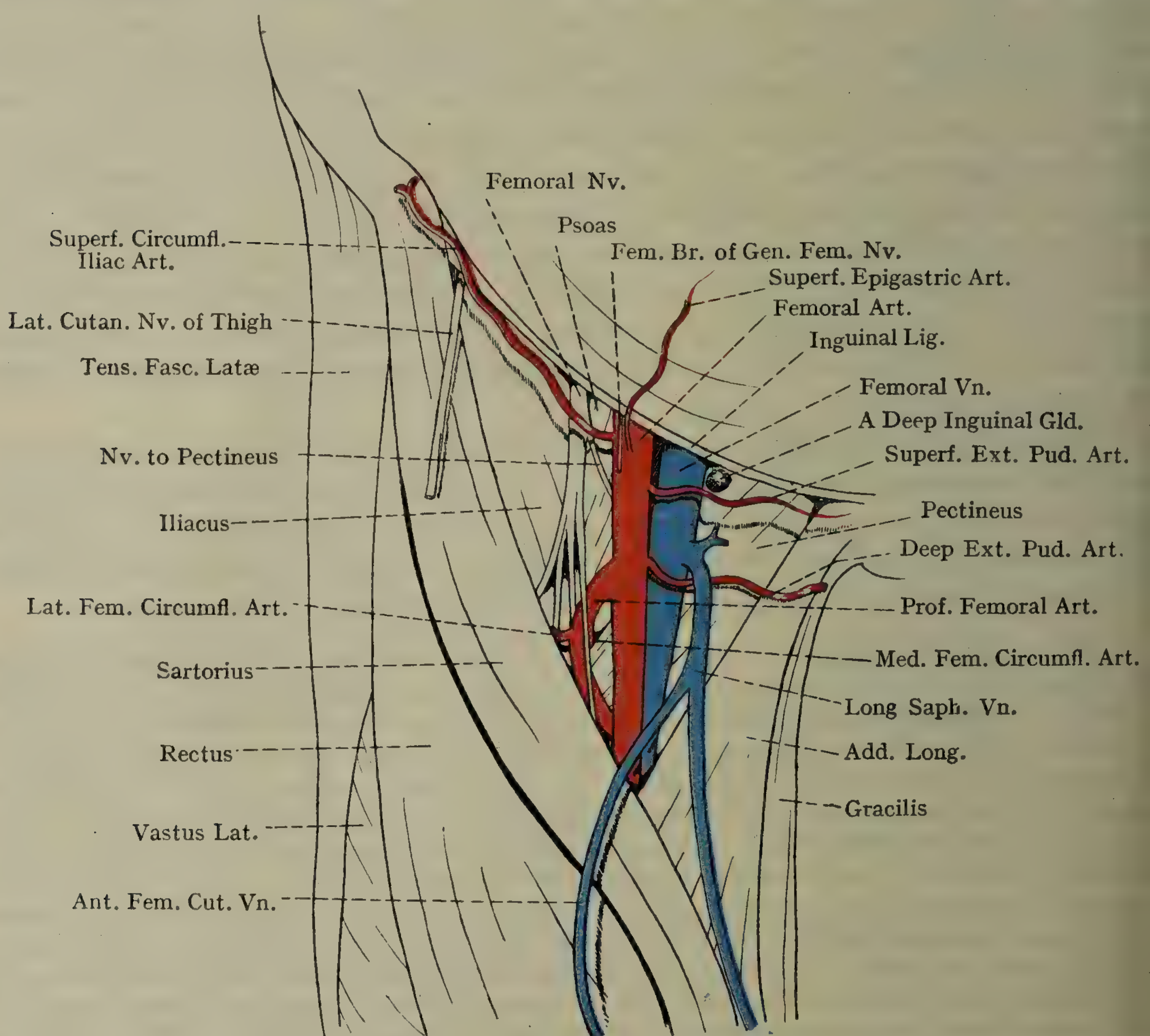
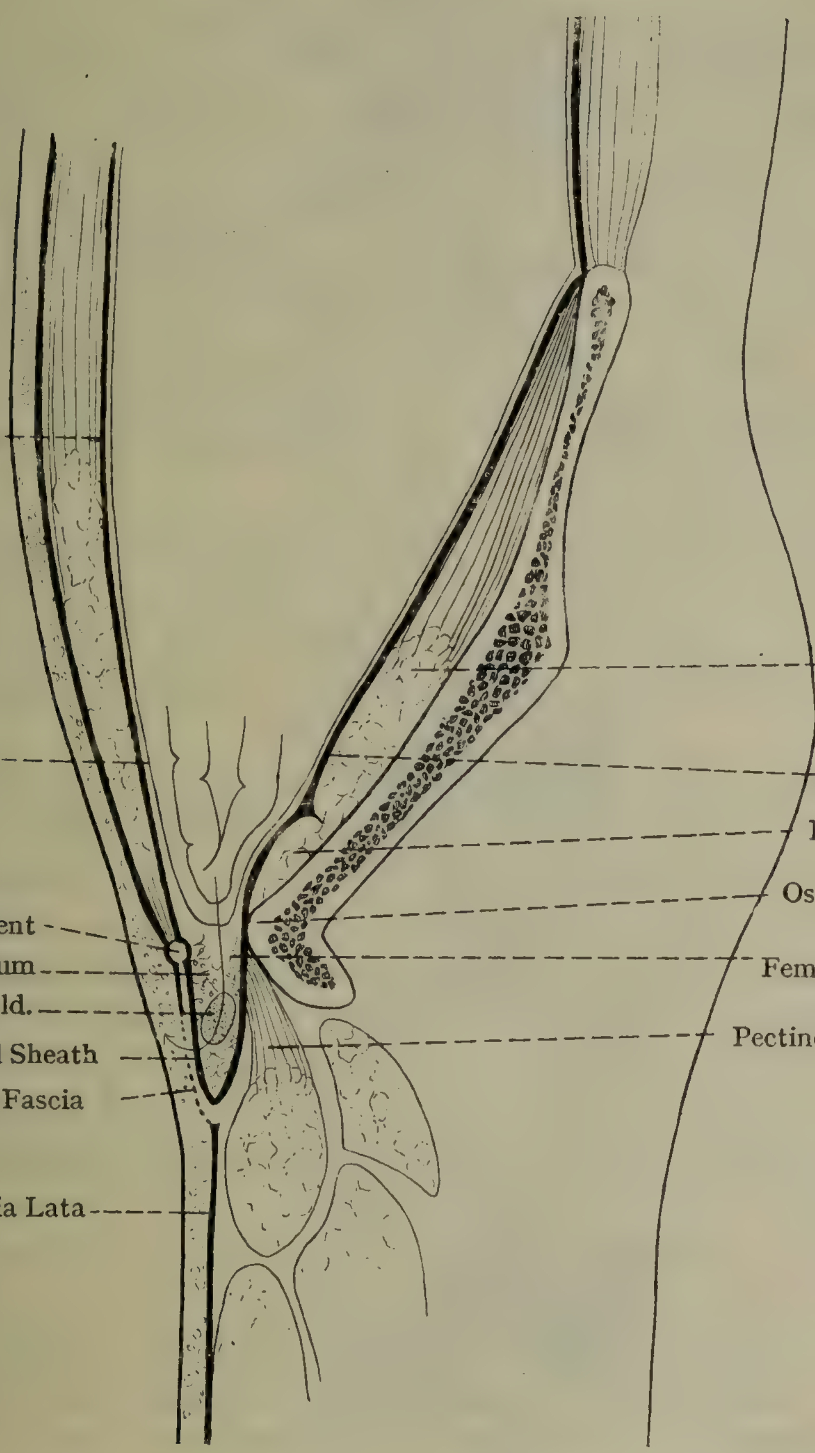


FIG. 343.—THE FEMORAL (SCARPA'S) TRIANGLE AND ITS CONTENTS.
For the sake of simplicity the branches of the femoral nerve are not all indicated

glands, pass upwards on the inner side of the femoral vein into th abdominal cavity, where they join the external iliac glands. *Th nerves* are three in number. Occupying the upper and outer angle i the lateral cutaneous nerve of thigh. This nerve passes into the thig from behind the outer extremity of the inguinal ligament, where it lie to the inner side and below the anterior superior iliac spine; it is usuall contained in the space for a very short distance only.

The position of the lateral cutaneous nerve of thigh is very variable; it may b found at any point between the anterior superior iliac spine laterally and th femoral nerve medially.

The femoral is a large nerve which lies on the outer side of the moral artery, a small part of the psoas intervening between them. occupies the groove indicating the junction of the iliacus and psoas uscles, and a short distance below the inguinal ligament subdivides to a sheaf of branches. The femoral branch of the genito-femoral,



IG. 344.—A Diagrammatic Section through the Femoral Canal and Lower Part of Abdominal Cavity, illustrating the Relations of the Femoral Canal and Femoral Ring.

The path of a femoral hernia is indicated by an arrow.

fter escaping into the thigh from behind the inguinal ligament, lies in ont of and somewhat to the outer side of the femoral artery.

The Femoral Sheath.—After removal of the fascia lata, the femoral essels in the upper part of the femoral triangle do not at once come ito view, as they are completely surrounded by a bag-like investment f fibrous tissue, the femoral sheath. The femoral sheath is prolonged

upwards behind the inguinal ligament, and is continuous above w the fascial lining of the abdominal cavity. Its anterior wall, lying front of the femoral vessels, is continuous with the fascia lining t deep aspect of the anterior abdominal wall or fascia transversalis, wh its posterior layer, which lies behind the femoral vessels, is continuc with the fascia lining the posterior abdominal wall or fascia ilia (Fig. 344). The femoral sheath blends below with the connecti tissue walls of the femoral vessels, to which it is closely adherent.

Femoral Canal.—Extending between the front and back walls the sheath are two septa which subdivide it into three compartmen The outer or arterial compartment is occupied by the femoral artery; t middle or venous compartment by the femoral vein; the inner co partment contains loose fatty connective tissue, may lodge one of t deep inguinal glands (Cloquet's gland), and transmits the lympha vessels conveying lymph from the inguinal glands to the exterr iliac glands. It is essentially the lymphatic compartment, and known as the femoral (crural) canal.

The femoral canal is closed below by the blending of the femo sheath with the walls of the femoral vessels; on its outer side is t septum between it and the femoral vein, and on the inner side it limited by the continuity of the anterior and posterior walls of t femoral sheath.

Femoral Ring.—The upper end or mouth of the femoral canal, the level where the sac of the femoral sheath opens out to becor continuous with the fascia lining the abdominal cavity, is known the femoral ring. It is somewhat oval in outline, is relatively larg in the male than the female, and has very important relations. front is the inguinal ligament, sometimes termed the superficial crur arch, deep to which are some transverse fibres adherent to and thicke ing the anterior wall of the femoral sheath, and known as the de crural arch. In close proximity to the inguinal ligament is the inferi epigastric artery. Behind is the pubis covered by a comparative thin layer of the pectineus muscle. To the outer side is the upp end of the femoral vein, and on the inner side it is adherent to t sharp resistant concave edge of the pectineal part of the inguinal lig ment, a deep, somewhat triangular reflection extending backwar from the deep aspect of the inner extremity of the inguinal ligame to the pectineal line.

Abnormal Obturator Artery (Fig. 345).—The obturator artery normal arises from the anterior division of the internal iliac. In about 30 per cen of cases, however, the obturator arises from the inferior epigastric artery ne its commencement. This origin is more common in the female than in t male, and is rarely bilateral. Such an abnormal obturator artery usually li close to the external iliac vein, and on the *outer side* of the femoral ri (Fig. 345, A). In rare cases the abnormal vessel crosses the femoral ring; still rarer cases it follows the free edge of the pectineal part of the inguin ligament more or less closely; in such cases it lies on the *inner side* of the femor ring (Fig. 345, B and C). If a femoral hernia should occur under these latt circumstances, the aberrant obturator artery would lie upon the inner side the neck of the sac, and it would thus be endangered in the operation for t

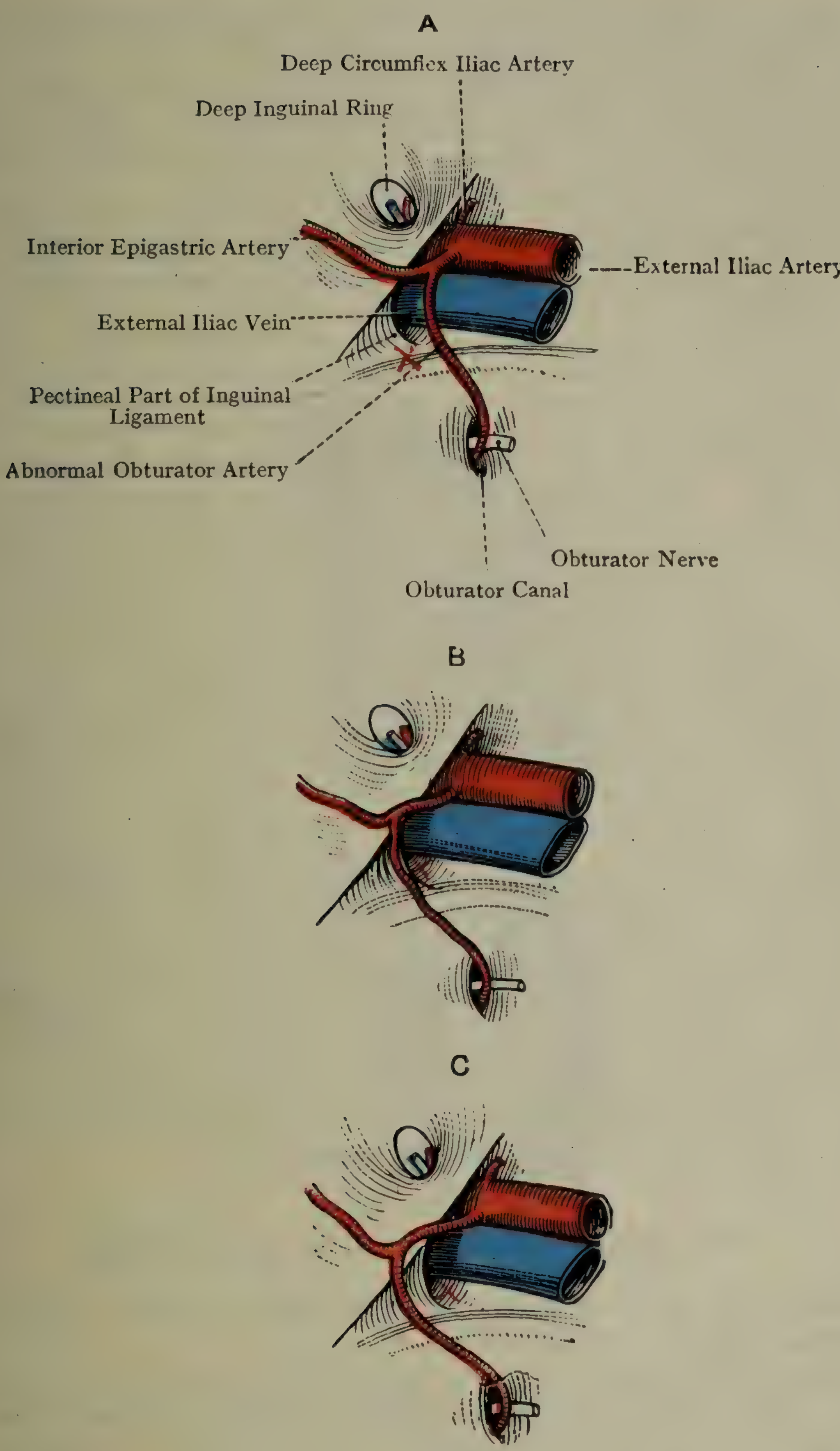


FIG. 345.—DIAGRAMS OF ABNORMAL OBTURATOR ARTERY.

(The red X indicates the position of the femoral ring.)

[A and B after Gray.]

A, artery lateral to femoral ring; B, artery medial to ring, and close to base of the pectineal part of the inguinal ligament; C, artery medial to ring, and one or two lines from base of the pectineal part of the inguinal ligament.

relief of the strangulation. This, however, is a very rare position of an abnorma obturator artery, and is more frequent in the male than in the female; it i said to occur once in a hundred cases.

An abnormal obturator artery arising from the inferior epigastric is due t the suppression of the proximal part of the normal trunk, and its replacemen by a dilatation of the anastomosis between the pubic branches of the inferio epigastric artery and the obturator artery respectively.

Femoral Hernia (Fig. 344).—The femoral ring is to be regarded as a weal spot in the abdominal wall through which one of the contents of the abdomina cavity, as, for instance, a loop of gut or a part of the great omentum, may pro trude downwards into the femoral canal, the resulting condition being know as a femoral hernia. As the hernia passes downwards it will necessarily b contained in a pouch of the peritoneum continuous with that lining the abdomina cavity. Owing to the pressure from above, the peritoneal pouch will, as i sinks downwards into the femoral canal, push the soft contents of the cana (femoral septum) before it, the femoral septum becoming condensed and form ing a cover for it. The progress downwards of the hernia will be arrested a the lower limit of the femoral sheath—*i.e.*, where its walls blend with the femora vessels. At this stage the hernia is said to be incomplete. As the lower limi of the femoral sheath is opposite the weak area of the fascia lata or cribriforn fascia, there is but little resistance in front, and the hernia may now bulg forwards, stretching and pushing before it the anterior wall of the femora sheath, the cribriform fascia, the superficial fascia, and the skin. When thi stage is reached the hernia is said to be complete. In order to open the peri toneal sac in which it is contained, and to expose the herniated viscus for th purpose of restoring it to the abdominal cavity, it would be necessary to incis the following layers or coverings of the hernia: (1) Skin; (2) subcutaneous tissue (3) cribriform fascia; (4) femoral sheath; (5) femoral septum; (6) peritoneum.

A femoral hernia may be constricted or strangulated, a circumstance whicl demands prompt relief. The strangulation usually occurs at the femoral ring where the surrounding structures are comparatively unyielding. To reliev the condition the ring must be enlarged by means of a hernia knife. If the knif is directed forwards and upwards, the inferior epigastric artery may be severed if directed outwards, the femoral vein would be opened; a backward direction i contra-indicated, as the knife would come against hard unyielding bone. Th knife is consequently directed inwards to sever the pectineal part of the inguina ligament, and in so doing an abnormal obturator artery arising from the dee epigastric and coursing downwards to the inner side of the femoral ring might b wounded. Happily this is a very rare contingency.

The Front and Inner Side of the Thigh.

Sartorius (Fig. 346)—*Origin.*—The anterior superior iliac spine, and the upper part of the notch below it.

Insertion.—The upper end of the medial surface of the shaft of the tibia. Its tendon broadens at its insertion, and is folded in such manner that its line of attachment is an inverted V, the anterior limb of which is considerably longer than the posterior. The two limbs embrace the insertions of the gracilis and semitendinosus.

Nerve-supply.—The femoral nerve. The nerve to the sartorius arises in common with the intermediate cutaneous nerve, and enters the muscle near the apex of the femoral triangle.

Action.—Flexes the knee-joint, and rotates the leg inwards; flexes the hip-joint, abducts the thigh, and rotates it outwards. By flexing, abducting, and rotating the thigh outwards, and at the same time

lexing the knee, it brings the lower limb into a position which is popuarly supposed to be habitually assumed by a tailor. Acting from the eg as its fixed point, it bends the trunk on the thigh and rotates it.

The sartorius is a long ribbon-like muscle, the fasciculi of which are longer than those of any other muscle in the body. It can, there-'ore, bring about extensive movements, but with comparatively little 'orce. Passing downwards and inwards from its origin, it crosses the ıpper part of the front of the thigh obliquely, here forming the outer

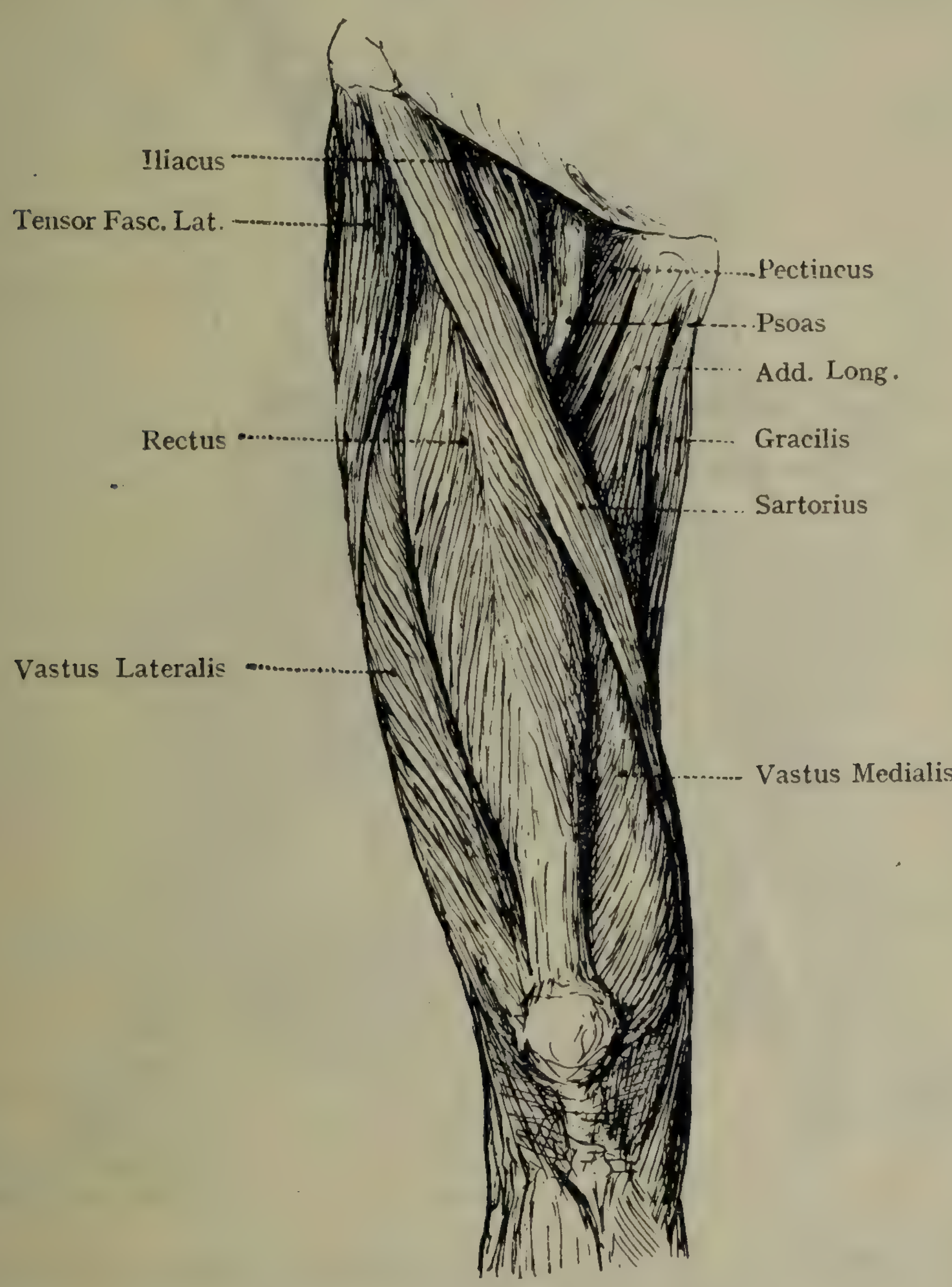
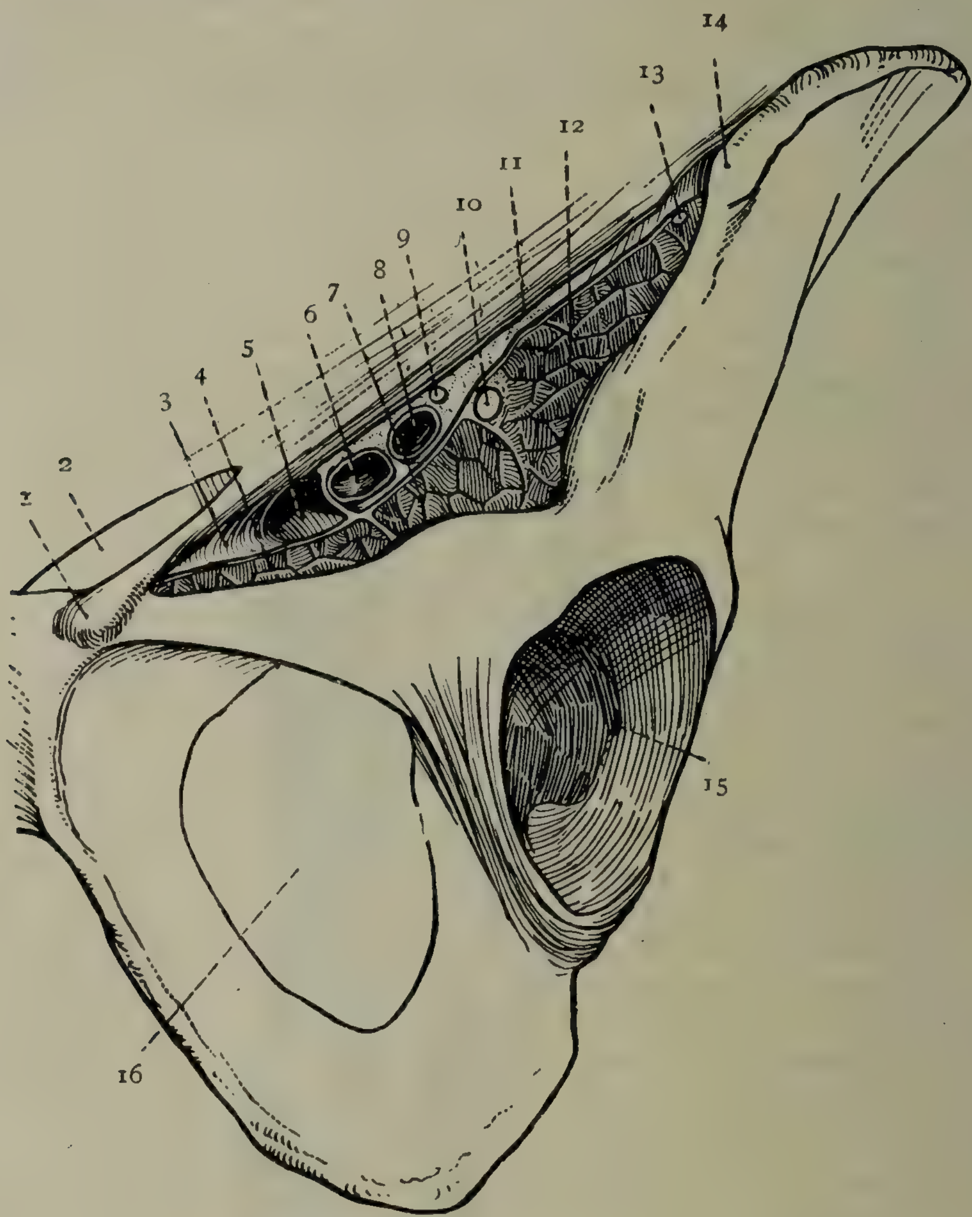


FIG. 346.—THE MUSCLES SEEN ON THE FRONT OF THE THIGH.

boundary of the femoral triangle. It then descends on the inner side of the thigh, where it helps to form the roof of the subsartorial canal. It is disposed on the inner side of the knee, where it is separated from the lateral ligament by a bursa. From the knee it passes downwards with an inclination forwards to its insertion (Fig. 350). The upper part of the muscle is traversed by one or two of the branches of the intermediate cutaneous nerve, its lower part by the patellar branch of the long saphenous nerve.

Tensor Fasciæ Latæ—*Origin.*—The outer aspect of the anterior superior iliac spine; the anterior end of the iliac crest for a short distance, and the bone immediately below it; some of its fibres are attached to the deep aspect of the fascia lata covering it.

Insertion.—The ilio-tibial tract of the fascia lata.



1. Pubic Tubercle
2. Superficial Abdominal Ring
3. Pectineal Part of Inguinal Ligament
4. Pectineus
5. Femoral Ring
6. Femoral Vein
7. Psoas Major
8. Femoral Artery
9. Femoral Branch of Genito-femoral Nerve
10. Femoral Nerve
11. Inguinal Ligament
12. Iliacus
13. Lateral Cutaneous Nerve of Thigh
14. Ant. Superior Iliac Spine
15. Acetabulum
16. Obturator Foramen

FIG. 347.—THE STRUCTURES PASSING DOWNWARDS INTO THE THIGH BEHIND THE INGUINAL LIGAMENT.

Seen in section to illustrate the relations of the crural ring.

Nerve-supply.—The lower division of the superior gluteal nerve, the terminal branch of which enters the deep surface of the muscle.

Action.—Abducts and rotates the thigh inwards; helps to flex the hip-joint; and extends the knee-joint. In the latter movement the muscle acts in conjunction with the gluteus maximus, the ilio-tibial tract playing the part of a tendon common to the two muscles. The more important effect on the knee-joint is to maintain it in the extended position in the erect posture.

The tensor fasciæ latæ is a flat, strap-like muscle, the direction of which is downwards, with a slight inclination outwards and backwards.

Ilio-Psoas (Fig. 348).—The femoral portion of this muscle is described here. A fuller description of the psoas major and iliacus will be found in the section on the abdomen.

The outer portion of the muscle is fleshy, and represents the iliacus; the inner portion is chiefly tendinous, and represents the psoas. The tendon of the psoas is inserted into the lesser trochanter of the femur; the fibres of the iliacus are attached obliquely on the side of the tendon

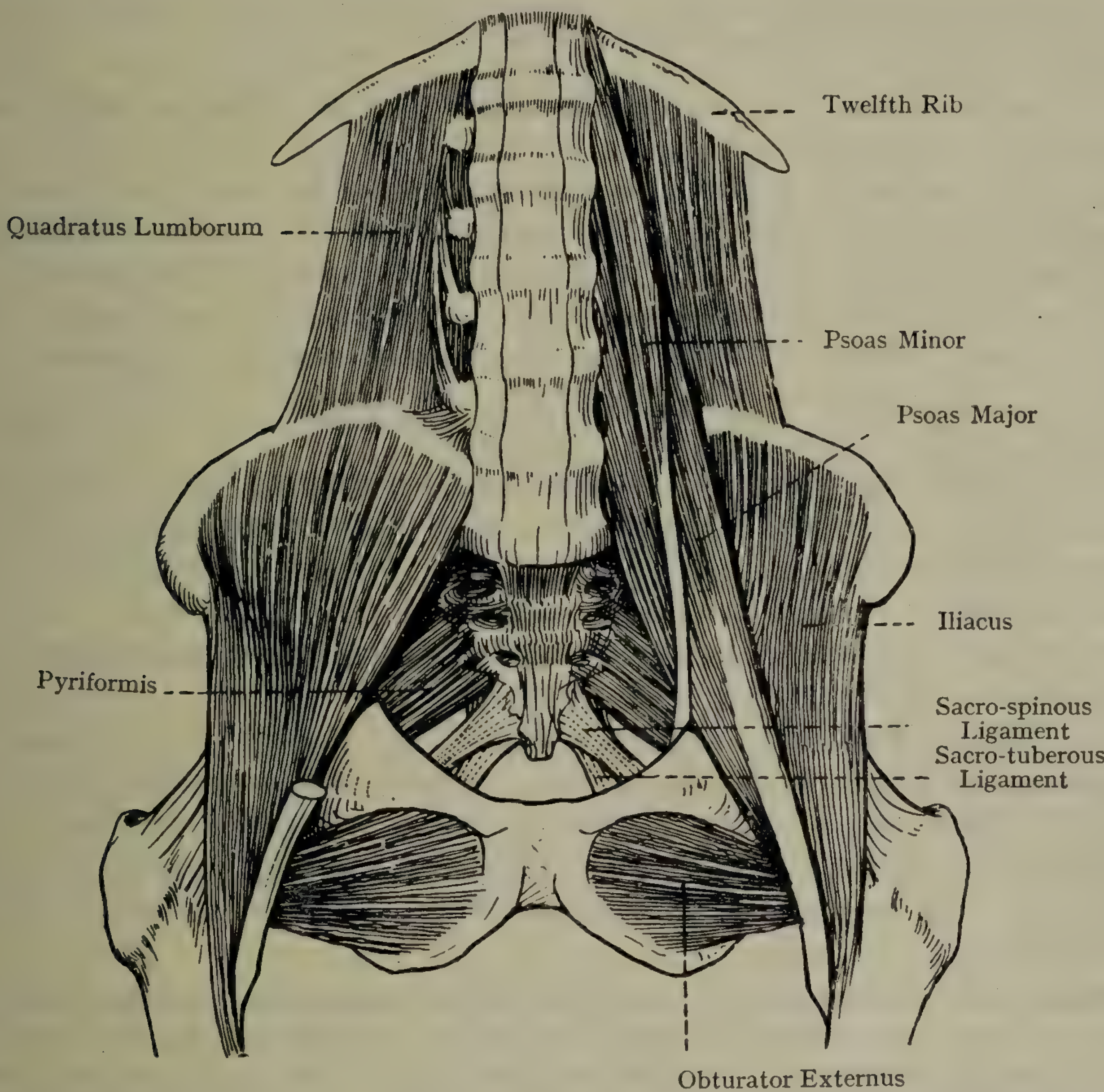


FIG. 348.—THE PSOAS, ILIACUS, AND QUADRATUS LUMBORUM MUSCLES.

of the psoas; the lowest fibres extend downwards, and are attached to the shaft of the femur for some little distance below the lesser trochanter. Lying in the groove marking the distinction between the two muscles is the femoral nerve; the femoral artery and vein, surrounded by the femoral sheath, lie in front of the psoas. The ilio-psoas covers the front of the hip-joint, where a bursa intervenes between the tendon of the psoas and the capsular ligament.

Pectineus—*Origin.*—A linear tendinous attachment to the pubic part of the ilio-pubic line, and a small area of muscular attachment in front of the inner extremity of the ilio-pubic line; upper or pectineal

surface of the superior pubic ramus; the fascia lata covering the muscle.

Insertion.—The line which extends downwards from the back of the lesser trochanter of the femur to the linea aspera.

Nerve-supply.—The femoral nerve, a branch of which passes inwards behind the femoral sheath and enters the superficial surface of the muscle close to its outer border. The pectineus occasionally receives an additional supply from the anterior division of the obturator, the branch of which (when present) enters the deep surface of the muscle.

The pectineus belongs to the extensor group of muscles, but a part of it may be derived from the adductor musculature.

Action.—Flexes the hip-joint, adducts the thigh, and rotates it outwards.

The pectineus is a flat quadrilateral muscle directed downwards, outwards, and backwards. The surfaces at first look forwards and backwards, but towards its insertion the muscle undergoes a slight twist, and its two surfaces are then directed outwards and inwards. On the deep aspect of the muscle are the capsular ligament of the hip-joint, the anterior division of the obturator nerve, the obturator externus, and adductor brevis muscles.

The **quadriceps femoris** consists of four parts: the rectus femoris, vastus lateralis, vastus intermedius, and vastus medialis. The rectus femoris, the most superficial part of the muscle, arises from the hip-bone; the other three muscles take origin from the femur. The vastus intermedius is situated between, and is overlapped on either side by the vastus lateralis and vastus medialis.

1. **Rectus Femoris**—*Origin.*—By two strong tendinous heads. The **straight head** arises from the anterior inferior iliac spine. The **reflected head** arises from a groove on the gluteal surface of ilium immediately above the margin of the acetabulum, where it lies deeply to the gluteus minimus. The two heads unite at an angle of about 60 degrees.

When the lower limb is at right angles to the trunk, the habitual position of the limb in pronograde animals, the so-called reflected head is in line with the rest of the muscle. The reflected head is the sole origin in such animals, and is consequently known as the *primary* head. The straight head is, phylogenetically, a recent acquirement, a necessity for this attachment of the muscle having arisen owing to the erect attitude and the habitual complete extension of the lower limb on the trunk; it is therefore known as the *secondary* or *acquired* head.

The muscle fibres are very short, have a penniform arrangement, and spring from either side of a superficially and centrally disposed tendon which occupies the upper part of the muscle. The fibres diverge from this tendon and are attached to a deeply-placed tendon of insertion, which spreads out and clothes the deep aspect of the muscle for some considerable distance.

2. **Vastus Lateralis**—*Origin.*—The upper part of the trochanteric line of the femur; the anterior and inferior borders of the greater tro-

chanter; the outer side of the gluteal tuberosity; the outer lip of the linea aspera in its upper half; the adjacent portion of the shaft of the femur; and the upper part of the lateral intermuscular septum.

The vastus lateralis is tendinous at its origin, and an aponeurosis spreads downwards upon the superficial surface of the muscle for a considerable distance. The fibres are directed downwards and inwards. The anterior border has a free edge.

3. **Vastus Intermedius** (**Crureus**)—*Origin.*—The lower two-thirds of the upper or anterior part of the trochanteric line; the upper three-fourths of the anterior and lateral surfaces of the shaft of the femur; the lower part of the outer lip of the linea aspera; the upper two-thirds of the lateral supracondylar line, and the bone immediately adjacent to it; and the lateral intermuscular septum.

The direction of the fibres of the vastus intermedius is chiefly downwards, but those of the lower and outer part of the muscle incline obliquely downwards and forwards. A broad aponeurotic sheet to which the muscle fibres are attached clothes the superficial or anterior aspect of the muscle. This aponeurosis narrows below and blends with the deep aspect of the tendon of the rectus.

The **articularis genu** (**subcrureus**) is a deep delamination of the lower part of the vastus intermedius. It usually arises in two bundles from the front of the shaft of the femur about 4 inches above the patellar surface. It is attached below to the large bursa which underlies the tendon of the quadriceps femoris, and which is continuous below with an upward prolongation of the synovial membrane of the knee-joint.

4. **Vastus Medialis**—*Origin.*—The posterior or lower part of the trochanteric line of the femur extending from the inferior cervical tubercle to the linea aspera; the inner lip of the linea aspera; and the medial intermuscular septum, by means of which it is adherent to the adductor longus and the tendon of insertion of the adductor magnus.

The general direction of the fibres of the muscle is downwards and outwards. The lower fibres of the muscle are much more horizontal and descend to a lower level than those of the vastus lateralis, which are more vertically disposed. The lower edge of the vastus medialis is opposite the middle of the patella.

At their attachments to the back of the shaft of the femur the vastus lateralis and the vastus intermedius are confluent with each other, but laterally and in front there is a connective tissue interval between the two, the vastus lateralis presenting a free edge on the front of the limb. The vastus medialis, on the other hand, has no free edge, and on the front of the limb cannot be separated from the vastus intermedius without rupturing muscle fibres; deeply, however, the attachments of the two muscles to the bone are separated from each other by the whole extent of the inner aspect of the shaft of the femur, which is free from muscular attachment and is sometimes termed the great bare area of the femur.

Insertion of the Quadriceps Femoris.—In the lower part of the thigh the tendon of the rectus femoris fuses with that of the vastus

intermedius to form a common or *suprapatellar tendon,* which is implanted on the upper edge of the patella. The superficial fibres of the common tendon are prolonged downwards in the form of an expansion which clothes the front of the patella and blends below with the ligamentum patellæ.

It may be noted that the effective insertion of the quadriceps femoris is the tubercle of the tibia to which the ligamentum patellæ is attached. The patella is a sesamoid bone developed in the common tendon, and the ligamentum patellæ, which functionally and morphologically is the part of the tendon distal to the patella, might conveniently be termed the *infrapatellar tendon.*

Situated deeply to the common tendon, between it and the front of the lower part of the shaft of the femur, is a large *suprapatellar* bursa which is continuous below with an upward prolongation of the synovial membrane of the knee-joint. In some cases the bursa is independent. This is frequently the case in young subjects, and represents the persistence of an early condition.

The muscle fibres of the vastus lateralis end in an aponeurosis which clothes the deep aspect of the muscle, blends with the outer side of the suprapatellar tendon, and sends an expansion downwards on the outer side of the patella. Most of the fibres of the vastus medialis also end in an aponeurosis which clothes the deep aspect of the muscle, and which blends with the inner side of the suprapatellar tendon. The lowest fibres, however, are attached directly to the upper half of the inner margin of the patella. From the lower edge of the muscle a tendinous expansion passes downwards on the inner side of the patella.

The **ligamentum patellæ** is a thick broad band attached above to the blunt apex and adjacent margins of the lower part of the patella, and below to a rough area occupying the lower part of the tubercle of the tibia. A bursa intervenes between the ligament and the upper smooth part of the tubercle.

Nerve-supply.—The four parts of the muscle are supplied by independent branches from the femoral nerve. The nerve to the rectus femoris enters the upper part of the muscle and sends a branch to the hip-joint. The nerves to the three vasti are all long nerves which are prolonged downwards through the muscles and end in the knee-joint. The nerve to the vastus medialis occupies the upper end of the subsartorial canal, where it lies to the outer side of the femoral artery. It leaves the canal by diving into the substance of the vastus medialis. Its terminal twig supplying the knee-joint is the largest articular branch derived from the femoral. The subcrureus is supplied by the nerve to the vastus intermedius.

Action.—The four parts of the muscle extend the knee-joint. When the hip-joint is extended, the attachment of the straight head is the fixed point from which the rectus femoris pulls; but when the hip-joint is flexed, the straight head is relaxed, while the reflected head is now in line with the rest of the muscle, and is the effective head, by pulling on which the rectus femoris extends the knee-joint. The rectus femoris is also concerned in flexing the hip-joint. During extension of the knee-joint the synovial membrane which occupies the

front part of the joint is relaxed, and the subcrureus is concerned in pulling it upwards, and thereby prevents it from being infolded and nipped between the bones.

The **femoral (anterior crural) nerve** is the largest branch of the lumbar plexus. Its fibres are derived from the second, third, and fourth lumbar nerves. In the iliac fossa the nerve lies in the interval between the psoas major and iliacus muscles, and this relationship

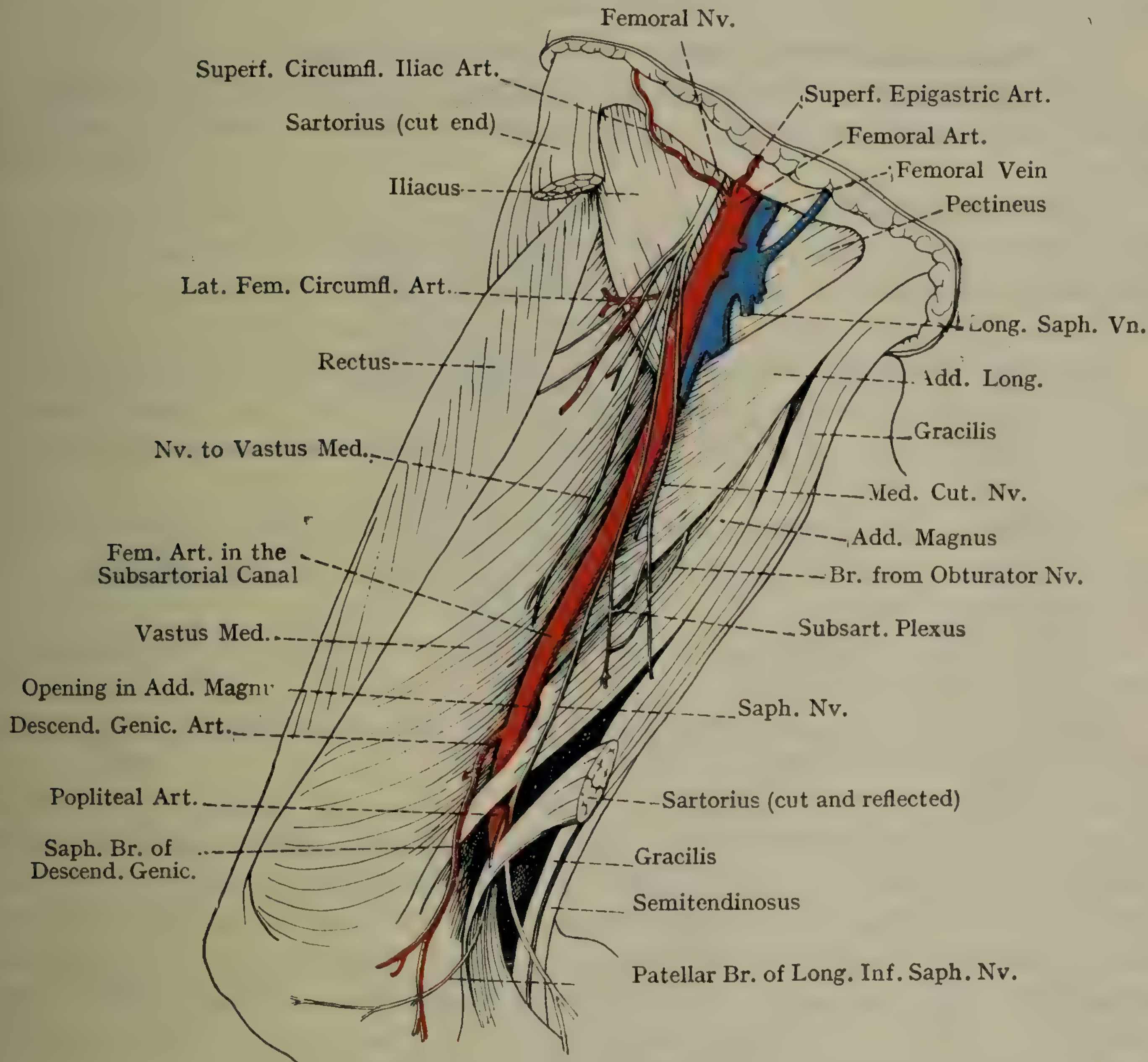


FIG. 349.—THE FRONT AND INNER SIDE OF THE THIGH.

The sartorius has been partially removed in order to expose the femoral artery in the subsartorial canal.

to the two muscles is maintained as it descends into the thigh behind the inguinal ligament. In the upper part of the femoral triangle it lies to the outer side of the femoral artery, a part of the psoas muscle intervening between the two. Some little distance below the inguinal ligament it subdivides into two sets of branches: a superficial or anterior set, consisting of nerves which are chiefly cutaneous; and a deep or posterior set of muscular branches with one cutaneous nerve, the saphenous.

The **branches** are conveniently divided into intra-abdominal and femoral.

The **intra-abdominal branches** arise from the nerve above the level of the inguinal ligament, and consist of three or four branches supplying the iliacus muscle, and a branch to the femoral artery.

The branch to the femoral artery forms a network on the vessel. From this network a subsidiary network follows the profunda femoral artery and its second perforating branch; an ultimate twig passes into the nutrient foramen of the femur.

The **femoral branches** arise in the femoral triangle.

The **branches** of the **anterior division** are muscular branches to the sartorius and pectineus, and the intermediate and medial cutaneous nerves.

The **branches** of the **posterior division** are the four nerves supplying respectively the rectus femoris, vastus lateralis, vastus medialis, and vastus intermedius (from these nerves genicular branches to the hip and knee joints are derived), and the saphenous nerve.

Adductor Muscles—Gracilis (Fig. 349)—*Origin.*—The lower part of the anterior or femoral surface of the body of the os pubis close to the symphysis; and the front of the inferior pubic ramus close to its inner border.

Insertion.—The upper part of the inner surface of the shaft of the tibia above the semitendinosus, its insertion being embraced by that of the sartorius.

Nerve-supply.—The anterior or superficial division of the obturator nerve.

Action.—Adducts the thigh and flexes the knee-joint. It is also a medial rotator of the leg.

The gracilis is flat and strap-like in the upper third of the thigh. In the middle third it becomes thick and narrow, and gradually tapers into a long, narrow, round tendon which finally expands at its insertion. It occupies the inner aspect of the thigh, its two surfaces being directed inwards and outwards, and its borders forwards and backwards. In the lower third of the thigh the tendon has the sartorius in front of it, and the semitendinosus behind it; it is separated from the medial ligament of the knee-joint by a bursa.

Adductor Longus (Fig. 349)—*Origin.*—By a narrow tendon attached to a depression on the femoral surface of the body of the os pubis close to its inner edge and immediately below the pubic crest.

Insertion.—The inner lip of the linea aspera of the femur.

Nerve-supply.—The anterior or superficial division of the obturator nerve.

Action.—Adducts the thigh and rotates it outwards.

The adductor longus is a flat, triangular muscle, its direction being downwards, outwards, and backwards. The tendon of origin is thick and narrow; as it extends downwards it broadens, and descends for some considerable distance along the inner edge of the muscle. It lies to the inner side of the pectineus, and in front of the adductor

brevis, the anterior or superficial division of the obturator nerve, and the adductor magnus. The femoral vessels are in front of it, and the profunda femoral vessels behind it.

Adductor Brevis—*Origin.*—The lower part of the femoral surface of the body of the os pubis, and from the inferior pubic ramus following and immediately lateral to the attachment of the gracilis.

Insertion.—To a line extending downwards from a little way below the back of the lesser trochanter to the linea aspera, and to the upper part of the linea aspera. The attachment extends downwards to about the middle of the shaft of the femur.

Nerve-supply.—From the anterior or superficial division of the obturator nerve, sometimes from the posterior division of the nerve, and occasionally from both.

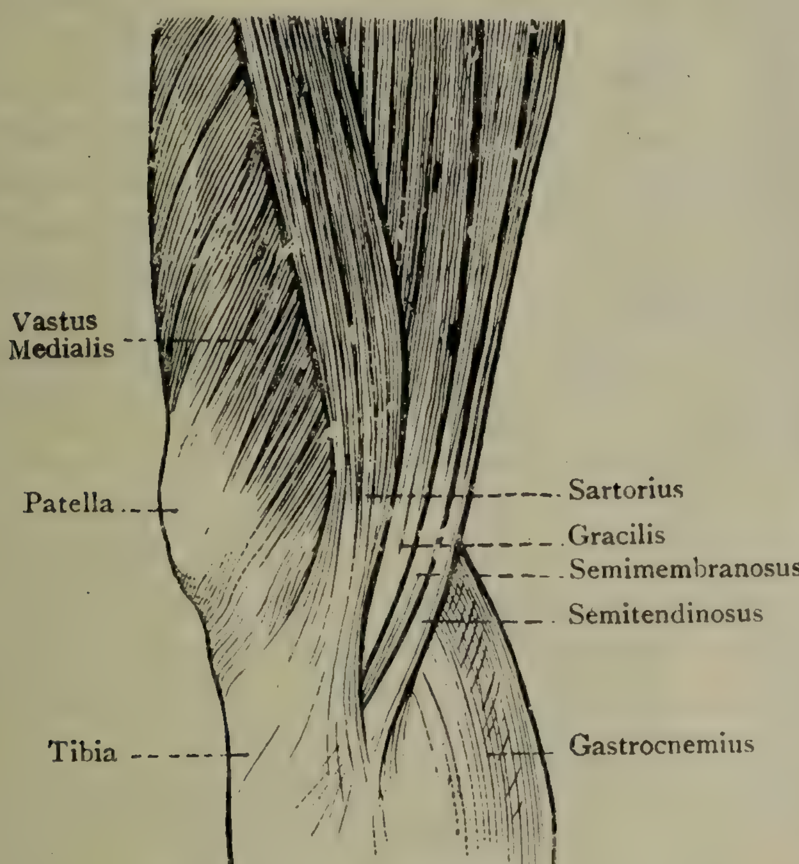


FIG. 350.—THE TENDONS ON THE INNER SIDE OF THE KNEE.

Action.—Adducts the thigh and rotates it outwards.

The adductor brevis is quadrilateral, and is directed downwards, outwards, and backwards. It lies behind the pectineus and adductor longus, and in front of the adductor magnus. The anterior division of the obturator nerve and the profunda femoral artery are in front of it, and the posterior division of the nerve behind it. Passing through it are the first two perforating branches of the profunda femoral artery.

Adductor Magnus (Fig. 351)—*Origin.*—The whole length of the ischio-pubic ramus, its attachment extending outwards to the inferior aspect of the ischial tuberosity.

Insertion.—The muscle is attached to practically the whole length of the shaft of the femur. From a point a little way below the back

of the greater trochanter the attachment extends downwards, follow ing the inner side of the gluteal tuberosity, to the linea aspera, wher it is attached to the inner lip. From the linea aspera it passes down wards to the medial supracondylar line. The attachment to th supracondylar ridge is interrupted, as here the muscle fibres end in tendinous arcade, arching over the femoral vessels, and attache above to the upper part of the supra condylar line, below to the adducto tubercle. The adductor tubercle, situate on the upper aspect of the medial condyle gives attachment to the main tendon o the muscle.

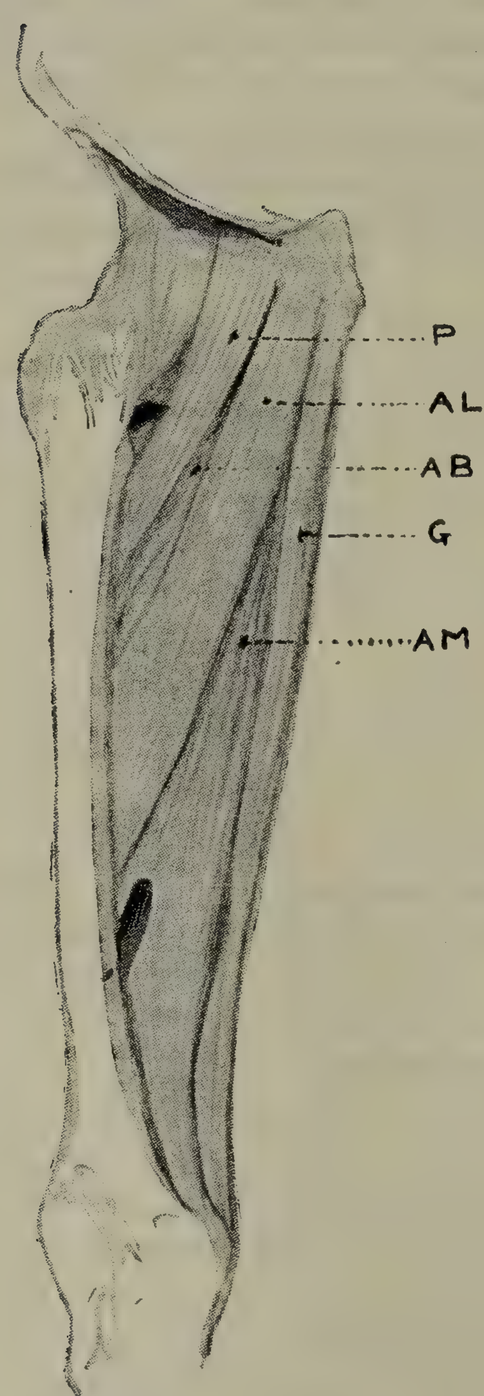


Fig. 351.—View of Muscles of Adductor Region exposed by Removal of Pectineus and Adductor Longus.

Nerve-supply.—The posterior or dee division of the obturator nerve, th branches of which enter the anterio surface of the muscles. The part of th muscle which consists of fibres arisin from the ischial tuberosity is supplie by a branch of the sciatic nerve, whic passes into the muscle from behind.

The part of the adductor magnus supplie by the sciatic nerve is derived from the mus culature which gives rise to the hamstrin muscles.

Action.—Adducts the thigh and rotate it outwards. The part of the muscl stretching from the ischial tuberosity t the adductor tubercle assists in extendin the hip-joint.

The adductor magnus is triangular o fan-shaped. The uppermost fibres ar horizontal; the succeeding fibres are ob lique; and those arising from the ischia tuberosity are almost vertical. An uppe part, lying above and behind the rest o the muscle, and inserted into the inne side of the gluteal tuberosity, is triangula in outline, and, being more or less inde pendent, is sometimes called the **adducto minimus.** The attachment of the muscl to the linea aspera is interrupted by fou tendinous arcades, which give passage t the perforating branches of the profunda femoral artery. In front of th adductor magnus muscle are the adductor brevis, the adductor longus the posterior division of the obturator nerve, and the profund femoris artery. Behind it are the hamstring muscles and the sciati nerve.

The adductors as a group are a very powerful set of muscles coming more especially into play when a rider grasps the saddle with his knees; they are therefore called ' the rider's muscles.'

Obturator Externus (Fig. 348)—*Origin.*—The inner two-thirds of the superficial aspect of the obturator membrane, and the adjacent parts of the body of the os pubis and of the ischio-pubic ramus.

Insertion.—The trochanteric fossa of the femur.

Nerve-supply.—A branch of the posterior division of the obturator nerve, arising in the pelvic cavity and entering the deep surface of the muscle.

Action.—Adducts the thigh and rotates it outwards.

The obturator externus is somewhat triangular, and is directed at first outwards, and then backwards and upwards. Its rounded tendon is closely applied to and imprints a slight groove on the back of the neck of the femur. Lying in front of it are the pectineus and the ilio-psoas; at its origin from the ischio-pubic ramus it is overlapped by the adductor brevis. It is in close contact with the lower and back part of the capsular ligament of the hip-joint, a bursa intervening between them. Behind its tendon, at the back of the neck of the femur, lie the adjoining edges of the gemellus inferior and quadratus femoris. The anterior division of the obturator nerve crosses its upper edge, and the posterior division of the nerve passes through its upper part, the two nerves descending in front of it. On its deep aspect, between it and the obturator membrane, are the two terminal branches of the obturator artery.

The **obturator nerve** is a branch of the lumbar plexus. It arises by three roots from the second, third, and fourth lumbar nerves; the upper root from the second lumbar nerve may be absent. A further description of the nerve is given in the section on the abdomen (*q.v.*). It escapes from the pelvic cavity by passing through the obturator canal, which is bounded above by the groove on the inferior aspect of the superior pubic ramus and below by the upper free crescentic margin of the obturator membrane and the muscles attached thereto. In the obturator canal it divides into two divisions—superficial or anterior, and deep or posterior. The **anterior division** winds over the upper edge of the obturator externus, and then descends in front of the adductor brevis, but behind the pectineus and the adductor longus, in which it ends. This division communicates with the accessory obturator nerve (when present).

Branches.—Articular to the hip-joint, which arises in the obturator canal and reaches the joint by passing through the acetabular notch; **muscular** to the gracilis, adductor longus, and adductor brevis, an occasional branch supplies the pectineus; **arterial** to the femoral artery; and a **cutaneous** branch which communicates with branches of the saphenous and of the medial cutaneous to form the subsartorial plexus on the deep aspect of the sartorius muscle. A branch of the subsartorial plexus becomes superficial between the posterior border of the sartorius and the anterior border of the gracilis;

it supplies the skin on the inner side of the thigh for a variable extent.

The **posterior division** passes through the upper part of the obturator externus and descends between the adductor brevis in front and the adductor magnus behind. It furnishes the following branches: **muscular** to the obturator externus, adductor magnus, and an occasional branch to adductor brevis; and an **articular** to the knee-joint, called the *geniculate branch*. This geniculate branch first descends in front of the adductor magnus, but passing through the muscle a little way above the opening for the femoral artery, it gains the popliteal space. In the popliteal space it lies behind and to the inner side of the popliteal artery. Opposite the knee-joint it passes forwards, accompanies the middle geniculate artery, and enters the knee-joint from behind. The geniculate nerve is occasionally absent.

Accessory Obturator Nerve.—This nerve is present in about 30 per cent. of bodies. It is comparatively small in size, and arises by two roots from the anterior primary divisions of the third and fourth lumbar nerves, the roots being interposed between those of the femoral and obturator nerves. It descends along the inner border of the psoas major, close to the brim of the pelvic cavity, where it lies deeply to the external iliac vessels. It passes downwards in front of the superior pubic ramus into the thigh, where it lies deeply to the pectineus, and divides into the following branches: *articular* to the hip-joint; a *muscular branch* entering the deep surface of the pectineus; and a *communicating branch* to the anterior division of the obturator nerve.

The Subsartorial (Hunter's) Canal (Fig. 352).—In the femoral triangle the main artery of the limb, here known as the femoral artery, lies in front of the hip-joint. Thence it extends downwards, and at the same time inclines backwards, approaching the obliquely disposed shaft of the femur as it does so (Fig. 354). In the lower part of the thigh it gains the back of the femur, and as in this situation it is contained in the popliteal space, it is here called the popliteal artery. In passing from the front to the back of the limb the femoral artery occupies an interval between the extensor and adductor muscle groups, and is embedded in the connective tissue of the antero-medial intermuscular septum. This intermuscular interval, which in vertical extent corresponds to about the middle third of the thigh, is known as the subsartorial canal. It is bounded in front and to the outer side by the innermost extensor muscle, the vastus lateralis, behind and to the inner side by the adductor longus, the most anterior of the adductor group. The roof of the canal is provided by the sartorius, which muscle, after crossing the front of the upper part of the thigh obliquely, passes vertically downwards on its inner aspect, and occupies superficially the interval between the extensor and the adductors. From the disposition of the muscle it is obvious that the antero-medial intermuscular septum must be continuous with the sheath of the sartorius, by means of which its continuity with the fascia lata ensheathing

the thigh muscles is attained. The layer of the sheath of the sartorius, investing the deep aspect of the muscle, is relatively thick and strong, ınd provides the canal with an aponeurotic roof, which may be seen stretching from the vastus medialis on the one side to the adductor ongus on the other when the sartorius muscle is removed. The vertical extent of the subsartorial canal is limited above by the apex of the femoral triangle, the point at which the femoral artery sinks deeply to the sartorius. The lower imit is the opening or deficiency n the adductor magnus, which s situated immediately below the lower edge of the adductor ongus, and through which the emoral artery passes to become continuous with the popliteal.

Contents.—The femoral artery ınd its branches; the corresponding part of the femoral vein and its tributaries; the saphenous nerve; and the nerve to the vastus medialis muscle, which occupies the upper part of the canal only.

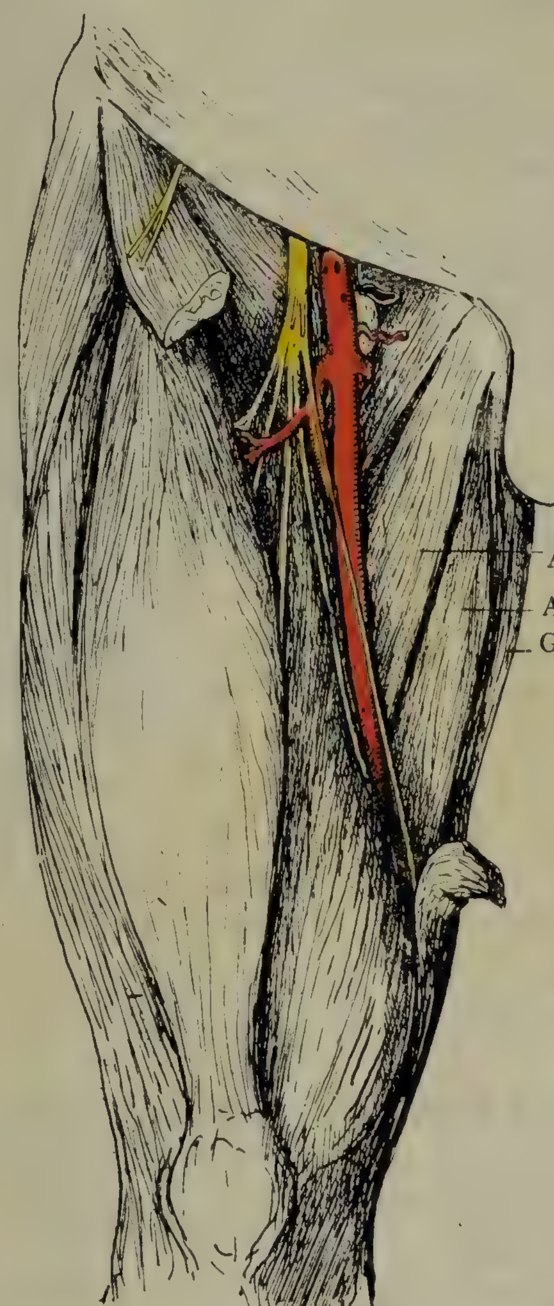


FIG. 352.—SHOWING STRUCTURES EXPOSED BY REMOVAL OF SARTORIUS: FEMORAL VEIN CUT AWAY.

The **femoral artery** (Fig. 349) extends from the inguinal ligament above to the opening in the adductor magnus below. It s continuous above with the external iliac artery, and below with the popliteal. It occupies the upper two-thirds of the thigh, ınd its direction is downwards ınd backwards. When the thigh s partially flexed upon the abdomen, and at the same time s slightly abducted and rotated outwards, the course of the vessel may be indicated on the surface by drawing a line from a point midway between the anterior superior iliac spine and the symphysis pubis to the adductor tubercle of the femur, or, if this tubercle cannot be felt, to the epicondyle on the inner aspect of the medial condyle of the femur. The upper two-thirds of this line represents the position of the vessel.

The upper part of the vessel is contained in the femoral triangle, and s quite superficial. The lower part is deeply situated, and occupies the subsartorial canal. About $1\frac{1}{2}$ to 2 inches below the inguinal ligament it gives off a large branch, the arteria profunda femoris,

below which it undergoes a sudden diminution in size. For conve ence of description, the femoral artery is divided into two parts, first part lying in the femoral triangle, and the second part occupy the subsartorial canal.

First Part.—The first part of the femoral artery extends from lower border of the inguinal ligament to the apex of the femo triangle.

Relations—*Superficial or Anterior.*—The skin; the superfic fascia, in which the superficial circumflex iliac vein, the anter femoral cutaneous vein, and one or two superficial lymphatic glan are embedded; the fascia lata; the anterior wall of the femoral shea in the upper part of which the femoral branch of the genito-femo nerve is embedded; the medial cutaneous nerve, represented by two more trunks; and branches of the medial cutaneous nerve cross vessel from without inwards.

Deep or Posterior.—The artery lies successively on the psoas a pectineus muscles. In the upper part of the triangle it is separa from the psoas by the deep layer of the femoral sheath and the ne to the pectineus. In the lower part of the triangle it is separated fr the pectineus by the femoral vein and the profunda femoral vess which lie behind the femoral vein.

Lateral.—The femoral nerve, which is separated from the arte by a narrow interval occupied by a part of the psoas muscle; saphenous nerve and the nerve to the vastus medialis muscle, former being nearer to the artery; and the profunda femoral arte for a short distance below its origin.

Medial.—Immediately below the inguinal ligament the femo vein lies to the inner side of the artery, but as the vein inclines obliqu downwards and outwards relatively to the artery and below occup a deeper plane, it lies behind the artery in the lower part of triangle.

Second Part.—The second part of the artery lies in the subsartor canal and extends from the apex of the femoral triangle to the ope ing in the adductor magnus, where it becomes continuous with popliteal artery.

Relations.—As this part of the artery lies in the subsartorial can the muscles forming the walls of this passage are necessarily in relati to it (p. 580), the vastus medialis being in front and to the outer sic the sartorius in front and to the inner side, and the adductor long behind. The femoral vein is, for the most part, behind, but inclini outwards it lies somewhat to the outer side of the artery in the lov part of the canal. The saphenous nerve lies at first to the outer si of the artery, but crosses in front of it, and at the lower end of canal lies to its inner side. The nerve to the vastus medialis lies its inner side in the upper part of the canal, but parts company wi the artery by diving into the substance of the muscle which it suppli The subsartorial plexus and the saphenous vein, which follows hinder edge of the sartorius, are superficial but not direct relations.

The **branches of the femoral artery** may be arranged in two sets:
ɪ) Arising in the femoral triangle. These branches are as follows:
'he superficial circumflex iliac, superficial epigastric, and superficial

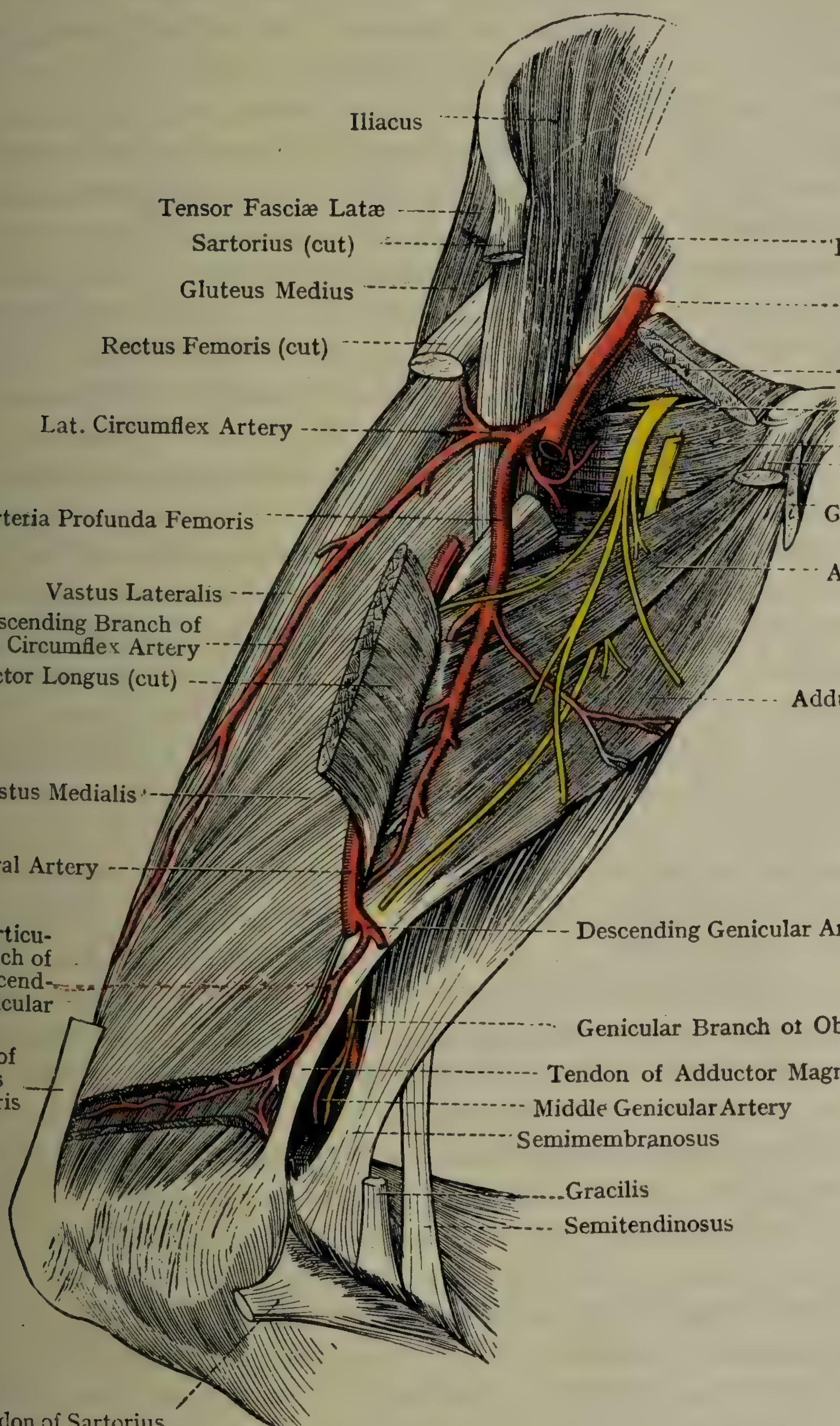


Fig. 353.—The Front and Inner Side of the Thigh
(Deep Dissection).

external pudendal arteries all arise close below the inguinal ligament. The deep external pudendal and arteria profunda femoris arteries arise at a lower level. Small irregular twigs supply the neighbouring muscles and skin, and the lymphatic glands.

(2) Arising in the subsartorial canal are the descending genicul
and muscular branches.

The **superficial circumflex iliac artery** may arise in common wi the superficial epigastric. It usually traverses the fascia lata abo and to the outer side of the saphenous opening. It extends oblique upwards and outwards parallel to and slightly below the inguin ligament, and ends by supplying the skin in the neighbourhood of t anterior superior iliac spine. It supplies small muscular branches the superficial inguinal glands, and anastomoses with the deep circu flex iliac, the superior gluteal, and the lateral femoral circumflex arteri

The **superficial epigastric artery** becomes superficial by passi through the cribriform fascia at the upper part of the saphenous ope ing. It passes upwards and inwards, crosses in front of the inguin ligament, and gains the abdominal wall, where it may extend as hi as the umbilicus. It is chiefly distributed to the skin of the anteri abdominal wall, but also supplies twigs to the inguinal glands; it anast moses with the inferior epigastric artery.

The **superficial external pudendal artery** traverses the cribrifo fascia covering the saphenous opening, and passes inwards in fro of the spermatic cord or the round ligament (according to the sex) be distributed to the skin of the suprapubic region and of the scrotu and penis in the male, and of the labium majus in the female. supplies branches to the inguinal (pubic) glands, and anastomos with the deep external pudendal and with branches of the intern pudendal artery.

The **deep external pudendal artery** is larger, arises at a lower leve and is on a deeper plane than its superficial namesake. It pass inwards deeply to the fascia lata, and lies on the pectineus (in fro of or behind the femoral vein) and the adductor longus. It travers the fascia lata towards the inner side of the thigh, and is distribute to the skin of the scrotum and of the perineum in the male, and to th labium majus in the female. It also gives small branches to th muscles upon which it lies, and anastomoses with the superficial extern pudendal and with branches of the internal pudendal artery.

The four arteries just described are known as the cutaneous arteri of the groin.

The **arteria profunda femoris** or **deep femoral artery** (Fig. 353), th largest and most important branch, arises from the outer side of th femoral artery at a point from $1\frac{1}{2}$ to 2 inches below the inguinal lig ment. It passes downwards in front of the psoas, and lies for a shor distance to the outer side of the parent trunk. Below the origin o its lateral femoral circumflex branch it inclines inwards on to th pectineus, and comes to lie behind the femoral artery, its companio vein, which is in front of it, and the femoral vein intervening betwee the two. At the upper edge of the adductor longus it become separated from the femoral artery as it passes downwards behin that muscle, and at the same time inclines outwards, coming into clos relationship with the linea aspera at the back of the femur. Th

adductor brevis and at a lower level the adductor magnus are behind it. It rapidly diminishes in size, and ends as the fourth perforating artery.

Branches.—The medial and lateral femoral circumflex arise in the femoral triangle; the four perforating arteries arise from the vessel as it lies behind the adductor longus.

The **lateral femoral circumflex artery** is large, and arises from the outer side of the arteria profunda femoris close to its origin. It passes outwards between the sartorius and rectus femoris superficially and the vastus intermedius deeply. Branches of the femoral nerve lie both in front of and behind it. It supplies a few muscular twigs, and ends by dividing into three sets of branches—ascending, transverse, and descending.

The *ascending branch* passes upwards under cover of the tensor fasciæ to the region of the anterior superior iliac spine, where it anastomoses with the superior gluteal and circumflex iliac arteries. It supplies muscular branches to the rectus femoris, the gluteus medius and gluteus minimus, and an articular branch to the hip-joint.

The *transverse branch* is usually represented by two arteries which dive into the vastus lateralis muscle and wind round the outer side of the femur. One of them pierces the femoral insertion of the gluteus maximus and reaches the back of the thigh, where by anastomosing with the first perforating artery, the sciatic, and the transverse branch of the internal circumflex, it helps to form the **cruciate anastomosis.**

The *descending branch* is the largest of the three, and is usually multiple. Its branches pass downwards with the nerve to the vastus lateralis, and follow the anterior border of that muscle. A long terminal branch traverses the lower part of the vastus lateralis and reaches the outer side of the knee, where it anastomoses with the lateral superior genicular branch of the popliteal artery. Muscular branches supplying the vastus lateralis and vastus intermedius anastomose with the perforating arteries.

The **medial femoral circumflex artery** is smaller than the lateral. Arising from the inner and back part of the arteria profunda femoris, opposite the origin of the lateral circumflex, it passes directly backwards on the inner side of the femur. It first lies between the pectineus and psoas major, and, on a deeper plane, occupies an interval between the adductor brevis and obturator externus, where it ends by dividing into two branches—ascending and transverse. It supplies large muscular branches to the obturator externus and to the adductor muscles, and an articular branch which passes through the acetabular notch with a branch from the obturator artery, with which it varies inversely in size.

The *ascending branch* follows the tendon of the obturator externus to the trochanteric fossa of the femur, where it anastomoses with the superior and inferior gluteal and first perforating arteries, thus taking part in the **trochanteric anastomosis.**

The *transverse branch* maintains the direction of the parent trunk, and passes backwards between the adductor magnus and the quad-

ratus femoris to the gluteal region, where by anastomosing with th transverse branch of the lateral circumflex, the first perforating, an the inferior gluteal arteries, it helps to form the cruciate anastomosis

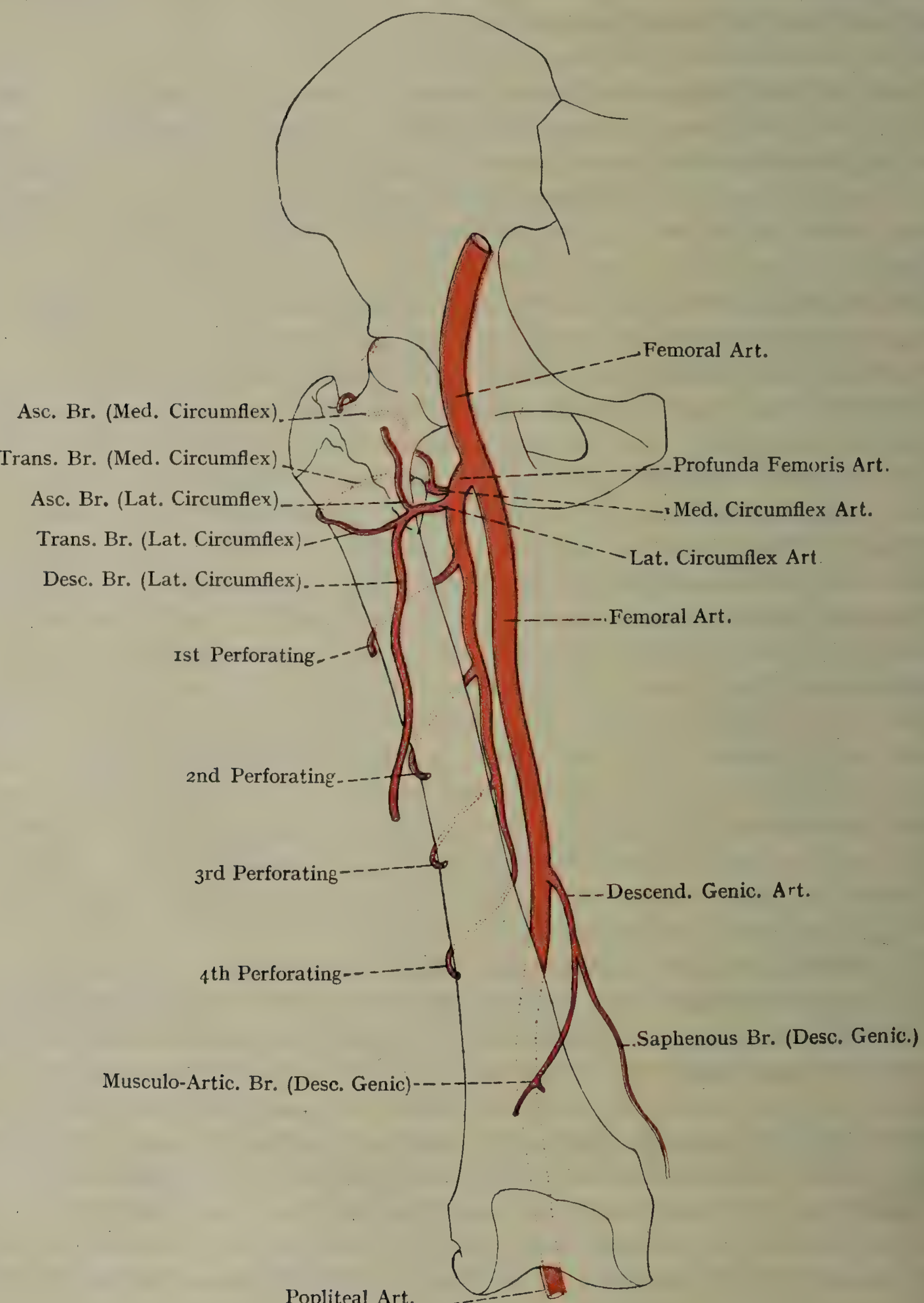


FIG. 354.—THE RELATIONS OF THE FEMORAL ARTERY AND ITS BRANCHES TO THE SKELETON.

The four **perforating arteries** (Fig. 354) all pass backwards rou the inner side of the femur, lying between the bone and the tendino arcades of the adductor magnus. The first and second arteries traver

both the adductor brevis and the adductor magnus, whilst the third and fourth traverse the adductor magnus only. On reaching the back of the thigh, all four arteries give off muscular branches to the hamstring muscles, branches to the sciatic nerve, and cutaneous branches which follow the lateral intermuscular septum and supply the skin. On the back of the thigh the first perforating artery traverses the femoral attachment of the gluteus maximus, while the lower three pass through the femoral head of the biceps. Terminally the perforating arteries traverse the lateral intermuscular septum, and end in the substance of the vastus lateralis. From the second perforating artery (sometimes from the third) the nutrient artery to the shaft of the femur is derived. The first perforating artery has a branch which ascends on the back of the adductor magnus, and takes part in the formation of the cruciate anastomosis, whereby it communicates with the circumflex and inferior gluteal arteries. It has a further communication with the latter artery by means of its branches to the sciatic nerve, which anastomose with the companion artery of sciatic nerve. The successive perforating arteries freely communicate with one another, and the last perforating artery anastomoses with branches of the popliteal artery. These arteries thus form a series of communicating links in an anastomotic chain at the back of the thigh, whereby blood may flow from the inferior gluteal artery above into the popliteal artery below.

The anastomotic chain at the back of the thigh is multiple, consisting of (1) direct communications between the inferior gluteal, the medial circumflex, and the successive perforating arteries at the back of the adductor magnus; (2) communications between the muscular branches; (3) communications between the branches supplying the sciatic nerve.

Branches of the Femoral Artery in the Subsartorial Canal.—Small muscular twigs are derived from the femoral artery as it lies in the femoral triangle, but the larger muscular branches come off from the lower part of the trunk in the subsartorial canal. They are mainly distributed to the muscles forming the walls of the canal.

The **descending genicular artery** (Fig. 354) arises from the femoral artery towards the lower end of the subsartorial canal, and divides into a saphenous and a musculo-articular branch. In some cases the two branches arise independently. The *saphenous branch* traverses the fascial roof of the subsartorial canal, appears at the hinder edge of the sartorius, along which it descends in company with the saphenous nerve to the inner side of the knee. It takes part in the anastomosis on the inner side of the knee, and ends by supplying the skin on the inner side of the leg for a variable distance. The *musculo-articular branch* first descends parallel to the tendon of the adductor magnus. Changing its direction, it passes outwards through the vastus medialis and crosses the front of the lower end of the femur obliquely. Its terminal branches end in the anastomosis between the two superior genicular branches of the popliteal artery.

Varieties—The Femoral Artery.—(1) In rare cases the femoral artery replaced by a large artery on the back of the thigh accompanying the sciat nerve, and continuous above with an enlarged inferior gluteal artery. In th condition the external iliac artery ends in the arteria profunda femoris.

(2) Occasionally the femoral artery divides below the origin of the arteri profunda femoris into two trunks of equal size, which reunite to form one trun at a lower level.

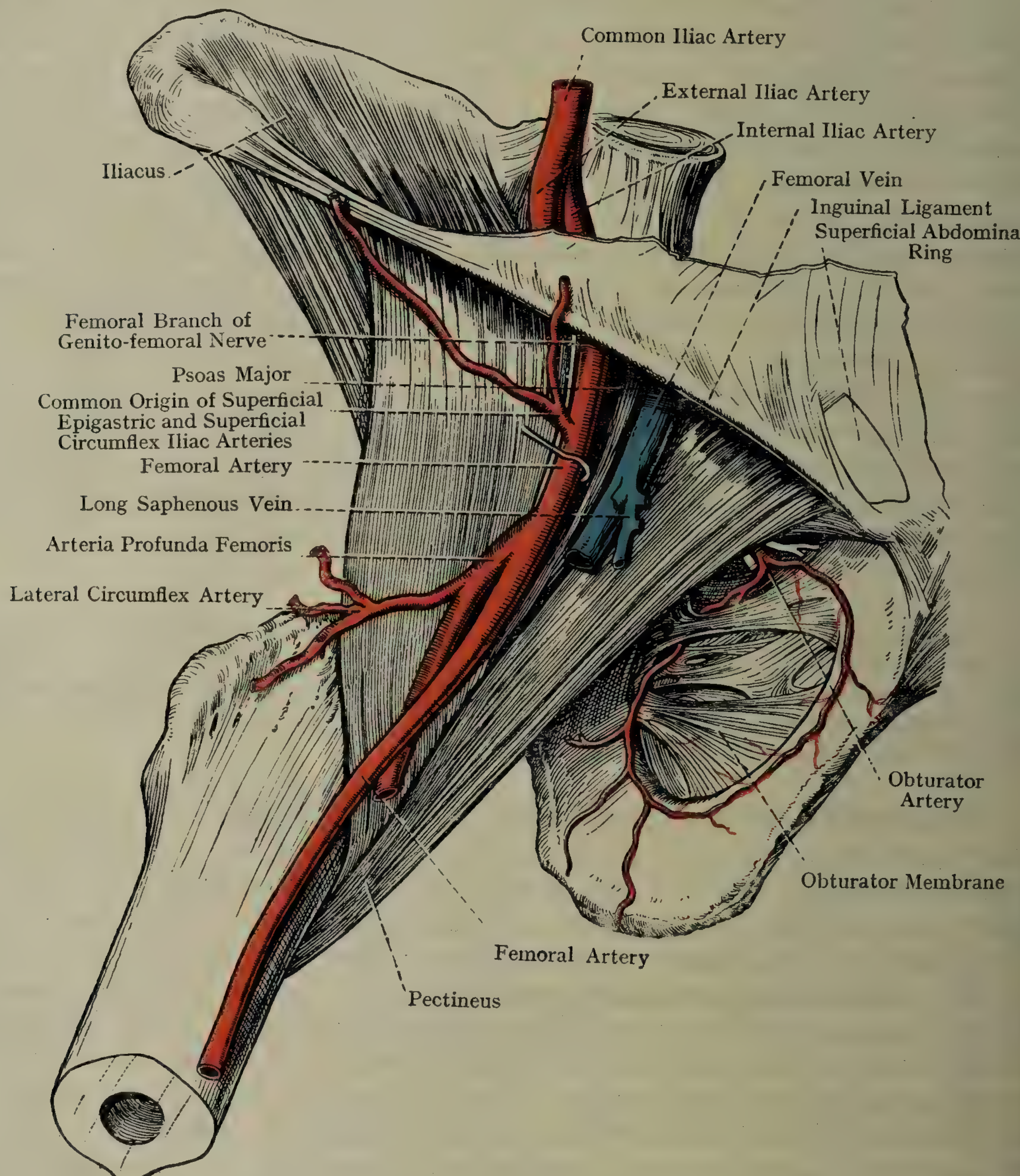


FIG. 355.—DEEP DISSECTION OF THE FEMORAL TRIANGLE.

The **arteria profunda femoris** normally arises from the femoral from $1\frac{1}{2}$ to 2 inches below the inguinal ligament, but the level at which the femoral artery divides is very variable. The profunda femoral artery may arise from the external iliac above the level of the inguinal ligament. In rare cases the subdivision of the femoral artery takes place at a low level, even as low as 4 inches below the inguinal ligament.

The **lateral circumflex artery** is very variable. It may arise from the femoral,

as is usually the case in low origin of the profunda femoris. It may be represented by two arteries arising variably from the profunda femoris or from the femoral.

The **medial circumflex artery** is more constant. It may arise in common with the lateral circumflex; from the femoral; from the inferior epigastric; or from the external iliac.

The Descending Genicular Artery.—In rare cases the superficial branch is enlarged, and extends downwards to the medial malleolus in company with the long saphenous vein. This condition resembles that found normally in some animals, where the vessel is known as the *saphenous artery*.

Abnormal Branches.—The inferior epigastric, the deep circumflex iliac, and the obturator artery have all been known to arise from the femoral artery.

The **femoral vein** extends upwards from the opening in the adductor magnus to the lower border of the inguinal ligament, where it is continuous with the external iliac vein. In the lower part of the subsartorial canal it is behind and to the outer side of the femoral artery. As it ascends it passes directly behind the artery, in which position it enters the femoral triangle. In the femoral triangle it inclines inwards and forwards, and below the inguinal ligament it lies to the inner side of and in the same plane as the femoral artery.

The **tributaries** correspond to the branches of the femoral artery, with the addition of the long saphenous vein, which joins the femoral vein in the femoral triangle. The veins corresponding to the three superficial branches of the femoral artery are tributaries of the long saphenous vein; they join this vein independently or more usually by a common trunk.

The femoral vein is provided with from one to five valves. The most constant is found at its upper end above the junction of the long saphenous vein, and controls the return of venous blood from the lower limb.

The **profunda femoris vein** lies in front of its companion artery, and in the lower part of the femoral triangle intervenes between it and the femoral vessels, which are here directly in front of it. It is provided with several valves.

The **obturator artery** (Fig. 355) arises from the anterior division of the internal iliac, and lies, for the greater part of its course, on the outer wall of the pelvic cavity. It passes through the obturator canal, and divides into two terminal branches, medial and lateral. The two pass downwards deeply to the obturator internus muscle, and follow the inner and outer margins of the obturator membrane respectively. The *medial branch* supplies the obturator externus and adjacent adductor muscles. The *lateral branch* divides into two. A *pubic branch* passes inwards, and, anastomosing with the medial branch, completes an arterial circle surrounding the obturator membrane. The other passes outwards below the acetabulum to the ischial tuberosity, where it supplies the origins of the hamstring muscles and anastomoses with the inferior gluteal artery; it also gives an *acetabular branch* which passes through the acetabular notch and supplies the hip-joint. Both terminal branches of the obturator anastomose with the medial circumflex artery of the arteria profunda femoris.

THE HIP-JOINT.

The articular surfaces taking part in the formation of the joint a the head of the femur and the acetabulum. The ligaments are a ca sular ligament supplemented by accessory ligaments, together with t ligament of head of femur, the labrum acetabulare, and the transve ligament.

The **capsular ligament** is very strong, and completely surrounds t joint. Its **attachments to the hip-bone** are: *Above* and *behind* it

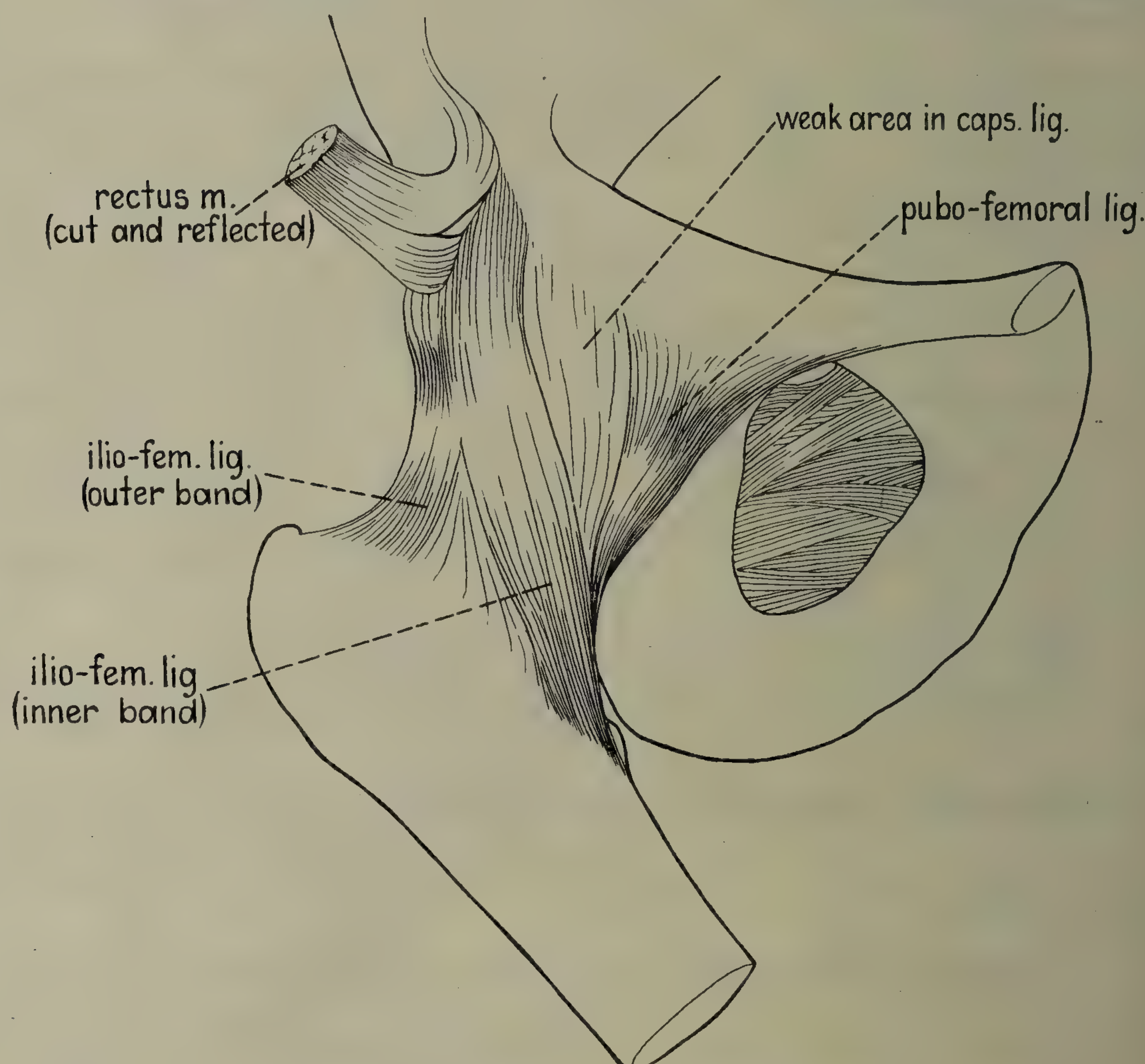


FIG. 356.—THE RIGHT HIP-JOINT VIEWED FROM IN FRONT (AFTER SOBOTTA

The weak area of the capsular ligament may have a deficiency through whic the synovial cavity communicates with the bursa underlying the tendon the psoas.

attached to the bone some little distance away from the edge of th acetabulum, being fixed above to the groove giving origin to th reflected head of the rectus. In *front* its attachment is close to th margin of the acetabulum, and it is here adherent to the labrur acetabulare. *Below* it is attached to the transverse ligament, whic bridges across the acetabular notch. Its **femoral attachments** are *Above* to the front part of the greater trochanter and the upper tubercl of the neck. In *front* to the upper rough part of the trochanteric line

hich is on the front of the femur, and extends between the upper and ower tubercles of the neck. *Behind* to a faint ridge which extends pwards for a short distance from the lower tubercle of the neck, and es to the inner side and in front of the lesser trochanter. Above this idge the capsular ligament has no direct attachment to the bone, but as a more or less free edge (Fig. 357), from under cover of which the ynovial membrane may protrude in certain joint movements. This ee edge corresponds in position to a line marking the junction of the uter third and inner two-thirds of the posterior surface of the femoral eck.

From the above description it can be realized that the only part of the neck hich is not clothed by the capsular ligament is the outer third of the posterior urface. This part of the neck may be involved by a fracture which is termed *xtracapsular* in contra-distinction to an *intracapsular* fracture which involves ny part of the neck situated within the limits of the capsule.

The fibres of the capsular ligament are disposed both longitudinally nd circularly. The longitudinal fibres are the more superficial, and re mainly provided by the accessory or supplementing ligaments. he circular fibres, or **zona orbicularis,** are the deeper, and are most pparent on the posterior and inferior aspects of the joint, where the apsular ligament is relatively thin and the longitudinal fibres are more r less deficient.

In certain situations the capsular ligament is thickened and trengthened by accessory or supplementing ligaments known as the lio-femoral, ischio-femoral, and pubo-femoral ligaments.

The **ilio-femoral ligament** (Fig. 356) is situated on the anterior spect of the joint, and is a triangular band, the apex of which is ttached above to the anterior inferior iliac spine below the origin of he straight head of the rectus femoris. From its upper attachment he fibres of the ligament spread out fanwise to its base, which is ttached below to the trochanteric line and extends from the upper o the lower tubercle of the neck. The central part of the ligament is elatively thin, but the marginal parts are thickened bands, and together present the appearance of an inverted Y. They account for the 'Y-*ligament of Bigelow*,' by which name it is sometimes known. The nner band is almost vertical, and is attached below to the lower tubercle of the neck. The outer band, shorter than the inner, passes bliquely downwards and outwards, and is attached to the upper tubercle of the neck.

The **ischio-femoral ligament** (Fig. 357) is a triangular band which occupies the posterior aspect of the joint. Its base is attached to the ischium close to the acetabular margin. The lowest fibres are attached to the upper lip of the groove below the acetabulum, and are disposed to a certain extent on the inferior aspect of the joint. From its ischial attachment the ligament stretches obliquely upwards and outwards, gains the upper aspect of the joint, and is attached for the most part to the deep or inner aspect of the greater trochanter immediately in front of the depression giving attachment to the obturator internus

and the two gemelli. Some of its fibres, especially the lower, sprea out and are continuous with the fibres of the zona orbicularis. Fro the foregoing description it may be gathered that the ischio-femor ligament has a somewhat spiral disposition extending from the inferi aspect on to the posterior, and thence on to the superior aspect of tl joint.

The **pubo-femoral ligament** (Fig. 356) is a triangular band with i base at the hip-bone, where its fibres are attached to the ilio-pub eminence and to the superior pubic ramus; they often extend inwar as far as the pubic tubercle. Some of its lower fibres are usually co tinuous with those of the obturator membrane. The main part of tl ligament occupies the medial aspect of the joint, and its fibres conver

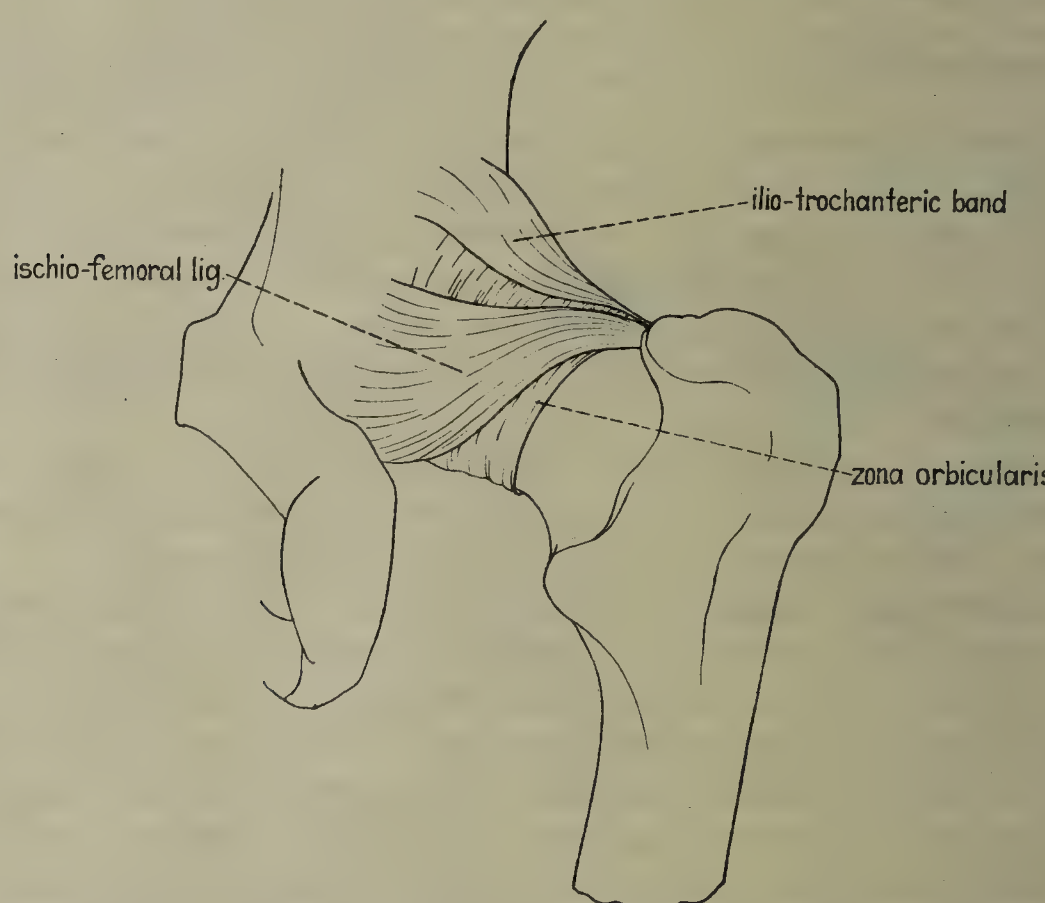


FIG. 357.—THE RIGHT HIP-JOINT (POSTERIOR VIEW).

towards and meet the medial band of the ilio-femoral ligament, wit which it is attached to the inferior tubercle of the neck; the lowe fibres gain the posterior aspect of the joint, and are attached to th ridge which extends upwards from the inferior tubercle of the neck t the inner side, and in front of the lesser trochanter.

Between the pubo-femoral ligament and the inner vertical band o the ilio-femoral ligament the capsular ligament clothing the front o the joint is relatively weak and thin. The tendon of the psoas is her lying directly in front of it, and it may present a deficiency througl which the synovial membrane of the joint is continuous with a burs underlying the psoas.

It may be noted that the three main accessory or supplementing ligament of the hip-joint are all triangular: the ischio-femoral and the pubo-femoral

vith their bases or more extensive attachments at the hip-bone and their more imited attachments at the femur; the ilio-femoral ligament, on the other hand, has its more limited attachment at the hip-bone, while its femoral attachment is the more extensive.

Between the outer oblique band of the ilio-femoral ligament and he ischio-femoral ligament the longitudinal fibres of the capsular igament, stretching from the groove above the margin of the acetabulum (giving attachment to the reflected head of the rectus femoris) o the greater trochanter, are sometimes regarded as an independent igament, the **ilio-trochanteric band** (Fig. 357).

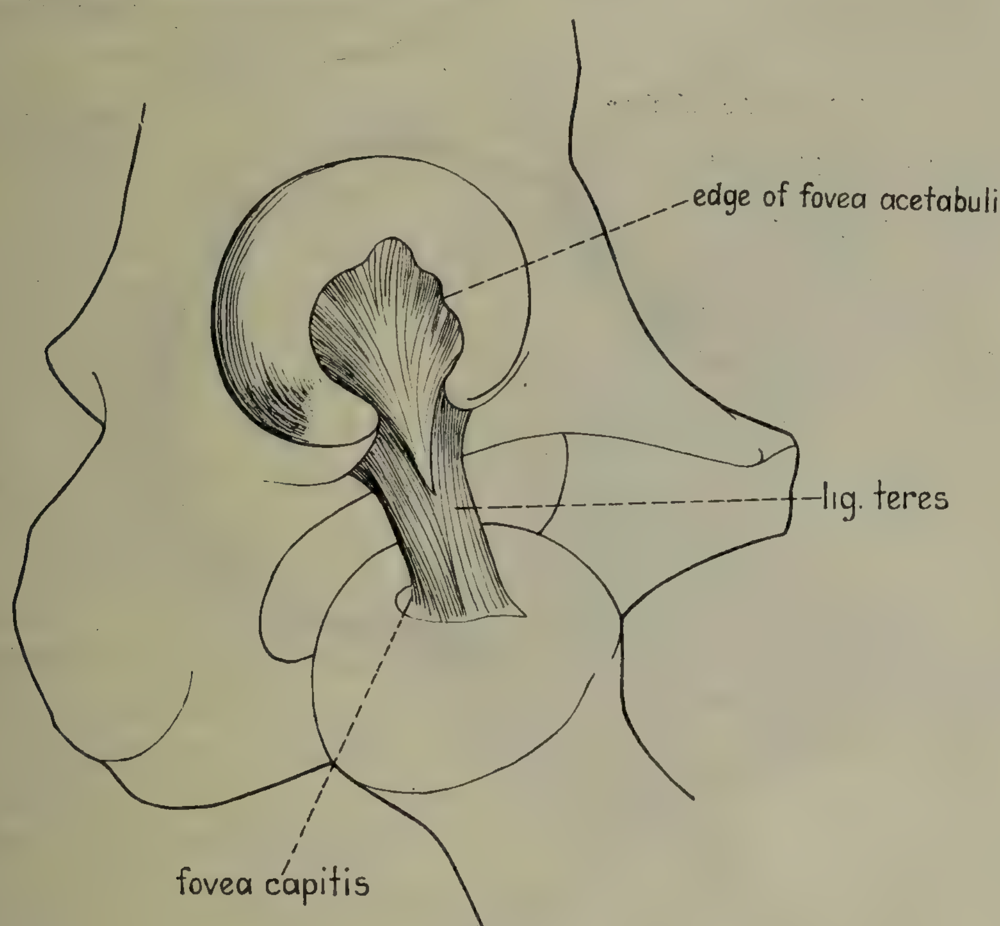


FIG. 358.—THE HEAD OF THE FEMUR WITHDRAWN FROM THE ACETABULAR CUP TO SHOW THE CENTRAL PART OF THE LIGAMENTUM TERES SPREADING OUT AND SURROUNDING THE FAT IN THE FOVEA ACETABULI, WHILE ITS TWO THICK LATERAL MARGINS PASS THROUGH THE COTYLOID NOTCH.

When the hip-joint is opened, the deepest fibres of the capsular igament are seen to be reflected from their femoral attachments on to the neck of the femur, which they clothe, and extend upwards as far as the margin of the articular cartilage of the head. Some of these reflected fibres form distinct bands best marked on the front and upper aspects of the neck of the femur and termed the *retinacula* (Fig. 359).

The **ligament of head of femur** (Fig. 358) extends between the head of the femur and the acetabulum, and is, as regards its position, an intracapsular structure. At one end it is attached as a relatively narrow flattened band to the small rough area interrupting the articular cartilage clothing the head of the femur (pit on head of femur). As it approaches the floor of the acetabulum it broadens into a triangular sheet, the margins of which are thickened bands attached on either

side of the acetabular notch and extending for a little distance beyo the limits of the joint. The central part is thin, and consists of scatte fibres thickening the synovial membrane which ensheathes the li ment of head of femur, and is attached with it to the margin of large rough area interrupting the articular cartilage lining the acet ulum (acetabular fossa), where it surrounds the pad of fat lod therein (Fig. 358). When the head of the femur and the acetabul

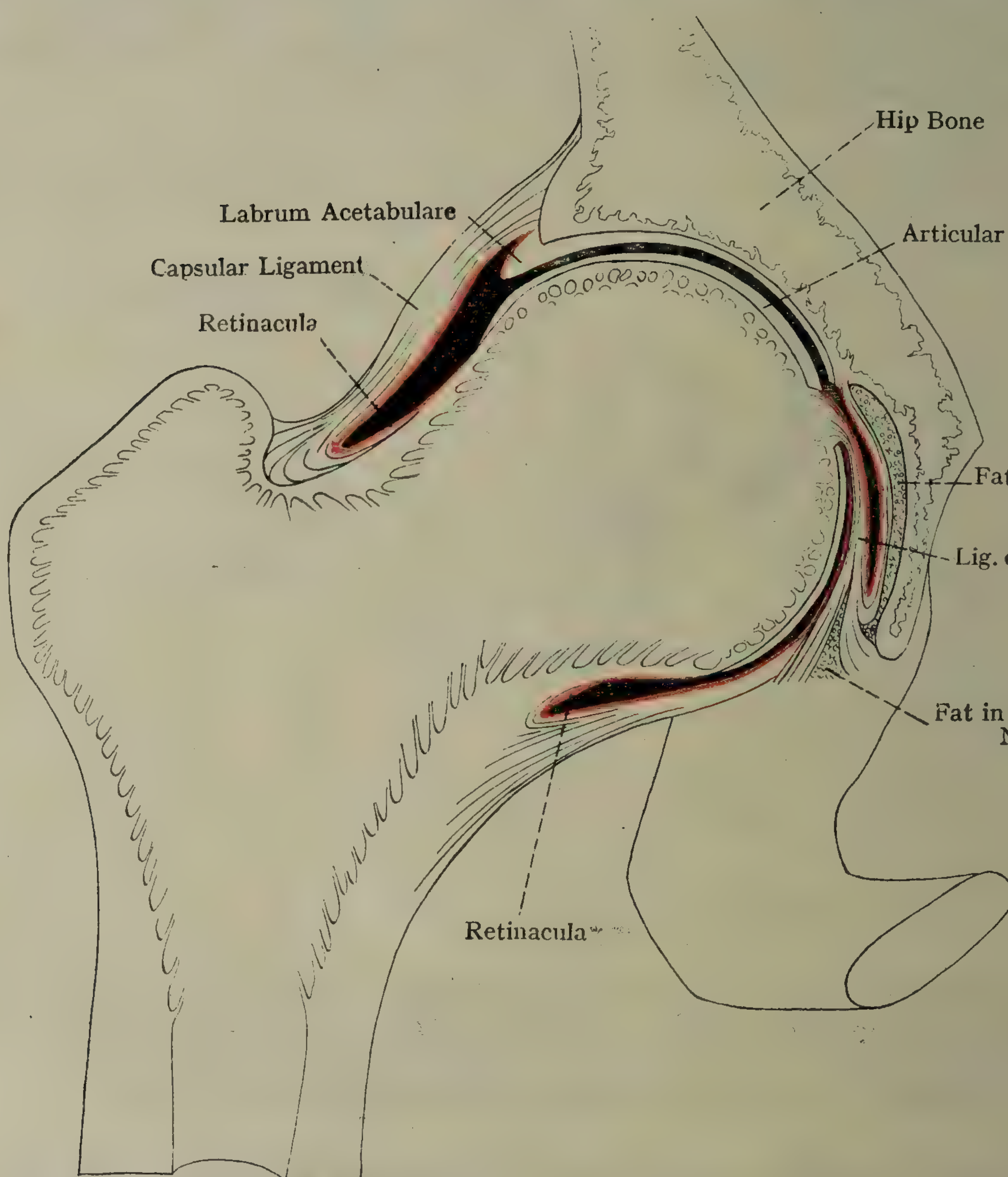


FIG. 359.—A CORONAL SECTION THROUGH THE HIP-JOINT TO SHOW THE D POSITION OF THE LIGAMENT OF HEAD WHEN THE HEAD OF THE FEMUR LODGED IN THE ACETABULAR CUP.

The synovial membrane is indicated by a red line.

are in apposition, the ligament of head is interposed between th articular surfaces (Fig. 359).

Morphologically the ligament is a thickened infolding of the synovial me brane, which has come into being as a result of the way in which the articu surfaces of the hip-joint have expanded, and which has become complet isolated at its femoral attachment.

The **labrum acetabulare** is a firm annular band of fibro-cartila which is implanted upon the brim of the acetabulum, and bridges ov

ıe acetabular notch. It serves to deepen the acetabular cup. Its bres are oblique in direction, and are for the most part attached to ıe outer and inner surfaces of the brim, but opposite the acetabular otch they are attached to the transverse ligament. The outer surface f the labrum is convex, whilst the inner surface is concave and closely pplied to the head of the femur. The labrum is triangular in section, he base being implanted on the brim of the acetabulum, and the apex epresenting the free margin, which is so incurved as to grasp the head f the femur.

The **transverse ligament** ridges over the acetabular otch. It is composed of hree bundles of fibres inimately blended with one nother. The superficial undle is formed by that art of the labrum acetaulare which stretches over he notch. The other two undles are more deeply laced, and are arranged as wo decussating bands exending between the margins f the notch, and blending losely with the superficial undle. Between the transerse ligament and the floor f the acetabular notch is a pace whereby the fat lodged n the fovea acetabular fossa s continuous with the extra rticular fat, and which gives assage to articular vessels nd nerves.

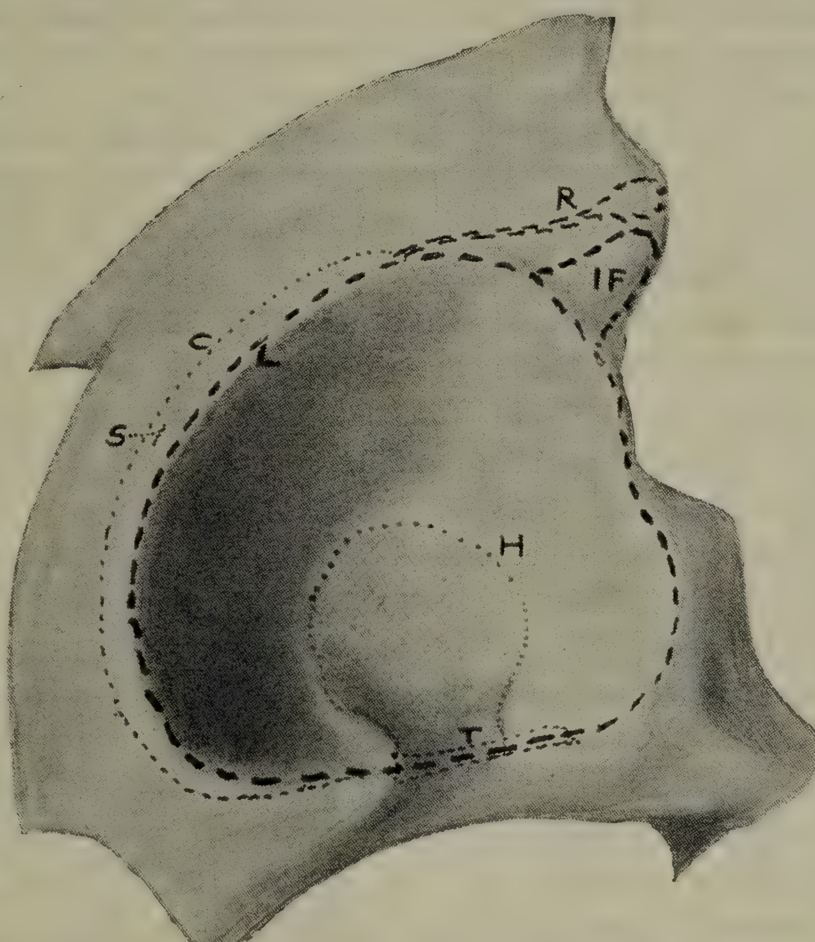


FIG. 360.—VIEW OF RIGHT ACETABULUM, SHOWING THE ACETABULAR LABRUM (L) ATTACHED ROUND THE MARGIN AND TO THE TRANSVERSE LIGAMENT (T).

Capsule is attached to labrum in front, but is a little distance away from it (C) behind, so that a synovial sulcus (S) lies between the two. IF, ilio-femoral band; R, rectus; H, dotted line showing attachment of base of 'ligament of head of femur.'

The Synovial Membrane.—The synovial membrane may be traced from the femur, where it is attached to the circumferential edge of the articular cartilage covering the rounded head of the bone. Thence it passes downwards and outwards as a cylindrical sheath surrounding the neck of the femur, and clothing the retinacula as far as the line of attachment of the capsular ligament. From this line it is reflected on to the deep aspect of the capsular ligament, which it lines completely, and extends to the margin of the acetabulum. At the margin of the acetabulum it is reflected on to the outer or superficial aspect of the labrum acetabulare, coming to an end at its free margin except n the region of the acetabular notch, where its line of attachment

is infolded into the joint, following the margin of the articular cartilag bordering the acetabular fossa. From this margin the synovial mem brane is prolonged as a tent-like arrangement surrounding the ligamen of head of femur and the pad of fat occupying the acetabular foss As a complete investment to the ligament of head the synovial mem brane may be traced to the femoral attachment of this band, where finally comes to an end around the margin of the pit of head of femur.

The synovial membrane is usually described as covering both aspects of th labrum acetabulare, but it is most improbable that as such it covers the dee aspect, which is in contact with the head of the femur.

The so-called **Haversian gland** occupies the acetabular fossa c rough area of the acetabulum. It is simply a mass of fat invested b the ligament of head of femur and the synovial membrane.

Muscular Relations.—The hip-joint is deeply placed, and is buried i a thick mass of surrounding muscles. As the head of the femur i almost completely lodged in the acetabular cup, and the neck of th femur is almost completely clothed by the capsular ligament, th muscular relations of the joint are, for all practical purposes, those c the femoral neck. Further, the neck of the femur is so obliquely dis posed that structures lying above it must also be to a certain extent o its outer side, while structures lying below it must also be to som extent on its inner side. Certain muscles which cross the joint pas from one aspect to another. For instance, the ilio-psoas passes down wards from in front of the joint to its lower and inner aspect in orde to gain the lesser trochanter; above, the pectineus lies in front of th pubo-femoral ligament, but in passing downwards and backwards t gain the back of the femur lies to the inner side of the neck of th femur; the main part of the obturator externus is to the inner side o the joint, but its tendon in passing outwards to gain the greate trochanter is applied to the posterior aspect of the femoral neck Keeping these facts in mind, the muscular relations of the joint ma be classified as follows: *In front:* Sartorius, rectus femoris, ilio-psoas pectineus. *Below and to the inner side:* Ilio-psoas, pectineus, obturato externus. *Behind:* Gluteus maximus superficially; the pyriformis obturator internus, the two gemelli, and quadratus femoris on a deepe plane, and the obturator externus in direct contact with the joint *Above and to the outer side:* Tensor fasciæ latæ, gluteus medius, gluteu minimus, and the reflected head of the rectus.

Arterial Supply.—The articular arteries to the hip-joint are derivec from the two circumflex, the obturator, the superior and inferio gluteal.

The articular arteries derived from the medial circumflex, or from the ob turator or from both vessels, and passing through the acetabular notch, suppl the fat lodged in the acetabular fossa, and may be traced into the ligament o head of femur. It has been thought that this ligament transmits the arterie which are responsible for the supply of the head of the femur, but the vessel in the ligament are so minute that they can convey little or no blood to th bone.

Nerve-supply.—The nerve-supply of the hip-joint is derived from the hree large nerves—the femoral, the obturator, and the sciatic—which upply the three muscle groups of the thigh: *Femoral,* by a branch rom the nerve supplying the rectus femoris; *obturator,* by a branch rom the anterior division; *sciatic,* by a branch from the nerve itself or rom the nerve to the quadratus, a nerve whose origin is closely ssociated with that of the sciatic, and of which it may be a branch.

The **movements** which occur in the joint are flexion, extension, abduction, dduction, rotation, and circumduction.

Flexion.—In flexion the thigh is drawn up towards the anterior abdominal vall. The extent of flexion possible depends upon the position of the knee-oint, being greater when that joint is flexed and more limited when it is ex-ended. This is due to the *passive insufficiency* of the hamstrings, these muscles eing incapable, without special training, of elongating sufficiently to permit ull extension of the knee-joint and full flexion of the hip-joint to occur simul-aneously. The hamstrings are, therefore, concerned in limiting movement oth at the hip-joint and at the knee-joint. If the knee-joint is flexed, flexion f the hip-joint is limited by the coming into contact of the soft parts on the ront of the thigh and on the anterior abdominal wall.

Extension is limited by the tension of the three chief accessory ligaments. The hip-joint is extended when standing in the erect posture. In this position he line of the centre of gravity falls behind the centre of rotation at the hip-oint, and there is consequently a tendency for the trunk to fall backwards t this joint. This tendency is counteracted not only by the tension of the lio-femoral and pubo-femoral ligaments on the front of the joint, but also by hat of the ischio-femoral ligament. During flexion and extension the neck f the femur is, owing to its oblique position, rotating about an imaginary line oughly corresponding to its own axis. During extension it is rotating forwards nd carrying the greater trochanter with it. The greater trochanter, to which ne end of the ischio-femoral is attached, travelling forwards, is displaced farther way from the attachment of the other end of the ligament to the ischial uberosity. Being spirally disposed, the ischio-femoral ligament is thus wound p or tightened during extension, while it is unwound or relaxed during flexion. Owing to the fact that in the erect posture the weight of the body tends to over-extend the hip-joint, and that this tendency is prevented by the tension f the strongest ligaments about the joint, the position can be maintained, as far s the hip-joint is concerned, with a minimal expenditure of muscular energy. Owing to the greater width of the pelvis, the direction of the articular surface f the acetabulum, and possibly the relative shortness of the ilio-femoral liga-nent, extension of the hip-joint is probably more limited in the female than n the male, and explains her characteristic gait.

Abduction is limited by the pubo-femoral ligament, the lower part of the apsule, and the tension of the adductor muscles.

Adduction is limited by the outer band of the ilio-femoral ligament and the pper part of the capsule.

Rotation consists of a movement of the femur round a longitudinal axis. This axis is represented by a line passing from the centre of the head of the emur to a point at the middle of the intercondylar notch.

Rotation may take place outwards or inwards. Lateral rotation is limited y the outer band of the ilio-femoral ligament; medial rotation by the ischio-emoral ligament, and by the muscles in contact with the back of the joint. The range of rotation is about 60 degrees.

Circumduction consists of flexion, abduction, extension, and adduction, ollowing one another in succession.

The labrum acetabulare is an elastic extensible ring tightly grasping the head of the femur in all positions of the joint. It plays a most important rôle, both n increasing the extent of the articular surface provided by the acetabulum

and in maintaining the apposition of the articular surfaces without interferin in any way with their mobility.

The Ligament of Head of Femur.—Although this ligament is in a conditio of tension in the position of adduction combined with flexion, it is not stron enough to have much influence in limiting the very forcible movements occurrin in the joint. Its acetabular end is intimately associated with and surrounds th Haversian gland or pad of fat lodged in the acetabular fossa. Its femora attachments must follow the displacements of the head of the femur occurrin in the different joint movements. Consequently, as it is pulled by the hea of the femur in various directions, as it is tightened or relaxed, so it must in fluence the position and amount of fat occupying the acetabular fossa. Tha the amount of fat within the joint varies may be easily proved by examinin the region of the acetabular notch of an intact joint when the neighbouring extra articular fat, which is continuous with the fat of the Haversian gland, has no been disturbed. If the joint be subjected to passive movements, at one momen this fat is apparently drawn into the joint through the acetabular notch, a another it escapes from the joint. That such an apparatus is a necessity arise from the fact that the head of the femur is not a perfect sphere, and that th various diameters of the acetabulum are unequal. Such being the case, in certai positions of the joint—when, for instance, the shortest diameter of the hea of the femur coincides with the longest diameter of the acetabular cup—cavita tion or a spatial interval would occur between the articular surfaces (a cir cumstance which would seriously interfere with the mobility of the joint) wer there no material ready at hand to be interposed between the two. Tha material is provided by the ligament of head and the Haversian pad, the forme being so disposed as to be always in the right place, and in the right degree o tension or relaxation at the right moment.

Muscles concerned in the Movements—**Flexion.**—Ilio-psoas, rectus femoris sartorius, and pectineus. **Extension.**—Gluteus maximus, the hamstring muscles and the ischial part of the adductor magnus. **Abduction.**—Gluteus medius gluteus minimus, the upper fibres of the gluteus maximus, tensor fasciæ latæ and sartorius. **Adduction.**—The adductor muscles and the pectineus. **Media Rotation.**—The anterior fibres of the gluteus medius and minimus, the tenso fasciæ latæ, the ilio-psoas, and the semitendinosus, especially when the kne is slightly flexed. **Lateral Rotation.**—The lower fibres of the gluteus maximus the posterior fibres of the gluteus medius and minimus, pyriformis, obturato internus and gemelli, quadratus femoris, pectineus, the adductor muscles, and sartorius.

Bursæ at the Hip-Joint.—The **subpsoas bursa** is situated between the tendon of the psoas and the anterior part of the capsular ligament in the interval between the ilio-femoral and pubo-capsular ligaments. Here the capsular ligament is very thin, and may present a deficiency through which the bursa is continuous with the synovial membrane of the joint. The **bursa of the gluteus medius** is situated between its tendon of insertion and the outer surface of the greater trochanter. The **bursa of the gluteus minimus** is situated between its tendon of insertion and the anterior surface of the greater trochanter.

A **bursa** associated with the **gluteus maximus** lies between its tendon of insertion and the vastus lateralis muscle.

THE LEG.

Landmarks.—The sharp sinuous anterior border or crest of the tibia is entirely subcutaneous, and is easily felt; it serves as a guide to the **tubercle,** which is situated at its upper end and gives attach-

ment to the ligamentum patellæ. The lower limit of the tubercle marks the level at which the popliteal divides into the anterior and posterior tibial arteries. The **head of the fibula** is a prominent landmark on the outer side of the leg; it is about 1 inch below the level of the upper surface of the lateral condyle of the tibia. The shaft of the fibula is for the most part obscured by muscles. It can be felt, however, in its lower fourth. The bone occupies a more posterior plane than the tibia. The prominence along the front of the leg in its upper two-thirds is mainly due to the fleshy belly of the tibialis anterior.

The **medial** and **lateral malleoli** are bold projections at the lower end of the leg, the medial being provided by the tibia, the lateral by the fibula. The malleoli are upon the same plane posteriorly, but the medial malleolus projects farther forwards than, and does not descend so low as, the lateral malleolus. This must be kept in mind in Syme's amputation at the ankle-joint. It should be carefully noted that, whilst the medial malleolus looks directly inwards, the medial tibial condyle has a slight inclination backwards as well as inwards. The tendons of the tibialis posterior and flexor digitorum longus may be felt behind the medial malleolus, the former being the larger and in closer contact with the bone. If the foot be inverted by raising its inner border, the tendon of the tibialis posterior will be more readily felt. The tendons of the peroneus longus and peroneus brevis are situated behind the lateral malleolus, where they lie one behind the other, the brevis tendon being in closer contact with the bone. Several tendons can readily be felt in front of the ankle-joint. From within outwards they are as follows: tibialis anterior, extensor hallucis longus, extensor digitorum longus, and peroneus tertius. All these tendons are best felt in the living subject when the foot is bent upon the leg.

The back of the leg is characterized by the prominence of the calf, which is produced by the gastrocnemius and soleus muscles. This prominence gives place inferiorly to the **tendo-calcaneus** (**Achillis**), which stands out boldly beneath the skin, and ends below at the calcanean tuberosity. On either side of the projection caused by the tendo-calcaneus there is a groove-like depression. The outer groove indicates the position of the short saphenous vein and sural nerve and the peroneal artery; the inner groove that of the posterior tibial vessels and nerve.

The course of the **anterior tibial artery** on the front of the leg is indicated by a line drawn from the superior tibio-fibular articulation to the centre of the front of the ankle-joint, midway between the two malleoli. This line practically coincides with the outer border of the tibialis anterior. The course of the **posterior tibial artery** corresponds with a line drawn from the centre of the popliteal space to a point midway between the tip of the medial malleolus and the point of the heel.

It is to be noted that in addition to the posterior tibial there is another large artery, the peroneal artery, on the back of the leg. In operations the guide to its position is the back of the fibula; the posterior

tibial lies between the two bones, except in the lower part of the le where it lies on the back of the tibia (Fig. 361).

The anterior and posterior tibial arteries can be compressed simu taneously with one hand by placing the thumb in front of the ankl joint midway between the two malleoli, and the middle finger midwa between the tip of the medial malleolus and the point of the heel.

The **long saphenous vein** may be visible in front of the medi malleolus, and from this point it may be traced upwards followin the medial subcutaneous surface of the tibia.

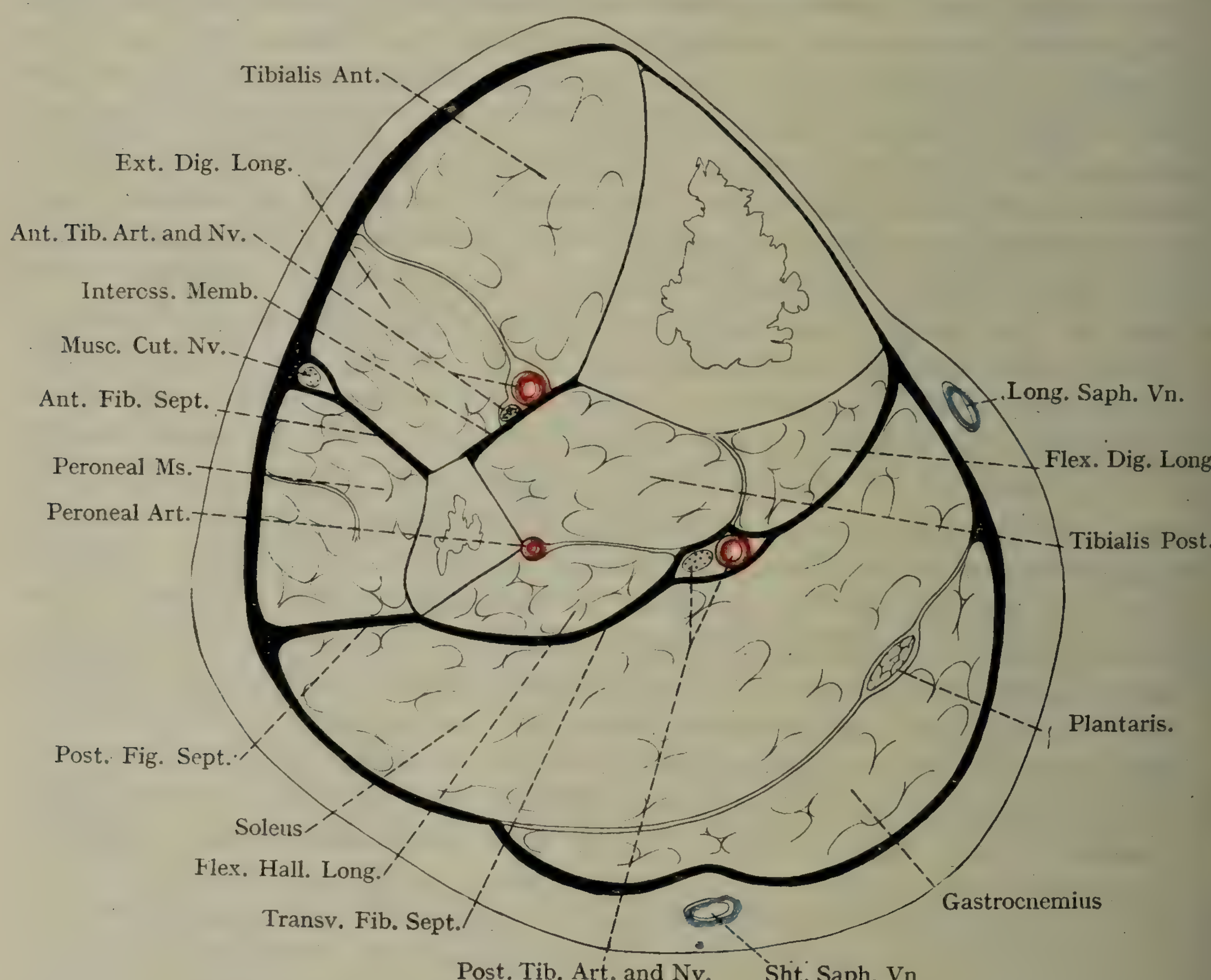


FIG. 361.—A TRANSVERSE SECTION THROUGH THE UPPER PART OF THE LE TO SHOW THE INTERMUSCULAR SEPTA AND THE RELATIVE POSITIONS O THE THREE CHIEF ARTERIES.

The short saphenous vein is rarely visible. It lies behind th lateral malleolus, in the groove on the outer side of the tendo-calcaneus It ascends to the middle line of the back of the leg, where it lies in th groove between the two heads of the gastrocnemius.

Deep Fascia.—The deep fascia is continuous above with the fasci lata of the thigh. In the region of the knee it is attached to the head of the fibula, the condyles of the tibia, the patella, ligamentum patellæ and tibial tubercle. In the leg it is attached to the crest and media border of the tibia. It is apparently interrupted by the medial subcu-taneous surface of the tibia, but is represented there by a thin layer

losely connected with the periosteum. At the ankle it is attached o the medial and lateral malleoli. The fibres are chiefly vertical in irection, but, in addition, there are transverse fibres, most marked t the back of the knee, and especially in the region of the ankle, where hickened bands of the transverse fibres of the deep fascia are known s retinacula. The deep fascia is very thin over the gastrocnemius, ut on the front and outer parts of the leg, more especially in its upper alf, it is very strong and dense, and here gives attachment to the uperficial fibres of the muscles which it covers. In the region of the nee it receives accessions of fibres from the tendons of the quadriceps emoris, biceps femoris, sartorius, gracilis, and semitendinosus.

Intermuscular Septa.—In addition to the interosseous membrane, vhich stretches from the lateral border of the tibia to the antero-lateral order of the fibula, and lies between the flexor muscles on the back of he leg and the extensor muscles in front, there are three intermuscular epta intervening between the main muscle groups of the leg. These re known as the anterior, posterior, and transverse fibular septa. The wo former are sometimes termed the anterior and posterior peroneal epta and are attached to the antero-lateral and postero-lateral borders f the fibula respectively. They are continuous with the deep fascia uperficially, and with it complete the walls of a fibro-osseous comartment containing the peroneus longus and peroneus brevis. They eparate these muscles from the extensors in front and the flexors ehind. The transverse septum occupies the back of the leg, and lies etween the superficial flexors, or calf muscles, and the deep flexor nuscles. There are thus four fascial compartments containing four nuscle groups: the extensor muscles supplied by the anterior tibial erve, the peroneal muscles supplied by the musculo-cutaneous nerve, he superficial flexors supplied by branches of the medial popliteal erve given off in the popliteal space, and the deep flexors supplied y the posterior tibial nerve. The posterior tibial vessels and nerve re contained in the transverse intermuscular septum; the anterior ibial vessels and nerve lie in front of the interosseous membrane and, eing covered anteriorly by a thin layer continuous on either side with he membrane, are to a certain extent embedded in it.

The **retinacula** (annular ligaments) are situated in the region of he ankle, and are simply thickened portions of the deep fascia, from vhich they may be artificially separated. They serve to confine and naintain the position of the strong tendons passing from leg to foot.

The **peroneal retinaculum** (external annular ligament) extends lownwards and backwards from the apex and posterior border of the ateral malleolus to the outer aspect of the hinder part of the calcaneum. It bridges over the peroneal groove behind the lateral malleolus, and serves to keep the tendons of the peroneus longus and brevis in place. The two tendons are here invested by a common synovial sheath. The lower part of the ligament is adherent deeply to the peroneal tubercle on the calcaneus. The tendon of the peroneus brevis is above the tubercle, that of the peroneus longus below it. Each tendon is here

contained in a separate compartment, and provided with its own synovial sheath, which in each case is continuous with, or a diverticulum of, the common synovial sheath behind the lateral malleolus.

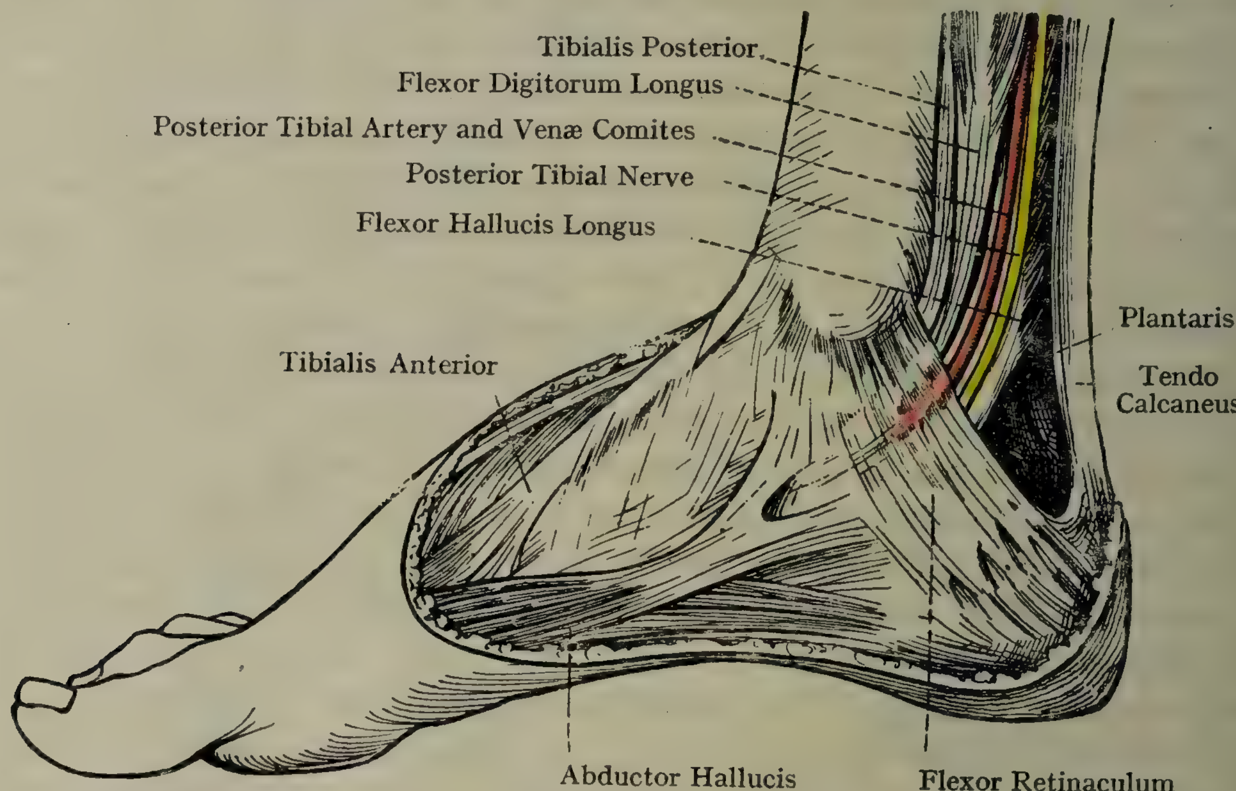


FIG. 362.—THE STRUCTURES BETWEEN THE MEDIAL MALLEOLUS AND THE HEEL.

The **flexor retinaculum** (internal annular ligament) (Fig. 362) extends obliquely downwards and backwards from the posterior border of the medial malleolus to the inner aspect of the hinder part of the calcaneus.

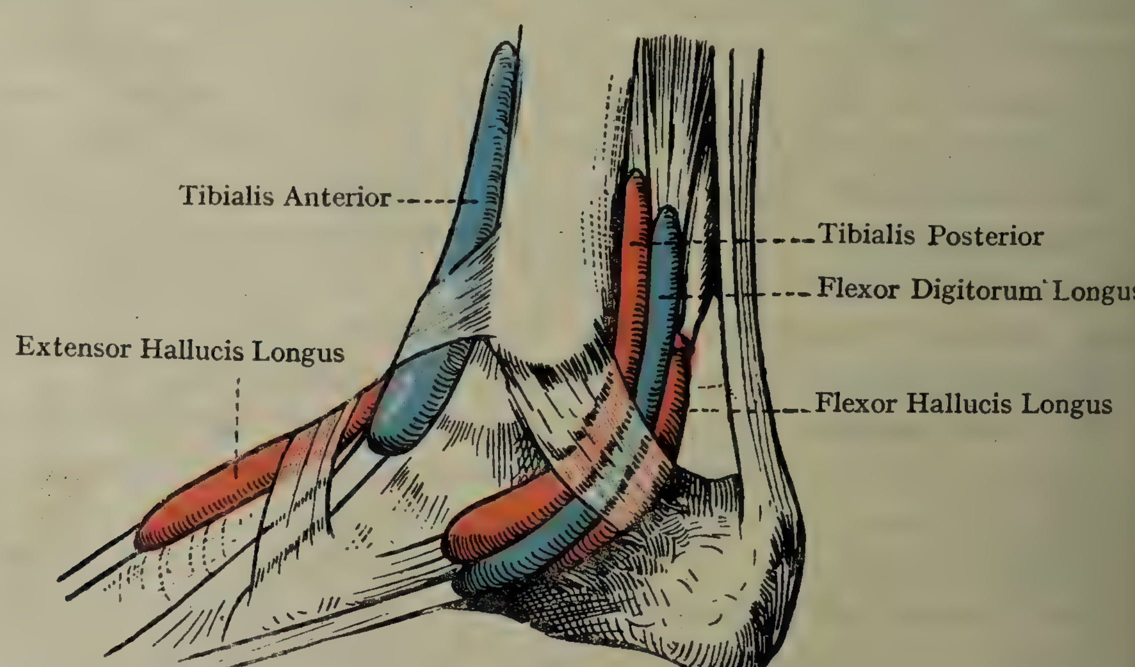


FIG. 363.—THE SYNOVIAL SHEATHS AT THE ANKLE (MEDIAL ASPECT) (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

It is continuous above both with the deep fascia of the leg and the transverse intermuscular septum, which here blend with one another. Its lower border gives origin to the abductor hallucis. It bridges across the grooves on the back of the lower end of the tibia, and con-

verts them into four canals containing, in order from within outwards: (1) the tendon of the tibialis posterior; (2) the tendon of the flexor digitorum longus; (3) the posterior tibial artery with a vena comes on either side of it, and the posterior tibial nerve; (4) the tendon of the flexor hallucis longus. Each of the three tendons is invested by an independent synovial sheath. Passing through the flexor retinaculum are the medial calcanean branch of the posterior tibial nerve and the medial calcanean branch of the posterior tibial artery.

The **extensor retinacula** (anterior annular ligament) (Fig. 364) consist of two parts: An upper, situated on the front of the leg above the ankle-joint, and called the superior extensor retinaculum; the lower lies in front of the bend of the ankle, and is called the inferior extensor retinaculum.

The *superior extensor retinaculum* is a broad band extending transversely between the anterior borders of the tibia and fibula, and measuring about 2 inches from above downwards. Above and below it the deep fascia is exceedingly thin. The structures lying deeply to it are in order from within outwards: (1) tibialis anterior, (2) extensor hallucis longus, (3) anterior tibial vessels, (4) anterior tibial nerve, (5) extensor digitorum longus, and (6) peroneus tertius. These structures occupy one common compartment, the tibialis anterior tendon alone being provided with a synovial sheath.

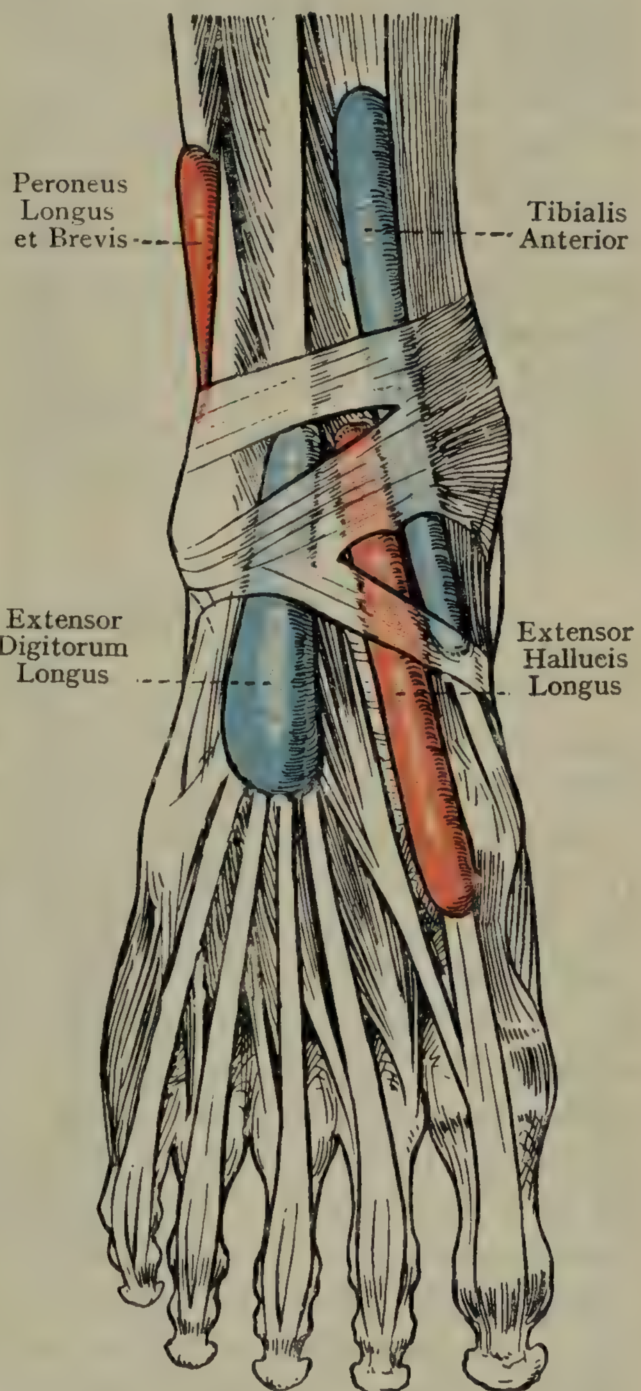


FIG. 364.—THE SYNOVIAL SHEATHS AT THE ANKLE (ANTERIOR VIEW) (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

The *inferior extensor retinaculum* is a thicker and more defined structure than the superior. It is placed in front of the ankle-joint, and serves to strap down the extensor tendons and prevents them from springing forwards in a region where the direction of the tendons suddenly changes from a vertical disposition in the leg to a nearly horizontal one in the foot. The ligament therefore plays the part of a pulley. It may be likened to the capital letter Y (Fig. 364). The outer part, or stem of the Y, is a narrow band attached to a depression on the upper surface of the front part of the calcaneum. Its attachment is closely associated with that of the extensor digitorum brevis,

some of the fibres of the muscle taking origin from it. This part i disposed in the form of a loop or sling (*fundiform ligament* of Retzius) through which the tendons of the extensor digitorum longus anc peroneus tertius pass, the two being invested by one synovial sheath Its inner end is continuous with two diverging bands, an upper and a lower. The upper band is attached to the medial malleolus; the anterior tibial vessels and nerve and the tendon of the extensor hallucis longus, surrounded by a synovial sheath, lie deeply to it. Farther inwards it splits to enclose the tendon of the tibialis anterior, the layer of the ligament lying deeply to the tendon being the thicker. The tendon of the tibialis anterior is provided with a synovial sheath, which is prolonged upwards into the leg behind the superior extensor retinaculum and downwards into the foot. The lower band is comparatively weak and arches across the foot to its inner side, where it is adherent deeply to the tuberosity of the navicular bone, and is continuous with the plantar aponeurosis. The dorsalis pedis vessels and anterior tibial nerve, together with the tendons of the extensor hallucis longus and tibialis anterior, each invested by its own synovial sheath, lie deeply to it.

The Inner Side of the Leg.

The inner surface of the tibia, except at its upper end, is subcutaneous. The deep fascia is here very thin, and is closely associated with the periosteum. The long saphenous vein lies about a finger's breadth behind the medial border of the tibia, and receives many tributaries from the front and back of the leg. In the upper part of the leg it is accompanied by the saphenous branch of the descending genicular artery. The long saphenous nerve lies immediately behind it. The terminal branches of the medial cutaneous nerve supply the skin in the upper part of the inner aspect of the leg. Attached to the upper part of the inner surface of the tibia are the tendons of insertion of the sartorius, gracilis, and semitendinosus, and the medial ligament of the knee-joint. The tendons of the sartorius, gracilis, and semitendinosus, in this order from before backwards, pass obliquely downwards and forwards superficially to the medial ligament, from which they are separated by a large bursa. Lying deeply to the medial ligament are the tendon of insertion of the semimembranosus, which is implanted into the horizontal groove on the medial tibial condyle, and at a lower level the inferior genicular artery.

The Front of the Leg.

The **musculo-cutaneous nerve** is one of the two terminal branches of the lateral popliteal, and arises from that nerve as it lies on the outer side of the neck of the fibula deeply to the peroneus longus. It descends in the anterior fibular intermuscular septum, lying between the extensor digitorum longus in front and the peroneus longus and

brevis behind. In the lower part of the leg it becomes superficial, and divides into two terminal cutaneous branches, medial and lateral.

Branches.—Muscular to the peroneus longus and peroneus brevis; and **cutaneous** to the skin covering the lower third of the front of the leg.

The **medial terminal branch** descends to the dorsum of the foot, is superficial to both parts of the extensor retinaculum, and divides into two branches, inner and outer. The *inner branch* supplies the

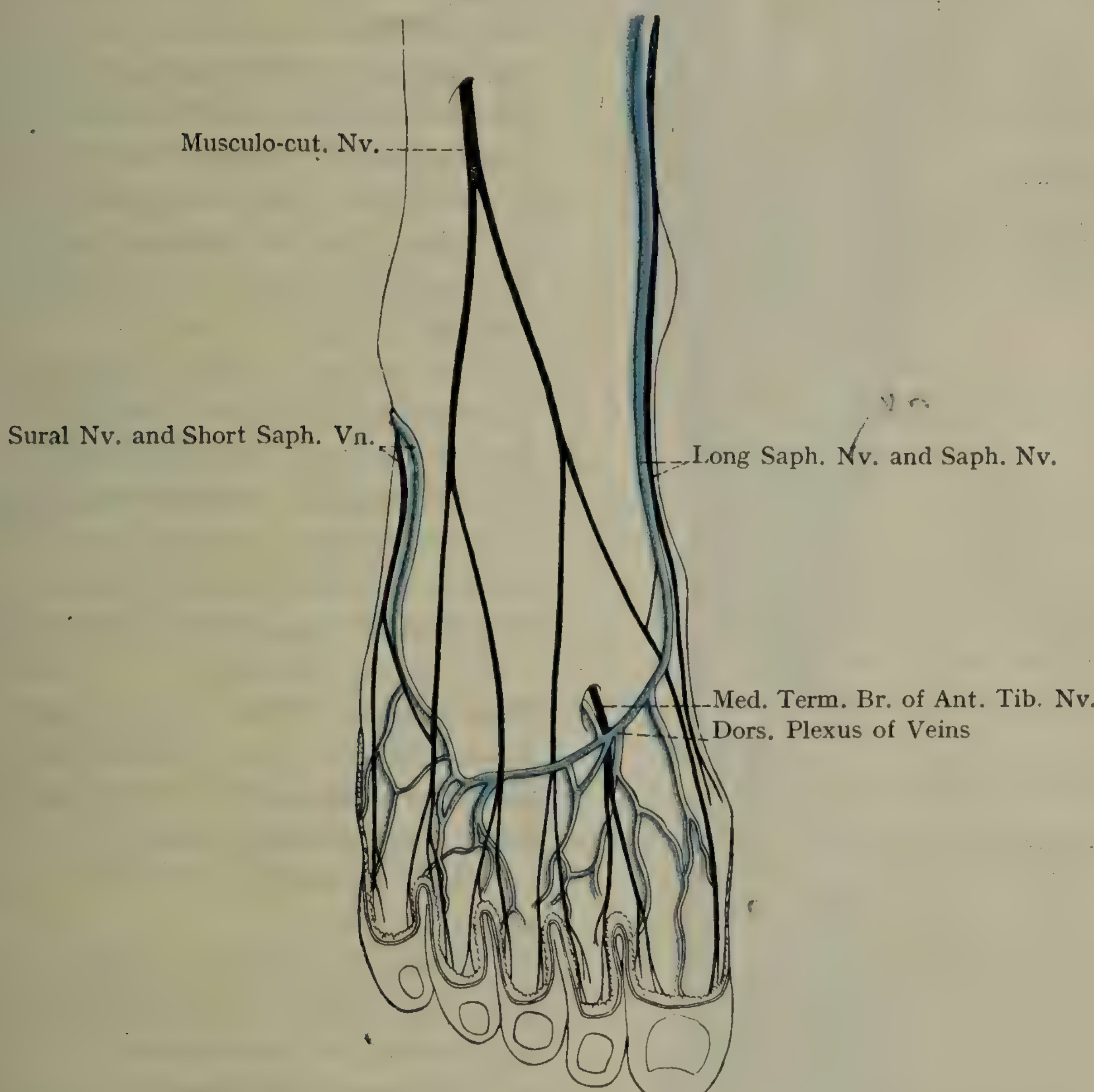


Fig. 365.—The Cutaneous Nerves and Dorsal Plexus of Veins on the Dorsum of the Foot.

skin on the inner side of the foot, communicates with the saphenous and anterior tibial nerves, and extends forward to supply the skin on the inner side of the great toe. The *outer branch* divides into two branches, which supply the skin lining the cleft between the second and third toes.

The **lateral terminal branch** also descends into the foot, and lies superficial to the extensor retinaculum. It divides into two branches, inner and outer. The *inner branch* subdivides and supplies the adjacent sides of the third and fourth toes; the *outer* has a similar distribution

to the fourth and fifth toes. The outer branch supplies the skin o the outer side of the foot, and communicates with the sural nerve.

The nerve supplying the skin of t adjacent sides of the fourth and fifth to is variable. It is often a branch of t sural nerve, in which case the later terminal branch of the musculo-cutaneo is small and supplies the cleft betwe the third and fourth toes only.

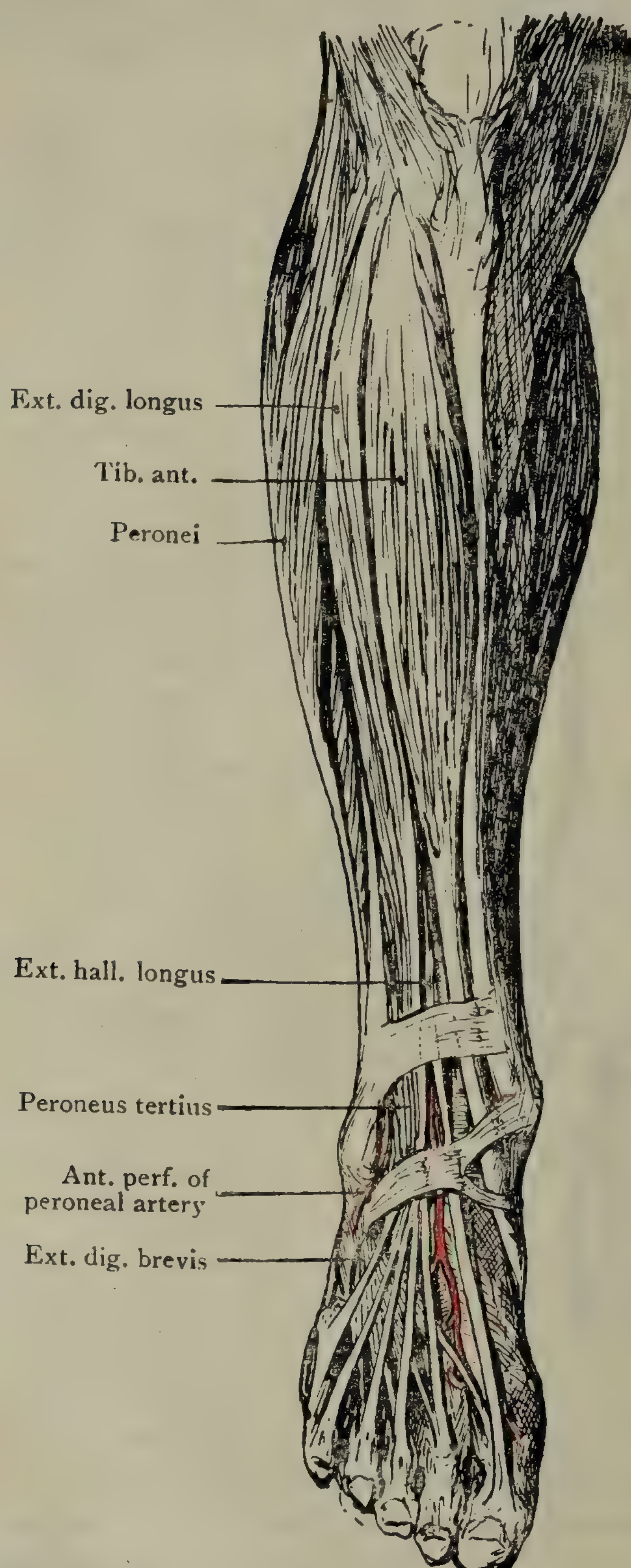


Fig. 366.—Dorsal Aspect of Leg and Foot: Superficial Dissection of Muscles.

Muscles—Tibialis Anterior (Fig. 366)—*Origin.*—The lower part o the lateral condyle of the tibia the upper two-thirds of the later surface of the shaft of the tibia an the adjacent part of the interosseou membrane; the deep fascia coverin it; and an intermuscular septum between it and the extensor dig torum longus.

Insertion.—The tendon extend downwards on the inner side of th foot to a groove on the inner surfac of the medial cuneiform bone, wher it divides into two slips. The pos terior slip is inserted into an ova impression at the lower part o the inner surface of the media cuneiform bone; the anterior i inserted into the tuberosity on th plantar aspect of the base of th first metatarsal bone.

Nerve-supply.—The anterio tibial nerve.

Action.—Flexes the foot upon the leg, and by raising its inne border inverts the foot.

Extensor Hallucis Longus—*Origin.*—The middle two-fourths of the anterior surface of the shaft o the fibula, and the adjacent part of the interosseous membrane.

Insertion.—The dorsal surface of the base of the distal phalanx of the great toe.

The extensor hallucis longus frequently gives an additional slip of insertion to the base of the proximal phalanx of the great toe.

Nerve-supply.—The anterior tibial nerve.

Action.—Extends the distal phalanx of the great toe, and flexes the foot upon the leg.

The extensor hallucis longus is a very narrow muscle which lies deeply between the tibialis anterior and extensor digitorum longus. It becomes superficial between the two in the lower part of the leg.

Extensor Digitorum Longus—*Origin.*—The lateral condyle of the tibia; the upper three-fourths of the anterior surface of the shaft of the fibula; the interosseous membrane; the deep fascia covering it; and the intermuscular septa between it and the adjacent muscles.

Insertion.—The intermediate and distal phalanges of the four outer toes. As the tendons pass across the dorsal aspects of the metatarso-phalangeal joints they broaden into expansions which occupy the dorsal aspects of the proximal phalanges and receive the tendons of the lumbrical and interosseous muscles, and, in the case of the tendons destined for the second, third, and fourth toes, by the tendons of the extensor digitorum brevis. Towards the distal end of the proximal phalanx each tendon divides into three bands. The central band is inserted into the base of the intermediate phalanx. The two lateral bands converge, and, having united, are inserted into the dorsal aspect of the base of the distal phalanx.

Nerve-supply.—The anterior tibial nerve.

Action.—Extends the intermediate and distal phalanges of the four outer toes, and flexes the foot upon the leg.

Peroneus Tertius—*Origin.*—Its muscular belly is inseparable from that of the extensor digitorum, of which it may be regarded as the lower part; it is consequently attached to the lower part of the anterior surface of the fibula and the adjoining part of the interosseous membrane.

Insertion.—It ends in a tendon which is inserted into the base of the fifth metatarsal bone.

Nerve-supply.—The anterior tibial nerve.

Action.—Flexes the foot upon the leg, and by raising its outer border everts the foot.

The peroneus tertius is a very variable muscle, and is not infrequently absent. It is a muscle peculiar to man, and is a detached slip from the extensor digitorum longus, with which its belly is more or less confluent. It is essentially a muscle associated with the erect posture, everting the foot and bringing it into the plantigrade position, where the sole is directly applied to the ground. Its tendon may be inserted at any point from the distal to the proximal end of the fifth metatarsal, and occasionally ends in a fan-shaped expansion which is attached for nearly the whole length of the shaft of the bone.

The **anterior tibial artery** is one of the two terminal branches of the popliteal artery. It commences at the lower border of the popliteus muscle on a level with the lower border of the tubercle of the tibia (fully $1\frac{3}{4}$ inches below the level of the upper surface of the head of that bone), and ends in front of the bend of the ankle, midway between the two malleoli, where it is continuous with the dorsalis pedis artery. At its commencement it is placed on the back of the leg, and thence passes forwards between the two heads of the tibialis posterior, and through a deficiency in the upper part of the interosseous membrane,

where it lies below the superior tibio-fibular joint. Having reached the front of the leg, the course of the vessel changes somewhat abruptly and it descends in close contact with and in front of the interosseous membrane until it reaches the junction of the upper two-thirds and lower third of the leg. Below this level it inclines inwards on to the front of the tibia, upon which it lies for the rest of its course. The course of the vessel on the anterior aspect of the leg corresponds with a line drawn from the superior tibio-fibular joint to a point on the front of the ankle midway between the two malleoli.

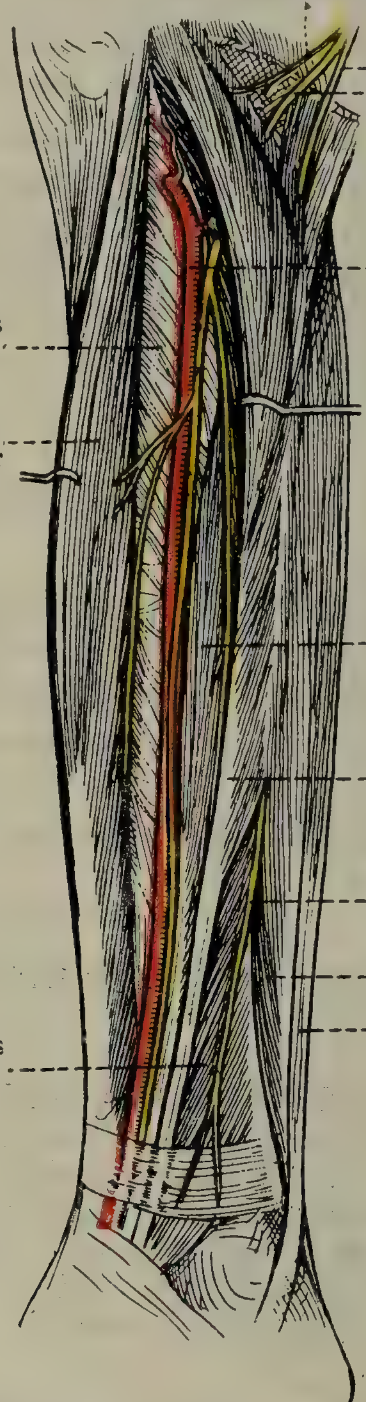


Fig. 367.—The Front of the Left Leg (Deep Dissection).

Relations—*On the Back of the Leg.*—The artery lies deeply to the gastrocnemius, and between the two heads of the tibialis posterior, the lower border of the popliteus muscle being directly above it.

On the Front of the Leg—Superficial.—In the upper three-fourths the artery is deeply placed, being overlapped by the adjoining edges of the tibialis anterior on the inner side and the extensor digitorum longus and extensor hallucis longus on the outer side. In the lower part of the leg, where the muscles are to a large extent replaced by tendons, the vessel is comparatively superficial. It is covered in front by the extensor retinacula and the extensor hallucis longus, which crosses it from without inwards at some little distance above the ankle-joint. *Deep.*—The interosseous membrane, the anterior surface of the tibia in its lower fourth, and the anterior ligament of the ankle-joint. *Lateral.*—Extensor digitorum longus in the upper part of the leg, the extensor hallucis longus at a lower level, and the extensor digitorum longus again for a short distance above the ankle. *Medial.*—Tibialis anterior for the greater part of its extent, and the extensor hallucis longus at the lower end of the leg.

It is accompanied by two venæ comites, between which are umerous transverse communications lying in front of the artery. 'he two venæ comites pass backwards through the upper part of the nterosseous membrane, and join the venæ comites of the posterior ibial artery to form the popliteal vein.

In the upper fourth of the leg the anterior tibial artery is separated rom the anterior tibial nerve by the extensor digitorum longus. The nterior tibial nerve, which gains the front of the limb by winding round he outer side of the neck of the fibula, passes through the upper part f the extensor digitorum longus obliquely, and comes into contact vith the artery, with which it descends on the front of the interosseous nembrane. The nerve is at first to the outer side of the artery, then es in front of it, and reverts to its outer side again in the lower part f the leg.

Branches.—In addition to cutaneous branches and muscular ranches which supply the muscles on the front of the leg, and also ass backwards through the interosseous membrane to supply the ibialis posterior, the anterior tibial artery gives off the following ranches:

The **posterior tibial recurrent artery** is inconstant. It arises from he commencement of the anterior tibial artery on the back of the eg. It passes upwards deeply to the popliteus muscle, to which it is listributed, as well as to the posterior ligament of the knee-joint. It nastomoses with inferior genicular branches of the popliteal artery.

The **circumflex fibular artery** also arises from the anterior tibial n the back of the leg. It winds round the neck of the fibula, and is listributed to the peroneus longus, the superior tibio-fibular joint, nd the skin.

The **anterior tibial recurrent artery** arises from the anterior tibial n the front of the leg. It passes upwards in company with the re-urrent genicular branch of the lateral popliteal nerve through the pper part of the tibialis anterior, to which it is distributed, and ends y anastomosing with the inferior genicular branches of the popliteal rtery.

The **medial anterior malleolar artery** is a small branch which arises rom the inner side of the anterior tibial near the lower end of the leg. t passes inwards deeply to the tendon of the tibialis anterior, and amifies over the medial malleolus, where it anastomoses with the orresponding branch of the posterior tibial artery and the tarsal ranches of the dorsalis pedis.

The **lateral anterior malleolar artery** arises from the outer side of the nterior tibial at a slightly lower level than the medial. It passes utwards deeply to the tendons of the extensor digitorum longus and eroneus tertius, and ramifies over the lateral malleolus, where it nastomoses with the anterior peroneal, the posterior peroneal, and he lateral tarsal branches of the dorsalis pedis.

Varieties—1. **Origin.**—The vessel may arise from the popliteal at the upper order of the popliteus muscle. In such cases it may descend on the posterior

surface of that muscle (this being the more frequent position), or it may pa
deeply to it.

2. **Course.**—The vessel in the lower fourth of the leg may be found upo
the fibula instead of the tibia, in which cases it makes a sudden bend at th
ankle-joint to become continuous with the dorsalis pedis artery. In very ra
cases the vessel may become superficial in the middle of the leg.

3. **Size.**—The vessel is occasionally very small, and if the diminution i
size is very pronounced, it may fail to furnish the dorsalis pedis artery, in whic
cases that vessel is supplied by the peroneal.

The **peroneal artery** reaches the front of the leg by passing throug
the lower part of the interosseous membrane, and descends in front o
the inferior tibio-fibular joint lying deeply to the peroneus tertius. I
ends by anastomosing with the lateral anterior malleolar artery, th
tarsal branches of the dorsalis pedis, and the peroneal.

The **anterior tibial nerve** is one of the two terminal branches of th
lateral popliteal. It commences upon the outer side of the neck of th
fibula, where it lies between the bone and the peroneus longus, extend
downwards to the ankle, and ends by dividing into two termina
branches. It passes through the upper end of the extensor digitorum
longus, and then descends with and has the same general relations a
the anterior tibial artery. Its relations to the artery have already bee
described.

The **branches** are muscular and articular. The **muscular branche**
supply the tibialis anterior, extensor digitorum longus, extensor halluci
longus, and peroneus tertius. The **articular branches** arise from th
lower part of the nerve, and are distributed to the ankle and inferio
tibio-fibular joints.

The nerve to the peroneus tertius is the terminal twig of a branch of th
anterior tibial given off in the upper part of the leg. This branch passes throug
the substance of the extensor digitorum longus, which it supplies, and ends i
the peroneus tertius.

The **anterior tibial lymphatic gland** is situated in front of the uppe
part of the interosseous membrane close to the anterior tibial artery
Its afferent vessels convey lymph from the deeper parts of the dorsum
of the foot and front of the leg. The efferent vessels pass backward
with the anterior tibial artery through the interosseous membrane an
join the popliteal glands.

Dorsum of the Foot.

Superficial Fascia.—Embedded in the superficial fascia are the
cutaneous nerves and the dorsal plexus of veins.

The **dorsal plexus of veins** is a network of veins embedded in the
subcutaneous tissue. The arrangement is very variable, but the
plexus is usually disposed in the form of an arcade occupying the
metatarsal region, and with its convexity towards the toes. The
plexus receives many tributaries coming from the plantar aspect of
the foot, from the dorsum, and from the toes. Most of the blood
distributed to the toes by the digital arteries is returned to the dorsal

›lexus. The inner side of the plexus is drained by the long saphenous 'ein, which passes upwards in front of the medial malleolus; the outer ide by the short saphenous vein, which passes upwards behind the ateral malleolus.

The **deep fascia** is a thin membranous layer continuous with the xtensor retinacula, and covering the long extensor tendons supericially. Another layer of deep fascia lies deeply to the extensor tendons, nd covers the extensor digitorum brevis; a third layer on a still deeper lane invests the dorsal interosseous muscles and the dorsal surfaces f the metatarsal bones.

Extensor Digitorum Brevis (Fig. 369)—*Origin.*—The front part of he upper surface and the adjacent part of the lateral surface of the alcaneum, and the stem of the inferior extensor retinaculum.

Insertion.—The four inner toes by means of four tendons; the nnermost tendon has an independent insertion into the base of the roximal phalanx of the great toe. The other three tendons join the uter borders of the long extensor tendons passing to the second, third, nd fourth toes, the junctions taking place opposite the metatarsohalangeal joints.

Nerve-supply.—The lateral terminal branch of the anterior tibial erve.

Action.—The innermost tendon extends the great toe at the metaarso-phalangeal joint, and also acts as an adductor. The second, hird, and fourth tendons extend the corresponding toes in conjunction vith the long extensor tendons. In so doing they tend, by the obliquity f their direction, to draw the toes outwards, and in this way they eutralize the effect of the long extensor tendons, which are so disposed s to draw the toes inwards.

The muscle lies obliquely on the dorsum of the foot, being directed orwards and inwards. The innermost fleshy bundle is more or less ndependent of the rest of the muscle, and is sometimes regarded as an ndependent muscle, called the *extensor hallucis brevis.*

The **dorsalis pedis artery** (Fig. 368) is the continuation of the anterior ibial artery, and commences at the bend of the ankle, midway between he two malleoli. It ends at the proximal end of the first intermetaarsal space, where it divides into two branches, the deep plantar or erforating, and the arteria dorsalis hallucis or first dorsal metatarsal rtery. The course of the vessel is indicated by a line drawn from a oint on the front of the ankle, midway between the two malleoli, to he proximal end of the first interosseous space.

Relations.—The artery is covered superficially by the inferior xtensor retinaculum, fascial layers and the innermost tendon of the xtensor digitorum brevis. It lies on the talus, navicular, intermediate uneiform, base of second metatarsal, and the ligaments connecting hese bones together. It lies for the most part between the tendons of he extensor digitorum longus on its outer side and that of the extensor allucis longus on its inner side. Close to its termination it is crossed uperficially by the tendon of the extensor brevis hallucis, which passes

from its outer to its inner side. The medial terminal branch of th anterior tibial nerve (dorsalis pedis nerve) lies to its outer side. It accompanied by two venæ comites. The artery is very superficial, a the only structures which separate it from the surface are, with th exception of the tendon of the extensor hallucis brevis, fascial layer and skin.

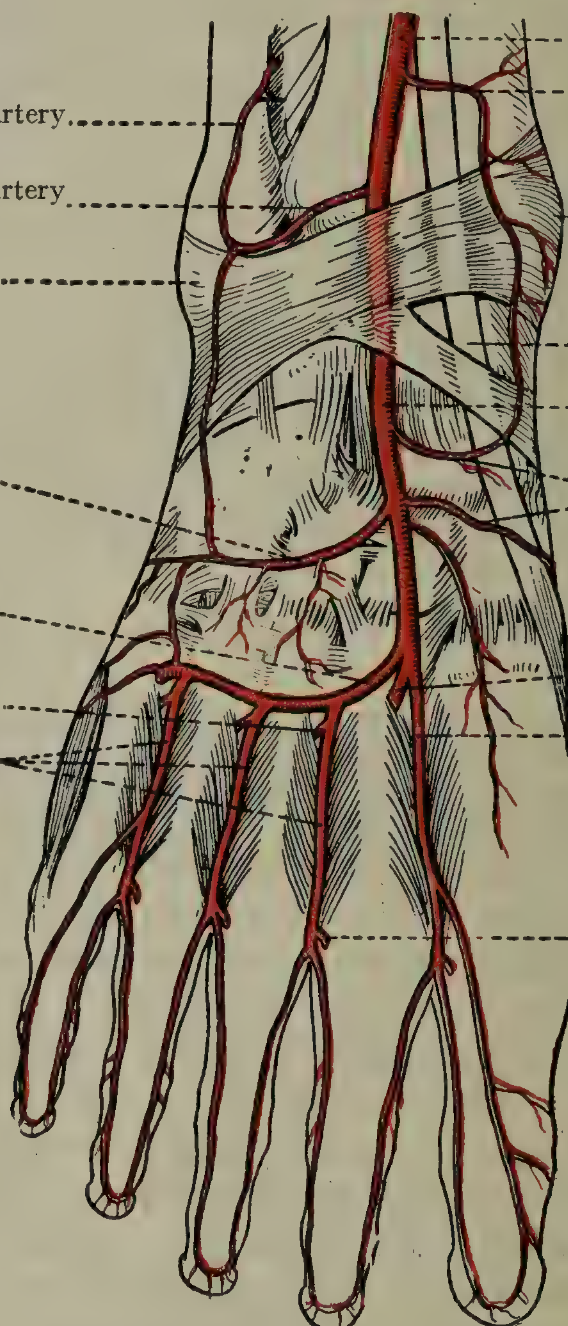


FIG. 368.—THE ARTERIES ON THE DORSUM OF THE RIGHT FOOT (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

Branches.—The **tarsal arteries,** two or three in number, supply th structures on the inner border of the foot, where they anastomose witl branches of the medial plantar artery.

A **lateral branch** passes outwards deeply to the extensor brevis digi torum, which it supplies; it is also distributed to the tarsal joints anc the skin. It anastomoses with the lateral anterior malleolar, th arcuate, and lateral plantar arteries.

The **arcuate (metatarsal) artery** arises close to the proximal end o the first intermetatarsal space, and passes outwards to the outer border of the foot, crossing the bases of the metatarsal bones, and lying deeply

to the extensor digitorum brevis. It anastomoses with the tarsal and lateral plantar arteries. The vessel forms a slight arch, with the convexity directed forwards. From the concavity of the arch a few *recurrent branches* pass backwards to the tarsal joints. From the convexity *three dorsal metatarsal arteries* pass forwards and occupy the three outer intermetatarsal spaces. At the level of the metatarso-phalangeal joints each divides into two dorsal digital arteries, which supply the adjacent sides of the second and third, third and fourth,

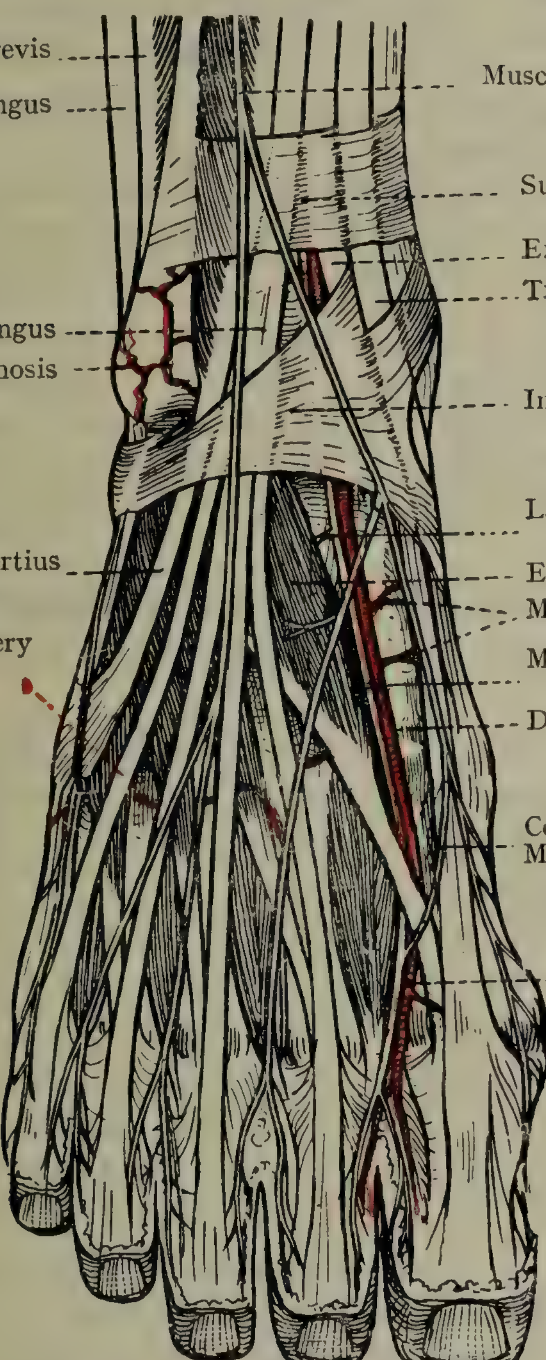


FIG. 369.—DISSECTION OF THE DORSUM OF THE RIGHT FOOT.

and fourth and fifth toes. The most lateral dorsal metatarsal artery also supplies a branch to the outer side of the little toe. At the proximal ends of the second, third, and fourth intermetatarsal spaces each of the three dorsal metatarsal arteries is joined by a *perforating artery* from the plantar arch.

The **first dorsal metatarsal artery** (**arteria dorsalis hallucis**) arises from the terminal part of the dorsalis pedis, and, continuing the direction of that vessel, passes forwards to the first intermetatarsal space. On

reaching the cleft between the great and second toes it divides int two dorsal digital branches supplying the adjacent sides of these tw toes; it also gives a branch to the inner side of the great toe.

The dorsal digital arteries as they pass along the sides of the toe communicate with each other across their dorsal aspects, and also wit the corresponding plantar digital arteries.

The **deep plantar** or **perforating branch** is to be regarded as the con tinuation of the dorsalis pedis artery. It passes downwards into th sole at the proximal end of the first intermetatarsal space. In the sol it completes the plantar arch by joining the lateral plantar artery.

Varieties of the Dorsalis Pedis Artery—1. **Origin.**—The vessel may be the con tinuation of the peroneal artery.

2. **Course.**—The vessel often describes a considerable curve outwards befor reaching the proximal end of the first intermetatarsal space. In these case the artery may end at the proximal end of the second intermetatarsal spac instead of at the first.

3. **Branches.**—These are very variable, especially the arcuate artery. Thi may arise in common with the tarsal branch. The arcuate arch is often ver indefinite. The arcuate artery is sometimes absent, and when this occurs th dorsal metatarsal arteries of the three outer spaces are usually furnished b the three perforating arteries from the plantar arch, or in some cases by th tarsal artery.

The Terminal Branches of the Anterior Tibial Nerve.—The anterio tibial nerve ends at the bend of the ankle by dividing into two branches lateral and medial.

The **lateral branch** is the shorter, and is distinguished by havin a swelling or pseudo-ganglion upon it. It descends on to the dorsum of the foot, where it lies on the deep aspect of the extensor digitorum brevis, to which it is distributed. It ends in branches supplying th tarsal joints, and in two or three very slender interosseous branche which extend forwards on the dorsal interosseous muscles and suppl the tarso-metatarsal and metatarso-phalangeal joints; one of them i said to supply the second dorsal interosseous muscle.

The **medial branch,** or dorsalis pedis nerve, extends forwards o the dorsum of the foot, accompanying and having the same genera relations as the dorsalis pedis artery, on the outer side of which it lies It ends by dividing into two branches, which supply the skin of th adjacent sides of the great and second toes. It gives a metatarsa branch, which occupies the first intermetatarsal space and supplie the tarso-metatarsal and metatarso-phalangeal joints of the great toe as well as the first dorsal interosseous muscle.

The nerves derived from the anterior tibial and supplying the first an second dorsal interosseous muscles are probably sensory and do not contai motor fibres.

The Outer Side of the Leg.

The skin on the outer side of the leg is supplied by the latera cutaneous nerve of calf and branches from the short external saphenou nerve.

The **sural nerve** (Fig. 329), from the medial popliteal, receives the sural communicating branch of the lateral popliteal nerve at, or just below, the middle of the calf. The nerve descends on the outer side of the short saphenous vein, and lateral to the tendo-calcaneus. It passes behind and below the lateral malleolus, and thus reaches the outer border of the root, along which it passes to the outer side of the little toe. The nerve supplies the skin on the back and outer side of the leg in its lower half, the outer side of the foot, and the outer side of the little toe. It also furnishes articular branches to the ankle and talo-calcaneal joints.

The **short saphenous vein** drains the outer side of the plexus of veins on the dorsum of the foot, and passes upwards from the foot behind the lateral malleolus, and thus reaches the back of the leg. In the lower part of the leg it lies to the outer side of the tendo-calcaneus, but inclining upwards and inwards it gains the middle line of the calf, and ascends in the groove between the two heads of the gastrocnemius. At the lower angle of the popliteal fossa it traverses the deep fascia, and ends by joining the popliteal vein. In the lower part of its course it is accompanied, on its outer side, by the sural nerve. In the groove between the two heads of the gastrocnemius it is accompanied by the terminal part of the posterior cutaneous nerve of the thigh, the sural cutaneous artery, and superficial lymphatic vessels which join the popliteal glands. In addition to draining the dorsal plexus, it receives numerous tributaries from the outer and back parts of the leg. At its termination it is usually joined by a vein descending from the back of the thigh, and by a fairly constant communicating vein which ascends to join the long saphenous vein. It communicates with the deep veins behind the lateral malleolus, and at intervals along the back of the leg. The short saphenous vein is provided with ten to twelve valves.

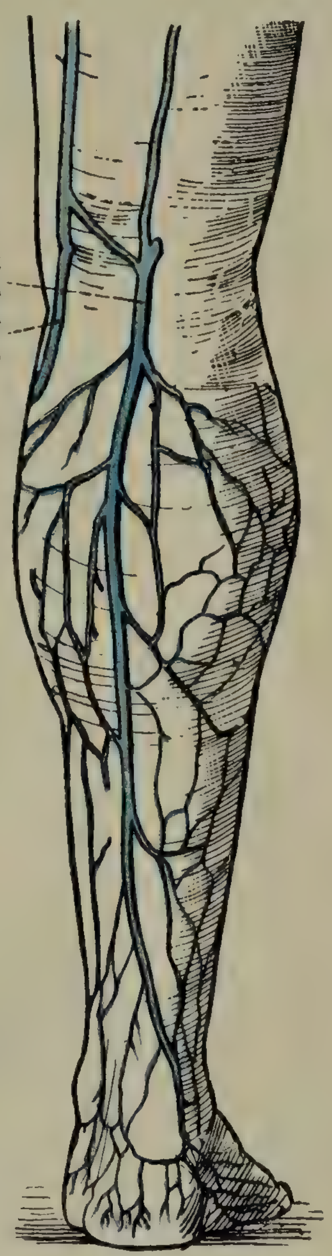


FIG. 370.—THE SHORT SAPHENOUS VEIN AND ITS TRIBUTARIES.

The termination of the short saphenous vein is very variable. Instead of joining the popliteal vein, it may ascend in the roof of the popliteal fossa, wind round the inner side of the lower part of the thigh, and end in the long saphenous vein; or it may ascend more deeply, accompany the medial popliteal nerve, and join the lowest perforating vein or one of its tributaries.

Muscles—Peroneus Longus (Fig. 371)—*Origin.*—The anterior aspect of the head of the fibula and the adjacent parts of the lateral

condyle of the tibia; the upper two-thirds of the lateral surface of the shaft of the fibula; the two fibular intermuscular septa and the deep fascia.

Insertion.—The tendon of insertion divides into two slips. The larger is inserted into the outer side of the tuberosity on the plantar surface of the base of the first metatarsal bone, and the smaller into

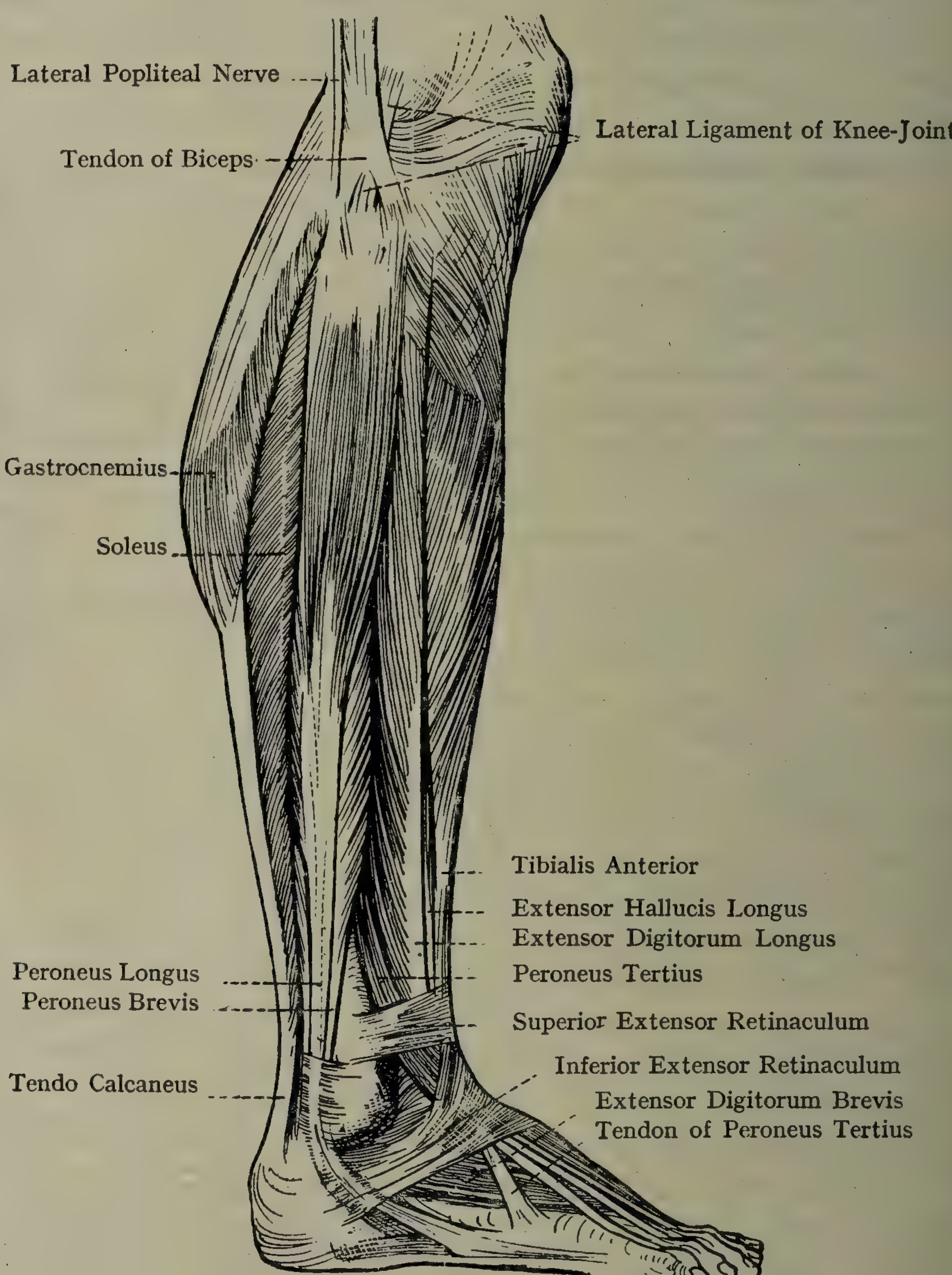


Fig. 371.—Muscles of the Leg (Lateral Aspect).

the lower and anterior part of the outer surface of the medial cuneiform bone.

Nerve-supply.—The musculo-cutaneous nerve.

Action.—Extends the foot upon the leg; abducts the front part of the foot—*i.e.*, turns it outwards; everts the foot by raising its outer border.

The tendon descends behind that of the peroneus brevis, and with it occupies the groove behind the lateral malleolus deeply to the peroneal

retinaculum, the two tendons having a common synovial sheath. Below the malleolus the tendon passes forwards and downwards on the outer surface of the calcaneum, where it occupies the groove below the peroneal tubercle. In this part of its course the tendon is surrounded by a fibrous sheath, which is derived from the lower part of the peroneal retinaculum, and is invested by an independent synovial sheath, which is a prolongation of the common sheath behind the lateral malleolus. It winds round the outer border of the foot, and then crosses the sole from without inwards, being lodged in the groove on the plantar surface of the cuboid. This groove is converted into a fibro-osseous canal by the long plantar ligament, and is lined by a synovial sheath. Embedded in the tendon as it winds round the cuboid is a sesamoid cartilage which may ossify.

Peroneus Brevis (Fig. 371)—*Origin.*—The lower two-thirds of the lateral surface of the shaft of the fibula, the two fibular intermuscular septa, and the deep fascia.

Insertion.—The tuberosity on the outer side of the base of the fifth metatarsal bone. A slip from the tendon of insertion is occasionally given to the long extensor tendon of the little toe.

Nerve-supply.—The musculo-cutaneous nerve.

Action.—Extends the foot and everts the foot by raising its outer border.

The middle third of the lateral surface of the fibula is occupied by both peroneus longus and peroneus brevis, the former arising from the posterior half, and the latter from the anterior half; the two muscles consequently overlap. The tendon of the peroneus brevis occupies the groove behind the lateral malleolus, the tendon of the peroneus longus being directly behind it. Both tendons lie deeply to the peroneal retinaculum, and are invested by a common synovial sheath. Below the lateral malleolus the tendon of the peroneus brevis passes downwards and forwards on the outer surface of the calcaneum, where it occupies the groove above the peroneal tubercle. The tendon is here surrounded by a fibrous sheath derived from the peroneal retinaculum, and is invested by a distinct synovial sheath continuous with the common sheath above. From the os calcis the tendon passes forwards on the cuboid bone to reach its insertion.

On the outer surface of the os calcis the two peroneal tendons are separated from each other by the peroneal tubercle, the tendon of the peroneus longus being below that of the peroneus brevis.

The Back of the Leg.

Muscles.—The muscles of the back of the leg are divided into two groups—superficial and deep.

Superficial Group.—The muscles of this group are the gastrocnemius, soleus, and plantaris, and are known as the sural or calf muscles.

Gastrocnemius—*Origin.*—The **outer head,** the shorter and thinner, arises mainly by tendon, but partly by muscle fibres from a depression

on the outer aspect of the lateral femoral condyle (immediately abo the most projecting point of the lateral epicondyle which gives attac ment to the lateral ligament of knee-joint) and from the lower end the lateral supracondylar lin The tendon is adherent the posterior ligament of t knee-joint, and at the se of adherence usually contai a sesamoid cartilage whi may ossify.

FIG. 372.—SUPERFICIAL ASPECT OF MUSCLES OF CALF.

The **inner head,** the long and thicker, arises by tendo from an impression above t posterior surface of the medi femoral condyle, abuttin upon the lower end of t medial supracondylar lin and extending downwar and inwards to the adduct tubercle.

Insertion.—The fleshy pa of the muscle ends in a fl tendon, which commences an aponeurotic sheet on t deep surface of the muscl and, in the lower part of t leg, joins the more deepl placed tendon of the sole to form the tendo-calcaneu The gastrocnemius is inserte by means of this commo tendon into a rough impre sion on the lower part of t posterior surface of the ca caneus; a bursa intervene between the tendon and t upper smooth part of th surface.

Nerve-supply. — The m dial popliteal nerve, whic furnishes two branches, o for each head.

Action.—The muscle is powerful extensor of the foot upon the leg and raises the heel. If t ankle-joint is fixed it can flex the knee-joint.

The two heads of the muscle converge, and together form the later boundaries of the lower part of the popliteal fossa. Below the low angle of the popliteal fossa the junction of the two heads is represente

ıperficially by a longitudinal groove, on the floor of which is a endinous band or raphé. The muscular fibres of the gastrocnemius re all relatively very short, and extend obliquely from two tendons f origin to a tendon of insertion. The two tendons of origin spread ut into aponeurotic sheets, and partially cover the two heads of the uscle superficially. The tendon of insertion commences as an poneurotic sheet which covers the deep or anterior aspect of the uscle for nearly its whole extent, and narrows below into the tendon hich takes part in the formation of the tendo-calcaneus.

Lying deeply to the medial head at the back of the knee, and also ntervening between it and the semimembranosus, is one of the largest nd most important bursæ in the neighbourhood of the joint. This ursa is usually continuous with the synovial membrane of the joint hrough a deficiency in the capsular ligament.

Soleus (Fig. 371)—*Origin.*—The posterior surface of the head and he upper third of the posterior surface of the shaft of the fibula; fibrous arcade attached on either side to the fibula and tibia and rching over the popliteal vessels and nerve; the soleal (popliteal) line f the tibia, from the lower of which it extends downwards on to the nternal border of the tibia for about its middle third; the posterior bular intermuscular septum.

Insertion.—The tendon, which is continuous with an extensive poneurosis coating the superficial surface of the muscle, joins that f the gastrocnemius to form the tendo-calcaneus.

Nerve-supply.—The medial popliteal nerve, the branch from which nters the muscle on its superficial surface near the upper border; and branch from the posterior tibial nerve, entering the muscle on its eep or anterior surface near the middle of the leg.

Action.—The muscle is a powerful extensor of the foot, and with he gastrocnemius is concerned in raising the heel.

The muscle fibres are short and oblique; they are attached to bone o a limited extent only. Most of the fibres arise from two tendinous lanes which extend downwards into the substance of the muscle, ne from the fibula and the other from the soleal line of the tibia, and he fibrous arcade arching over the popliteal vessels. These two planes xtend downwards into the substance of the deep part of the muscle, nd are obliquely disposed in such a way that when seen in section hey converge towards the superficial surface of the muscle. The bres arising from the anterior surfaces of these two tendinous planes erminate upon a median tendinous band which projects into the niddle of the muscle from its deep aspect; those arising from the osterior surfaces end upon a broad expanded aponeurosis, which overs the posterior or superficial surface of the muscle. In the lower art of the leg the median tendinous band blends with the aponeurosis overing the superficial aspect of the muscle to form the tendon of nsertion, which joins that of the gastrocnemius to form the tendo-alcaneus.

The **tendo-calcaneus** (Achillis) results from the junction of the

tendons of the gastrocnemius and soleus. It is at first broad and cor paratively thin. As it descends it becomes narrower and thicker unt it reaches a point about 1½ inches above the calcaneus, below which again broadens to its insertion. The short saphenous vein and nerv lie on its outer side, the tendon of the plantaris and the posterior tibi vessels and nerve on its inner side; there is a large mass of fat on i deep aspect.

The fibres of the gastrocnemius and soleus are so arranged that both the muscles can exert an exceedingly strong pull through a relatively short distanc Together they form one of the most powerful muscular combinations in t body, of such strength that, when standing on one leg, the heel can be easi raised from the ground, thereby lifting the whole weight of the body on to t toes, by the contraction of the muscles of one limb only.

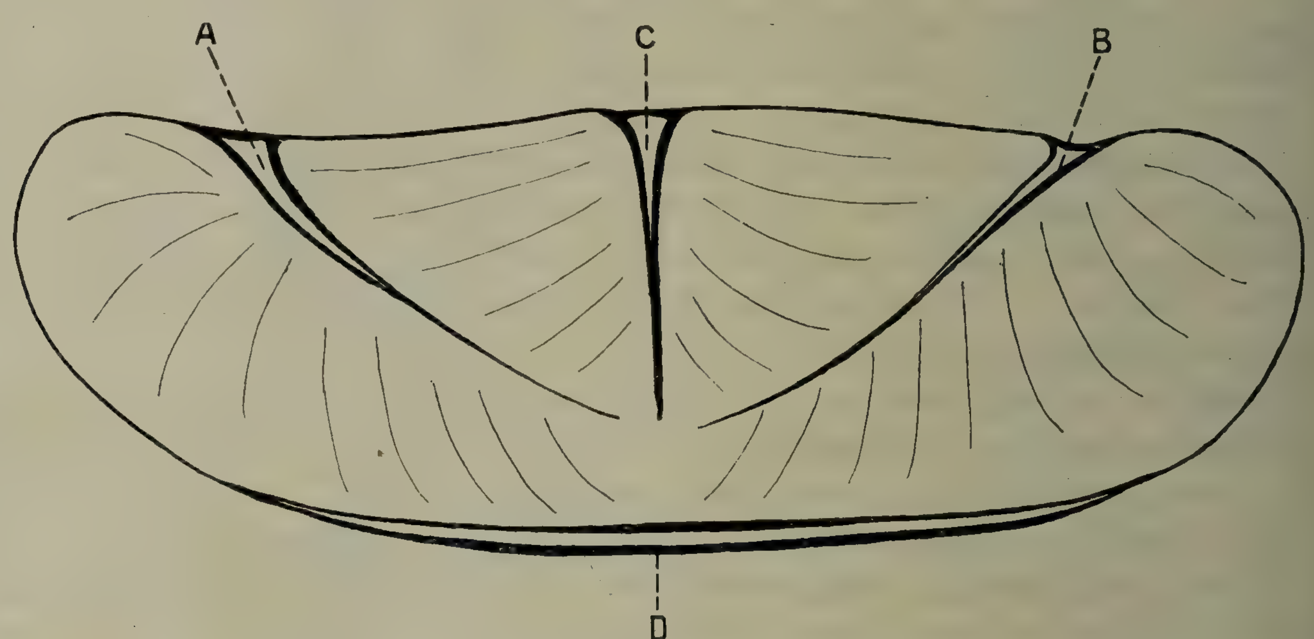


FIG. 373.—A SEMIDIAGRAMMATIC HORIZONTAL SECTION THROUGH THE SOLEUS TO ILLUSTRATE THE ARRANGEMENT OF THE MUSCLE FIBRES.

A and B, the two intramuscular tendons of origin arising from the tibia ar fibula; C, the intramuscular tendon of insertion, which below joins D, tl aponeurosis on the surface of the muscle, to form the main tendon.

Plantaris—*Origin.*—The lower part of the lateral supracondyla line of the femur, medial to, and to a slight extent above, the later head of the gastrocnemius. The lowest fibres are attached to th posterior ligament of the knee-joint.

Insertion.—The posterior surface of the os calcis to the inner sid of the tendo-calcaneus.

Its insertion is somewhat variable, as it may end in the tendo calcaneus, th deep fascia of the leg, the flexor retinaculum, or the plantar aponeurosis.

Nerve-supply.—The medial popliteal nerve.

Action.—The plantaris is a very weak extensor of the foot, and i a feeble auxiliary to the gastrocnemius.

The fleshy belly is very short. The tendon, very narrow and th longest in the body, descends obliquely downwards and inwards be tween the gastrocnemius superficially and the soleus deeply.

The plantaris is very variable and is sometimes absent. It is a vestigial uscle, and represents the flexor of the proximal phalanges of the toes, a muscle esent in quadrupeds. The foot portion of the tendon, from which it has come separated by the calcaneum, persists as the central part of the plantar poneurosis. The plantaris is the counterpart of the palmaris longus in the upper nb.

Deep Group.—The muscles in this group are the popliteus, flexor igitorum longus, tibialis posterior, and flexor hallucis longus. The opliteus is a small muscle confined to the region of the knee, and is overed by an expansion derived from the tendon of the semimem-ranosus. The other three muscles are situated below the popliteus, nd are covered by the transverse intermuscular septum.

Popliteus—*Origin*.—By a narrow rounded tendon from a pit which arks the front limit of the popliteal groove on the outer surface of ie lateral condyle of the femur.

Insertion.—The inner part of a triangular area occupying the upper art of the posterior surface of the tibia, and limited below by the oleal line. Some of its superficial fibres are adherent to the tendinous xpansion which covers the posterior surface of the muscle.

Nerve-supply.—A branch of the medial popliteal nerve, which escends on the posterior surface of the muscle, and, winding round s lower edge, finally ascends to enter its deep or anterior surface.

Action.—The muscle is a feeble flexor of the knee-joint; it also otates the leg inwards on the thigh.

The tendon of origin winds round the outer side of the knee-joint, vhere it is within the limits of the capsular ligament, and lies deeply to he lateral ligament, superficial to which is the tendon of the biceps. t is in contact with the posterior and outer aspect of the lateral semi-unar cartilage, upon which it impresses a groove. It escapes from he posterior part of the capsule, and, becoming replaced by muscle ibres, spreads out in a fan-like manner on to the back of the tibia.

Flexor Digitorum Longus—*Origin*.—The inner part of the posterior urface of the shaft of the tibia, extending downwards from the soleal ine above for about the middle two-fourths of the bone; the transverse ntermuscular septum; and a septum between it and the tibialis osterior.

Insertion.—By four tendons attached to the four outer toes; each endon is inserted into the plantar surface of the base of the distal phalanx.

Nerve-supply.—The posterior tibial nerve.

Action.—Flexes the distal phalanges of the four outer toes, and extends the foot on the leg.

The muscle crosses the tibialis posterior superficially, being to the inner side of this muscle above and to its outer side below. The tendon passes behind the medial malleolus, where it lies deeply to the flexor retinaculum, and external to the tendon of the tibialis posterior. It occupies a fibrous canal, in which it is invested by a distinct synovial sheath. From behind the medial malleolus it passes downwards and forwards, and thus gains the sole of the foot, where it inclines forwards

and outwards, and crosses the tendon of the flexor hallucis longus, fro which it receives a slip, superficially. After crossing the flexor halluc iongus it receives the attachment of the flexor accessorius, and divid lnto four tendons, which, after having given origin to the four lumbric muscles, are prolonged on to the four outer toes. On the toe ea tendon has a tendon the flexor digitorum brev lying superficially to the two tendons being co tained in a fibro-osseo canal lined by a synovi sheath. On the proxim phalanx the tendon of t flexor brevis splits to gi passage to the tendon the flexor longus; the fibr osseous canals and the synovial membranes, wi the vincula of the latt —namely, vincula brev and vincula longa—corr spond with those of t fingers, the dispositions the tendons, the fibr osseous canals, the syn vial sheaths and their vi cula being similar to tho which are found in t fingers (p. 491).

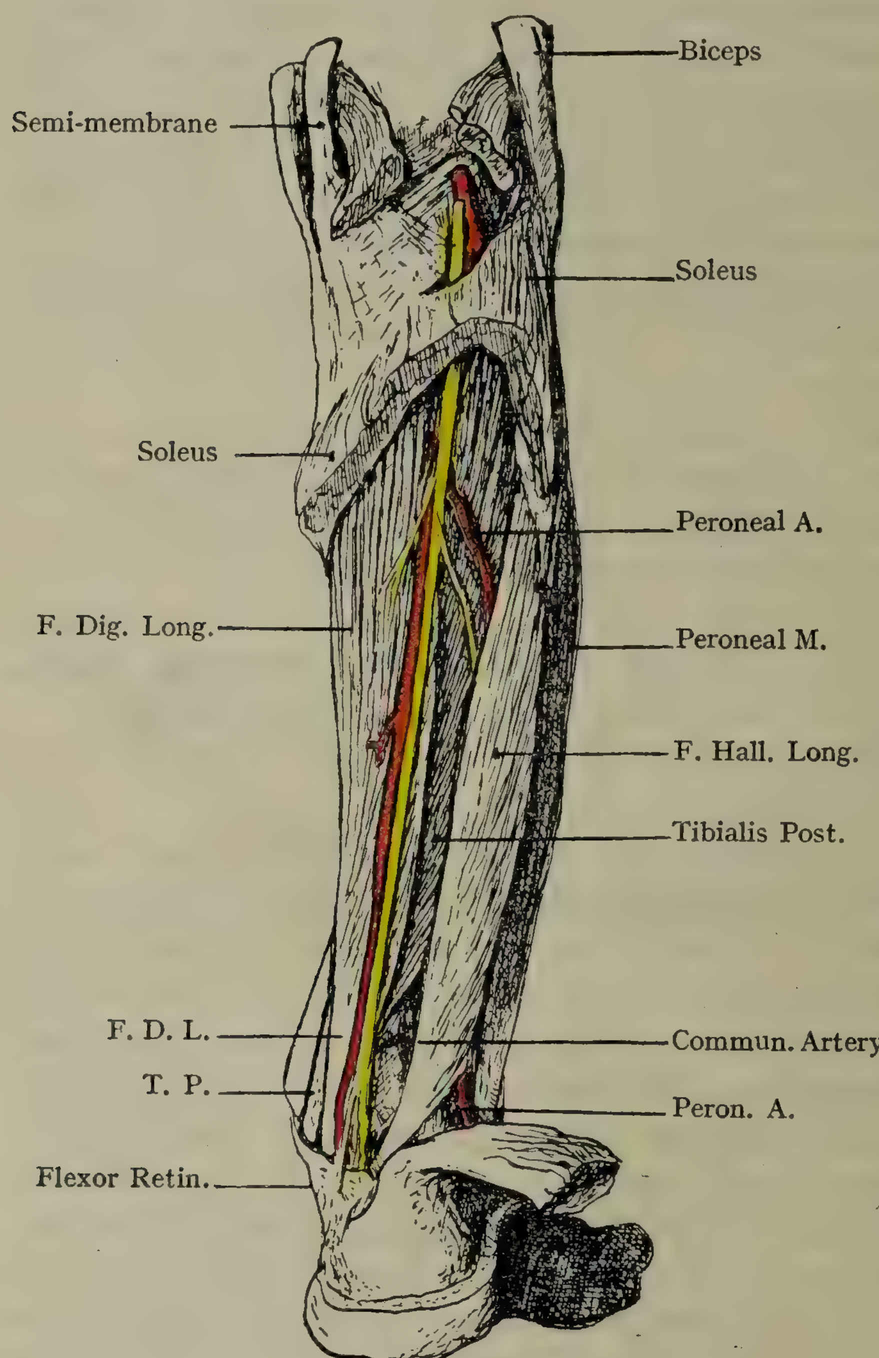


FIG. 374.—THE BACK OF THE LEG, EXPOSING DEEP MUSCLES, ETC., AFTER REMOVAL OF SUPERFICIAL FLEXORS.

Tibialis Posterior—*Origin.*—The outer part the posterior surface the shaft of the tibia, ex tending upwards to th soleal line and downward to about the middle the bone; the posterio surface of the interosseou membrane; the medi surface of the shaft of the fibula; the transverse intermuscular septum and the septa intervening between it and the flexor digitorum longu medially and the flexor hallucis longus laterally.

Insertion.—The tuberosity of the navicular bone. From the mai insertion into the tuberosity of the navicular bone tendinous slip spread out in various directions on the plantar aspect of the tarsus One passes backwards and is attached to the sustentaculum tali of th calcaneum, one passes outwards to the cuboid, one passes forward to the medial cuneiform, while several slips pass forwards and outward

ı to the intermediate and lateral cuneiforms, from which they are rolonged on to the bases of the second, third, and fourth metatarsal ɔnes. The latter cross the tendon of the ɛroneus longus superficially, and help to complete the fibro-osseous canal in which it is ɔntained.

Nerve-supply.—The posterior tibial nerve.

Action.—Inverts the foot, and is an extensor f the foot, upon the leg. Owing to its extenve attachments on the plantar aspect of the ırsus and metatarsus, it braces up and accenıates the arches of the foot.

In the lower third of the leg the muscle rosses the deep aspect of the flexor digitorum ɔngus obliquely, passing from its outer to its ıner side. The tendon occupies the groove ehind the medial malleolus, where it is covered ıperficially by the flexor retinaculum, and contained in a fibro-osseous canal, with the ɛndon of the flexor digitorum longus lying ıteral to it. It is invested here with a synovial ıeath, which follows it to its insertion on the avicular bone. In the foot it passes forwards elow the head of the talus, which it helps to ıpport, and here contains a sesamoid cartiıge. At the back of the leg the muscle is artially overlapped on either side by the flexor allucis longus and the flexor digitorum longus. overing its posterior surface is a dense fascial ıyer, which is attached on either side to the bia and fibula.

Flexor Hallucis Longus—*Origin.*—The lower wo-thirds of the posterior surface of the shaft f the fibula—this surface winds on to the inner spect of the bone in the lower part of the leg; ıe posterior fibular intermuscular septum; a ɛptum between it and the tibialis posterior, nd the transverse intermuscular septum.

Insertion.—The plantar surface of the base f the distal phalanx of the great toe.

Nerve-supply.—The posterior tibial nerve.

Action.—Flexes the distal phalanx of the reat toe. It also helps to maintain the longiıdinal arch of the foot, and is to a certain exɛnt an auxiliary of the flexor digitorum longus, ɔ which it is fastened by a tendinous slip.

FIG. 375.—PLAN TO SHOW THE CHANGING RELATIONS BETWEEN THE MAIN ARTERY AND NERVE ON THE BACK OF THE LOWER LIMB.

The tendon occupies a groove on the back of the lower end of ıe tibia, which is converted into a fibro-osseous canal by the flexor

retinaculum, and within which the tendon is provided with a synovi sheath. Below the tibia the tendon occupies successively the groove on the posterior aspect of the talus, and on the under surface of th sustentaculum tali of the calcaneum. These grooves are converte by a fibrous roof into a fibro-osseous canal, in which the tendon i surrounded by a synovial sheath. In the sole the tendon is crosse superficially, and from within outwards, by that of the flexor digitorur longus, to which it is fastened by a tendinous slip. In most cases th fibres of this slip are prolonged into the flexor tendons of the secon and third toes (Turner).

In some cases the tendinous slip extends from the tendon of the flexor digitoru longus into that of the flexor hallucis longus.

The **posterior tibial artery** (Fig. 376) is the larger of the two termin branches of the popliteal. It commences at the lower border of th popliteus muscle on a level with the lower limit of the tubercle of th tibia, and usually ends deeply to the flexor retinaculum by dividin into the medial and lateral plantar arteries.

The level at which the artery divides into the two plantar arteries i variable.

In the upper two-thirds of the leg it is deeply placed, being situate between the superficial and deep muscles, opposite to the interva between the tibia and fibula. It inclines downwards and inwards and in the lower third of the leg it becomes superficial, lying on th back of the tibia to the inner side of the tendo-calcaneus. The cours of the vessel may be indicated by drawing a line from the middle of th back of the leg at the lower angle of the popliteal fossa to a poin midway between the projection of the heel and the tip of the media malleolus.

Relations.—In the upper two-thirds the vessel is covered superficially by the soleus, and is embedded in the transverse intermuscula septum; in the lower third it is covered by the skin, superficial fascia and the flexor retinaculum. Lying deeply to it are the tibialis posterior the flexor digitorum longus, the posterior surface of the tibia, and th medial ligament of the ankle-joint (in this order from above downwards) In the lower part of the leg the tendo-calcaneus is lateral to it. Unde cover of the flexor retinaculum the artery and its two venæ comites together with the posterior tibial nerve on its outer side, are lodge in a fibro-osseous canal. Here the tendons of the tibialis posterior an flexor digitorum longus are on its inner side and the tendon of th flexor hallucis longus on its outer side.

The artery is accompanied by two venæ comites, which are connected together by numerous transverse communications lying superficially to the artery, and which, at the lower border of the popliteus join the venæ comites of the anterior tibial artery to form the poplitea vein. Above the posterior tibial nerve is medial to the artery, but crossing the vessel superficially just below the origin of the peronea

artery, the nerve lies on its outer side for the rest of its course. Deeply to the flexor retinaculum the artery has usually a nerve on either side

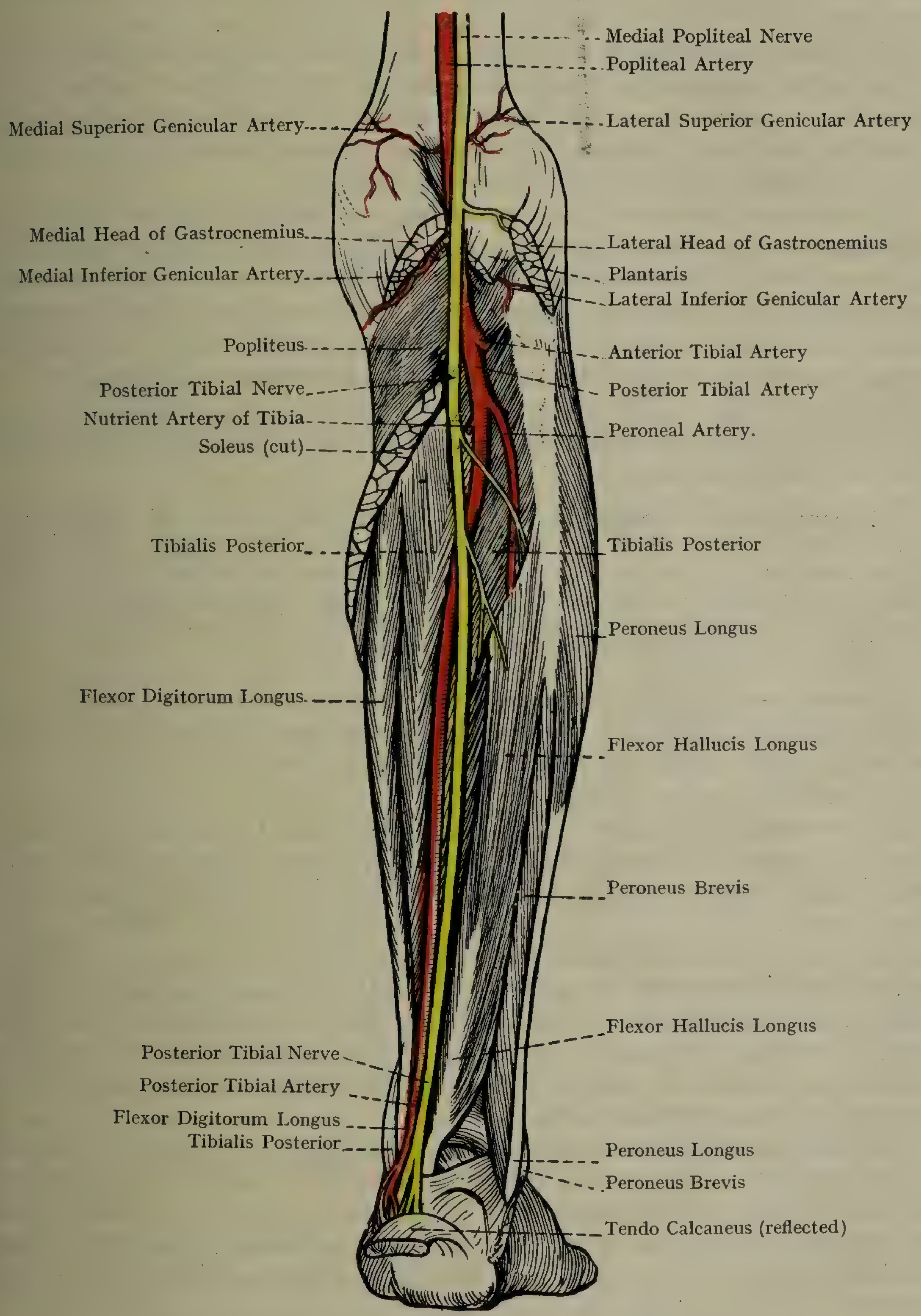


FIG. 376.—THE BACK OF THE RIGHT LEG (DEEP DISSECTION).

of it, an arrangement which results from the posterior tibial nerve dividing into its terminal branches at a higher level than the artery.

Branches.—In addition to numerous muscular and cutaneou branches, the latter being distributed to the skin on the back an inner side of the leg, the posterior tibial artery gives off the followin branches:

The **nutrient artery** is peculiar in being the largest nutrient arter in the body. Arising a short distance below the lower border of th popliteus, it passes through the substance of the tibialis posterior an enters the nutrient foramen of the tibia, accompanied by the nutrien nerve, a branch of the nerve to the popliteus.

The **peroneal artery** is the largest branch, and is often as large as th continuation of the posterior tibial artery, from which it arises abou 1 inch below the bifurcation of the popliteal artery. It first incline downwards and outwards, lying superficially to the tibialis posterio At a lower level it descends vertically, lying deeply to the flexor halluci longus and in close approximation to the shaft of the fibula. At som little distance above the ankle-joint it escapes from under cover of th flexor hallucis longus, and ends by dividing into two terminal branches anterior and posterior.

It is convenient to remember that in a horizontal section of the lower lim *one inch* below the level of the knee-joint one large artery only, the popliteal will be involved; if the section is made *two inches* below the joint two larg arteries, the anterior and posterior tibials, will be severed; but if the sectio takes place at *three inches* or more below the joint, three large arteries, the peroneal in addition to the two tibials, will be cut across.

Branches.—In addition to muscular and cutaneous branches, th latter supplying the skin on the back and outer side of the leg, th peroneal artery gives off the following branches:

The *nutrient artery* to the fibula.

A *communicating branch* usually arises from the posterior termina branch a short distance above the ankle-joint, passes transversel inwards and anastomoses with the corresponding branch of the posterio tibial artery.

The anterior terminal branch passes forwards through the lowe part of the interosseous membrane. On the front of the leg it descend deeply to the peroneus tertius, and in front of the inferior tibio-fibula joint. On the dorsum of the foot it anastomoses with the latera anterior malleolar branch of the anterior tibial and the lateral tarsa branches of the dorsalis pedis.

The *lateral calcanean branches* continue the direction of the peronea artery and pass downwards behind the lateral malleolus to the oute side and finally to the under side of the heel. They anastomose wit the medial calcanean branches of the posterior tibial and latera plantar arteries. The peroneal artery is accompanied by two vena comites.

Varieties of the Peroneal Artery.—The level at which this vessel arises i subject to variation. It may be at a higher level or at a lower level than normal In the former case it may be a branch of the popliteal or of the anterior tibial The peroneal artery is often enlarged, and replaces the posterior tibial to

arying extent. The peroneal artery supplements the supply of blood to the orsum of the foot, and may be so enlarged as to take the place of the dorsalis edis artery.

The **communicating branch** arises a little distance above the ankle-oint. It passes transversely outwards deeply to the tendon of the exor hallucis longus, and anastomoses with a corresponding branch f the peroneal artery. (to the posterior [illegible])

The **malleolar branches,** often two in number, pass inwards deeply o the tendons of the flexor digitorum longus and tibialis posterior, nd ramify on the medial malleolus.

The **medial calcanean branches** pass through the flexor retinaculum, eeply to which it arises, and is distributed to the inner aspect and nder side of the heel, where it anastomoses with the calcaneal branches f the lateral plantar and peroneal arteries.

The **terminal branches** are the medial and lateral plantar arteries.

Varieties of the Posterior Tibial Artery.—This vessel may be much diminished n size. In such cases the peroneal artery is relatively increased, and by means f an enlarged communicating branch conveys blood to the distal end of the osterior tibial artery. In rare cases the vessel does not extend to the ankle, nd may be entirely absent, in which cases the deficiency is made good by an nlarged peroneal artery.

The **posterior tibial nerve** (Fig. 376) is the continuation of the nedial popliteal, and commences at the lower border of the popliteus nuscle. It ends behind the medial malleolus, and under cover of the lexor retinaculum, by dividing into the medial and lateral plantar erves. The division usually takes place at a higher level than that f the artery. From its commencement the nerve inclines down-vards and inwards to the interval between the medial malleolus and he heel. It accompanies closely, and has the same general relations s, the posterior tibial artery, to the inner side of which it lies at its ommencement, but crossing the artery superficially it lies on its uter side in the lower part of the leg.

The **branches** are muscular, medial calcanean, articular, and terminal.

The **muscular branches** are given off from the upper part of the erve, and supply the flexor digitorum longus, tibialis posterior, flexor allucis longus, and soleus. The branch to the soleus enters the deep r anterior surface of the muscle. The nerve to the flexor hallucis ongus is a long nerve which accompanies the peroneal artery, to vhich it furnishes branches, and also supplies a nutrient nerve to the ibula.

The **medial calcanean branches** arise under cover of the flexor etinaculum, through which they pass. They supply the skin on the nner side of the heel and the hinder part of the sole of the foot.

The **articular branches** arise from the posterior tibial nerve close to ts termination. They pass through the medial ligament and supply the ankle-joint.

The **terminal branches** are the medial plantar and lateral plantar erves.

THE KNEE-JOINT.

The **articular surfaces** taking part in the joint are provided by th femur, patella, and tibia. The articular surfaces of the two femora condyles play upon the two shallow, cup-like, articular surfaces o the upper surface of the tibia; the patellar surface of the femur con fluent with the condylar surfaces articulates with the patella. Th ligamentous apparatus consists of a capsular investment supple mented by accessory ligaments and a large number of intracapsula structures.

The **capsular ligament** is a more or less cylindrical arrangemen surrounding the joint, but is so obscured by accessory or supplement ing ligaments that it is only obvious on its posterior aspect, and her only to a limited extent, on the posterior surfaces of the two femora condyles. In these situations it is represented by a comparativel thin membrane, which on the back of the medial condyle usuall presents a deficiency through which the large bursa situated deepl to the semimembranosus and inner head of the gastrocnemius is con tinuous with the synovial membrane. The capsular ligament is onl partially visible on the back of the lateral condyle, as its upper par is clothed superficially by a part of the oblique posterior ligament, t which the tendon of the outer head of the gastrocnemius, usuall containing a sesamoid cartilage, is adherent. At a lower level th capsular ligament can be distinguished, and here a bursa intervene between it and the tendon of the outer head of the gastrocnemius; i also gives passage to the tendon of the popliteus (Fig. 378).

Attachments of Capsular Ligament—*Femoral Attachments.*—I front the capsule lies deeply to the tendon of the quadriceps femori and is very thin. It is attached to the front of the femur some distanc above the level of the patellar surface, and covers a pouch of synovia membrane prolonged upwards on to the front of the shaft of the femur The attachment to the bone is usually interrupted, as the pouch o synovial membrane is, in most cases, continuous with the subcrura bursa through a deficiency in the capsule. On the lateral aspects o the condyles the attachment follows the lower limits of the two epi condyles some distance above the margins of the articular cartilage being just below the epiphysial line on the lateral condyle, but som considerable distance below it on the medial condyle.

On the back of the femur the line of attachment is close to the uppe margins of the condylar articular surfaces, but above the epiphysia line; it is here inseparable from the attachments of the gastrocnemius Between the two condyles it crosses the intercondylar notch behind the femoral attachments of the cruciate ligaments.

The capsular ligament is adherent deeply to the two semilunar cartilages and its lower part, which extends from the semilunar cartilages to the tibia and serves to keep them in place when the femoral attachments of the ligament are severed, is known as the *coronary ligament*, but has no real claim to be dis tinguished by a special name.

Tibial Attachments.—On the sides of the tibia the line of attachment is some little distance below the margins of the articular cartilage. In front it dips downwards on either side to the level of the tubercle of the tibia. Behind it dips downwards opposite the popliteal notch to the lower limit of the attachment of the posterior cruciate ligament. At the back of the lateral condyle the line of attachment is interrupted for the passage of the tendon of the popliteus.

Accessory Ligaments.—The front of the joint is occupied by the quadriceps femoris represented by the common tendon, the patella, and the ligamentum patellæ.

The **ligamentum patellæ** is a thick, broad band, attached above to the apex and adjacent margins of the patella, below to the lower rough part of the tubercle of the tibia. A bursa intervenes between it and the upper smooth part of the tubercle. Above its superficial fibres are continuous with those of the tendon of the quadriceps by means of an expansion covering the front of the patella. On either side the patella retinacula are attached to it.

The **medial and lateral patellar retinacula** occupy the intervals between the patella and the ligamentum patellæ in front and the medial and lateral ligaments on either side. In each patellar retinaculum are two planes of fibres which are closely blended with each other. The superficial layer is derived from the deep fascia, which is continuous above with the fascia lata of the thigh, and is here firmly adherent to the deeper layer. To the outer side of the patella the lateral patellar retinaculum is especially thick and strong, as its fascial element is provided to some considerable extent by the ilio-tibial tract. Deeply to, and with difficulty separable from, the fascial layer are tendinous expansions of the vastus lateralis et medialis continuous with these muscles above, and prolonged downwards to the tibia.

Between each patellar retinaculum superficially and the capsular ligament deeply are intervals containing connective tissue and blood-vessels. The interval is especially well marked on the inner side of the patella, where the capsular ligament is relatively thick and consists largely of curved fibres which arch backwards from the patella to the hinder part of the medial condyle (Fig. 377).

On either side of the joint is a well-marked ligament.

The **medial ligament** (Fig. 380) is a long, broad, flattened band attached above to a rough impression on the inner aspect of the medial condyle of the femur immediately below the adductor tubercle. It passes obliquely downwards and forwards, and is attached below to the medial condyle of the tibia, where it bridges over the horizontal groove lodging the tendon of insertion of the semimembranosus, which thus lies deeply to it. From the medial condyle it is prolonged downwards for some considerable distance on the inner aspect of the shaft of the tibia, and bridges over the depression below the medial condyle, thus forming the roof of a short canal in which the medial inferior genicular branch of the popliteal artery is contained. Its hinder part is adherent deeply to the medial semilunar cartilage. Superficial to the

medial ligament, but with a bursa or bursæ intervening, are the tendons of the sartorius, gracilis, and semitendinosus.

Some of the fibres of the tendon of insertion of the adductor magnus are prolonged into the medial ligament of the knee-joint, which represents, partially at all events, a distal prolongation of the muscle.

The **lateral ligament** (Fig. 380) is a short rounded cord remarkably like a tendon in appearance. Attached above to the prominence on

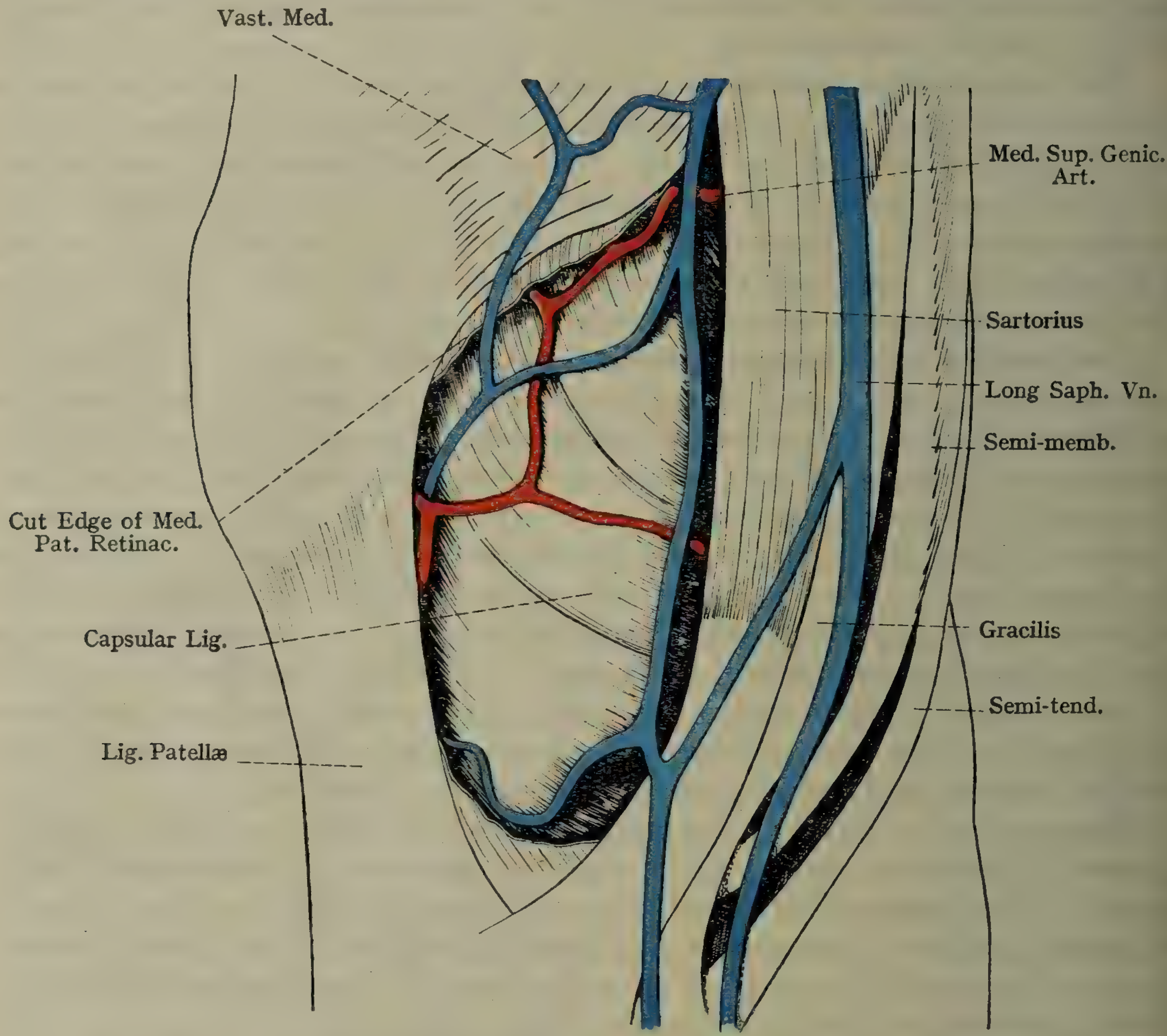


FIG. 377.—THE MEDIAL SIDE OF THE KNEE (FROM A DISSECTION).

The medial patellar retinaculum has been removed to expose the bloodvessels, which are contained in the connective tissue between it and the capsular ligament.

the outer aspect of the lateral condyle of the femur, immediately above the groove lodging the tendon of the popliteus, it extends downwards and backwards, and is attached below to the head of the fibula in front of the styloid process. Lying superficially to it is the tendon of the biceps, a bursa being interposed between them. Just above its fibular attachment the tendon embraces the lower part of the ligament. On its deep aspect, with a synovial pouch between them, is the tendon of the popliteus, which intervenes between it and the lateral semilunar

cartilage. At a lower level the lateral inferior genicular artery lies deeply to it.

The lateral ligament represents the proximal end of the peroneus longus muscle, which in some animals and in the human embryo arises from the lower end of the femur.

The arcuate ligament is a name given to a somewhat indefinite and inconstant band lying behind the lateral ligament and attached below to the styloid process of the fibula. It arches across and is frequently attached to the tendon of the popliteus, which passes through the capsular ligament immediately behind it. It is simply a differentiated band of the capsular ligament.

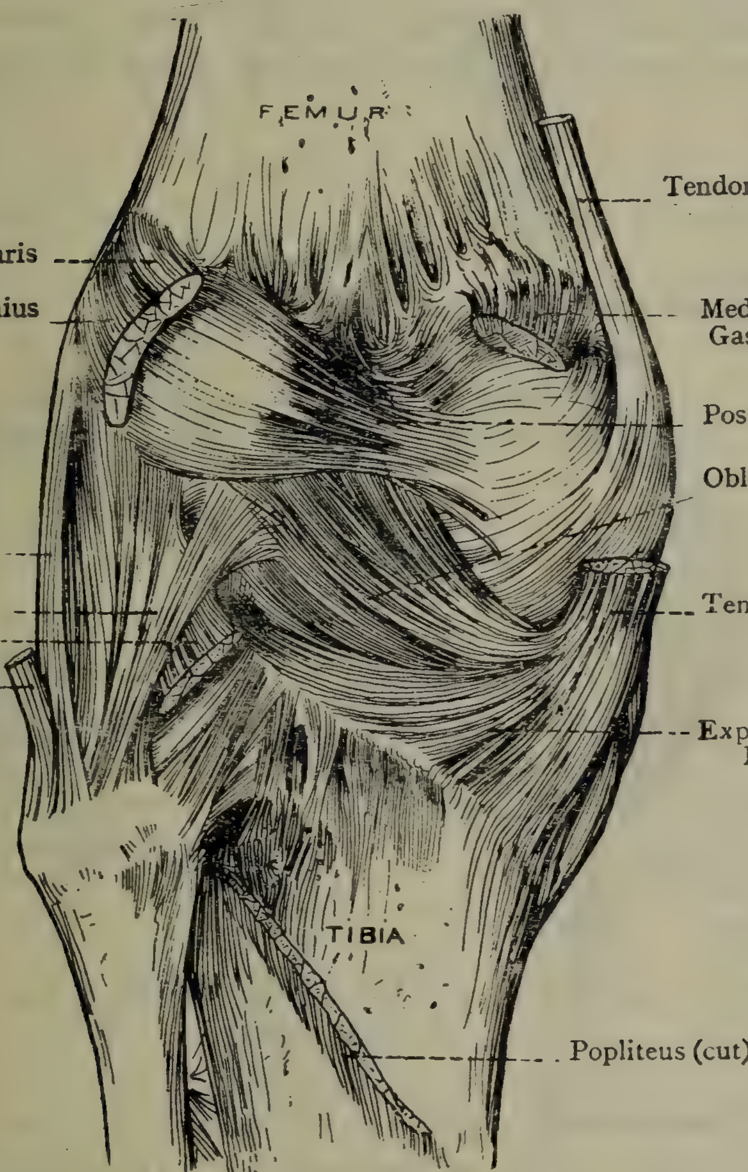


FIG. 378.—THE LEFT KNEE-JOINT (POSTERIOR VIEW).

The **oblique posterior ligament** (Winslowii) (Fig. 378) is an expansion from the lower part of the tendon of the semimembranosus, which extends obliquely upwards and outwards across the intercondylar notch, and is attached to the lateral condyle of the femur. Deeply it is adherent to the posterior part of the capsular ligament, which it supplements on this aspect of the joint. Passing through it are the middle genicular branch of the popliteal artery and the genicular branch of the obturator nerve.

The **intrascapular structures** include the two semilunar cartilages, the transverse ligament, and the cruciate ligaments.

The **semilunar cartilages** (Fig. 379) are two crescentic plates o fibro-cartilage, which occupy the periphery of the articular surface in the upper surface of the tibia. They serve to deepen the socket of reception for the two femoral condyles, and, being movable on th tibia, they, together with the femoral condyles, undergo gliding move-ments upon the former bone. The extremities of each crescenti plate are fibrous, are the most fixed parts, and are known as the tw horns. Each semilunar cartilage is triangular in section; the narrov base represents a circumferential area adherent to the deep aspect o the capsular ligament, a concave upper surface is adapted to th convexity of the femoral condyle, a flattened lower surface rests o the articular surface of the tibia, and an apex or thin lip projects int the joint cavity.

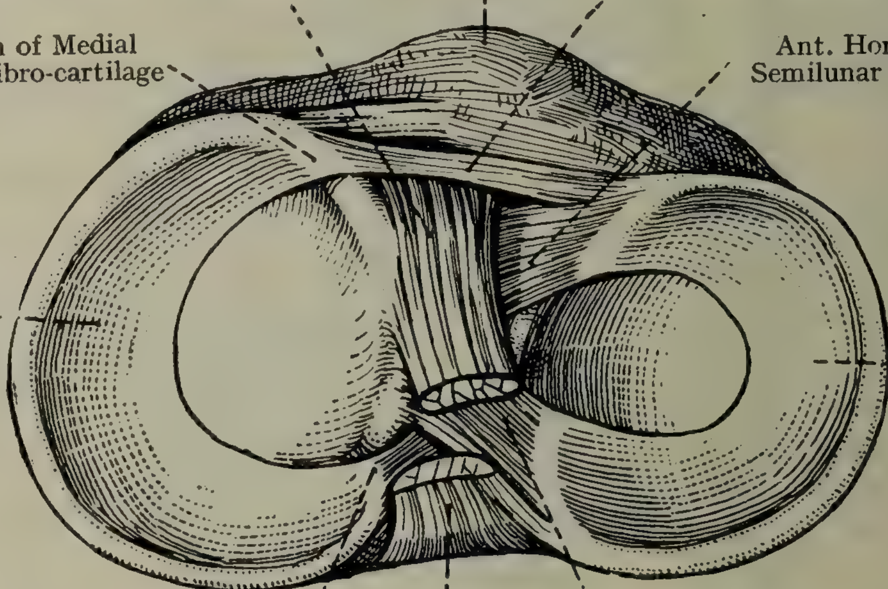


Fig. 379.—The Ligaments and Fibro-cartilages on the Head of the Right Tibia.

The **medial semilunar cartilage** is less complete than the lateral being not much more than a semicircle. It is wider behind than i front. Its anterior horn is attached to the fore end of the depresse area in front of the intercondylar eminence, and is, as a rule, con-tinuous with the transverse ligament. Its posterior horn is attache to the tibia behind the intercondylar eminence immediately in fron of the attachment of the posterior cruciate ligament. The media semilunar cartilage is firmly adherent to the deep aspect of the posterio part of the medial ligament.

The **lateral semilunar cartilage** is in form nearly a complete circle Its two horns are close together, and are attached immediately i front of and behind the intercondylar eminence, being embraced by those of the medial semilunar cartilage. It is much more uniform in width than the medial semilunar cartilage. From its posterior aspect

a well-marked band, the *ligament of Wrisberg* (Fig. 380), passes obliquely upwards and inwards, blends with the upper part of the posterior cruciate ligament, and is attached with it to the fore part of the deep aspect of the medial condyle.

The ligament of Wrisberg usually divides into two bands, which embrace the posterior cruciate ligament; one band blends with its posterior aspect, the other with its anterior. The latter band is known as *Humphry's ligament.*

The ligament of Wrisberg represents the primitive attachment of the lateral semilunar cartilage in pronograde mammals, in which the cartilage is attached at one end to the femur, at the other to the tibia.

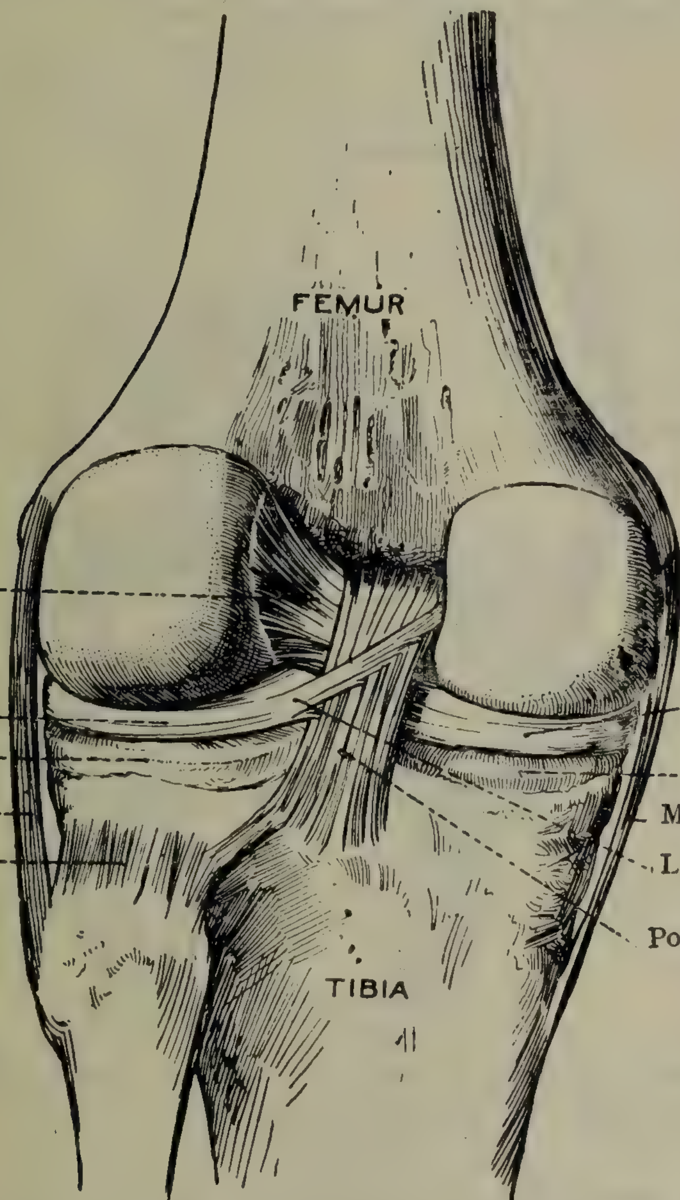


FIG. 380.—THE CRUCIATE LIGAMENTS OF THE LEFT KNEE-JOINT (POSTERIOR VIEW) (AFTER SPALTEHOLZ).

The outer aspect of the lateral semilunar cartilage is grooved by the tendon of the popliteus, which intervenes between it and the lateral ligament of knee. The groove is lined with synovial membrane, which is interjected between the tendon and the cartilage.

The **transverse ligament** (Fig. 379) is a narrow band towards the front of the joint, and links the two semilunar cartilages together. Medially it is continuous with the anterior horn of the medial semilunar cartilage, from which it passes outwards to blend with the anterior aspects of the lateral semilunar cartilage. It is sometimes absent.

The **two cruciate ligaments** (Fig. 381) are two strong ligamentous bands which fasten the femur and tibia directly together. They cross each other as they pass upwards from the area between the two articular surfaces of the tibia to the intercondylar notch, where they are attached to the deep aspects of the two condyles.

The **anterior cruciate ligament** is attached below to the rough area in front of the intercondylar eminence between the attachments of the anterior horns of the two semilunar cartilages, that of the medial being in front of it and the lateral behind it. It passes very obliquely upwards, backwards, and outwards, and is attached to the hinder end of the deep aspect of the lateral condyle.

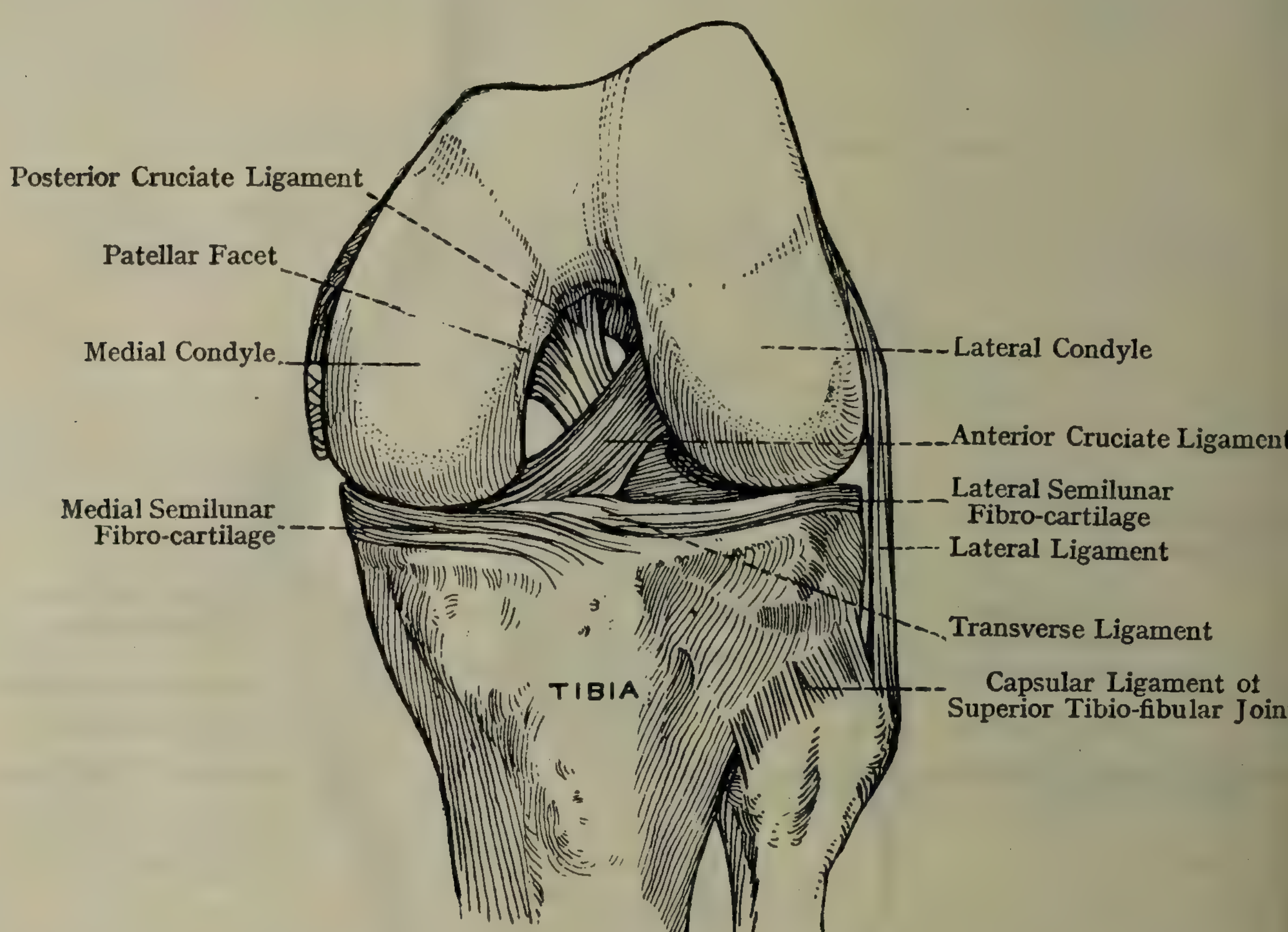


FIG. 381.—THE CRUCIATE LIGAMENTS OF THE LEFT KNEE-JOINT (ANTERIOR VIEW).

The **posterior cruciate ligament,** thicker and shorter than the anterior, is attached below to the floor of the popliteal notch at the back of the upper end of the tibia, and behind the attachments of the posterior horns of both semilunar cartilages. It passes obliquely upwards, forwards, and inwards; it is attached above to the fore part of the deep aspect of the medial condyle. The posterior aspect of its upper end is joined by the ligament of Wrisberg, and Humphry's ligament, when present, blends with its anterior aspect. By means of these ligaments it is fastened to the posterior surface of the *lateral semilunar cartilage.*

The **synovial membrane** (Fig. 383) is very extensive. It lines the deep aspect of the capsular ligament above and below the semilunar cartilages. It is not infolded into the joint to provide an investment

or the semilunar cartilages, as is usually described, but comes to an end, above and below, close to the circumferential limits of these structures. From the deep aspect of the posterior part of the capsular ligament it is inflected into the joint as a double-layered fold investing the two cruciate ligaments. The two layers are continuous with each other in front of the two cruciate ligaments, and also through a small interval between them, thus forming a kind of bursal arrangement diminishing friction between the two ligaments. The posterior aspect of the posterior cruciate ligament is bare of synovial membrane, as it

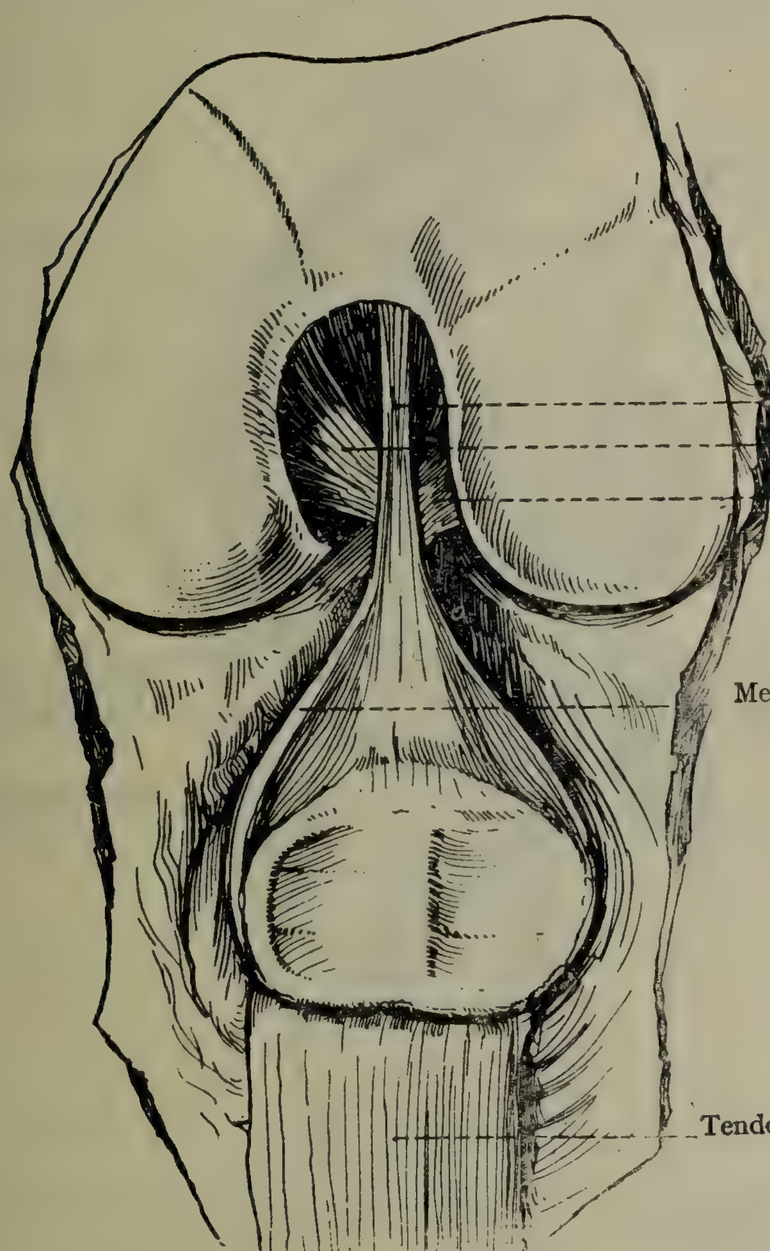


FIG. 382.—INTERIOR OF THE LEFT KNEE-JOINT (ANTERIOR VIEW).

is in direct contact with the capsular ligament. Towards the front of the joint the synovial membrane invests a large conical mass of fat, the lower part of which occupies the interval between the ligamentum patellæ and the lower part of the patella in front, and the tibia behind. From the apex of the pad of fat a band-like fold, the *infrapatellar synovial fold* (*ligamentum mucosum*), extends backwards and upwards, and is attached to the front end of the intercondylar notch of the femur. The synovial membrane investing the lateral limits of the pad of fat is disposed as two fringed folds, the *alar folds* (Fig. 382), which diverge

from the lower limit of the synovial fold and arch forwards and outwards to the lateral margins of the articular surface of the patella. The alar folds form the upper limits of a pouch of synovial membrane between the lower part of the patella in front and the pad of fat behind.

The synovial membrane extends upwards for some distance above the level of the patella, and is, in most cases, continuous here with the large bursa between the tendon of the quadriceps and the shaft of the femur. At the junction of this suprapatellar pouch of synovial membrane with the bursa are fringed folds containing fat.

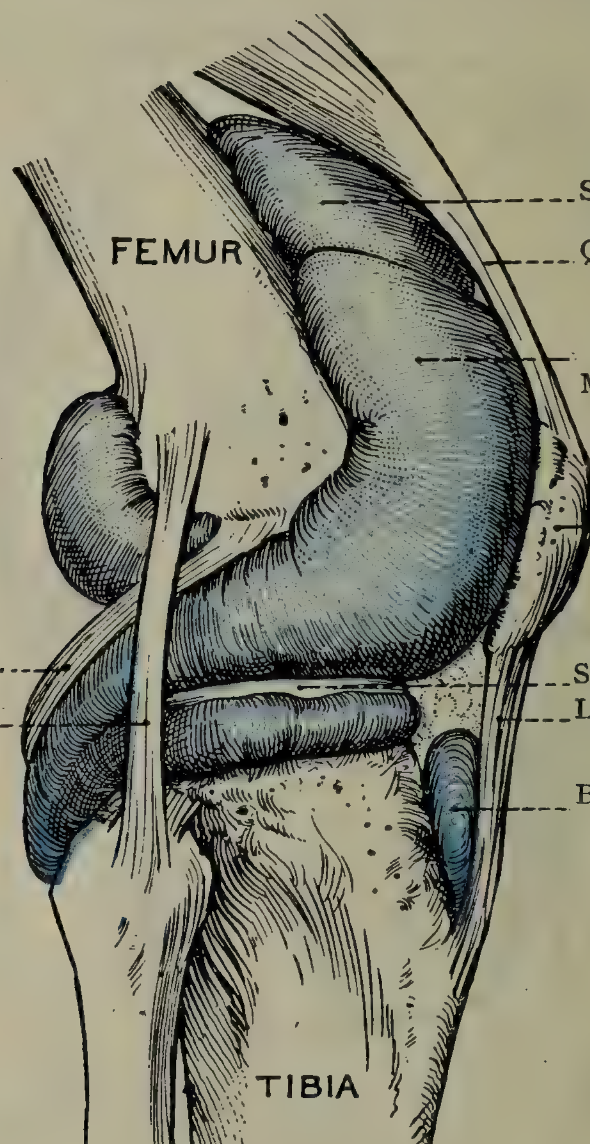


FIG. 383.—THE SYNOVIAL MEMBRANE OF THE RIGHT KNEE-JOINT (LATERAL ASPECT) (AFTER SPALTEHOLZ).

A transverse section through the knee-joint of a human embryo exhibits three cavities—two posterior or condylo-tibial joint cavities, lying side by side, and completely independent of each other, being separated by a vertical partition; an anterior or subpatellar cavity, which is to be regarded as an enlarged bursal sac between the tendon of the quadriceps and the capsule clothing the two condylo-tibial joint cavities in front. The three cavities become one, and give rise to the single complicated cavity of the knee-joint by the partial disappearance of the partition between the two posterior cavities and the anterior cavity, whereby the latter communicates with both condylo-tibial cavities behind. The partition between the two condylo-tibial cavities persists, and is modified into the two cruciate ligaments. The remnants of the partition between the subpatellar cavity and the two condylo-tibial cavities are represented by the infrapatellar synovial fold and the synovial folds, the pouch of synovial mem-

rane behind the lower part of the patella being the persistent lower part of the ubpatellar bursal sac. The capsular ligament is regarded by some anatomists s being inflected into the joint from behind, the inflected part being represented y the connective tissue basis of the synovial membrane investing the cruciate gaments. According to this view, the two cruciate ligaments are extracapsular tructures.

The **arterial supply** is derived from the extensive anastomosis about he joint, in which branches of the popliteal, descending branch of lateral ircumflex, descending genicular, and tibial arteries take part.

The **nerve-supply** is very extensive, and is derived from the sciatic y means of twigs from its terminal popliteal branches, from the emoral, and from the obturator nerves.

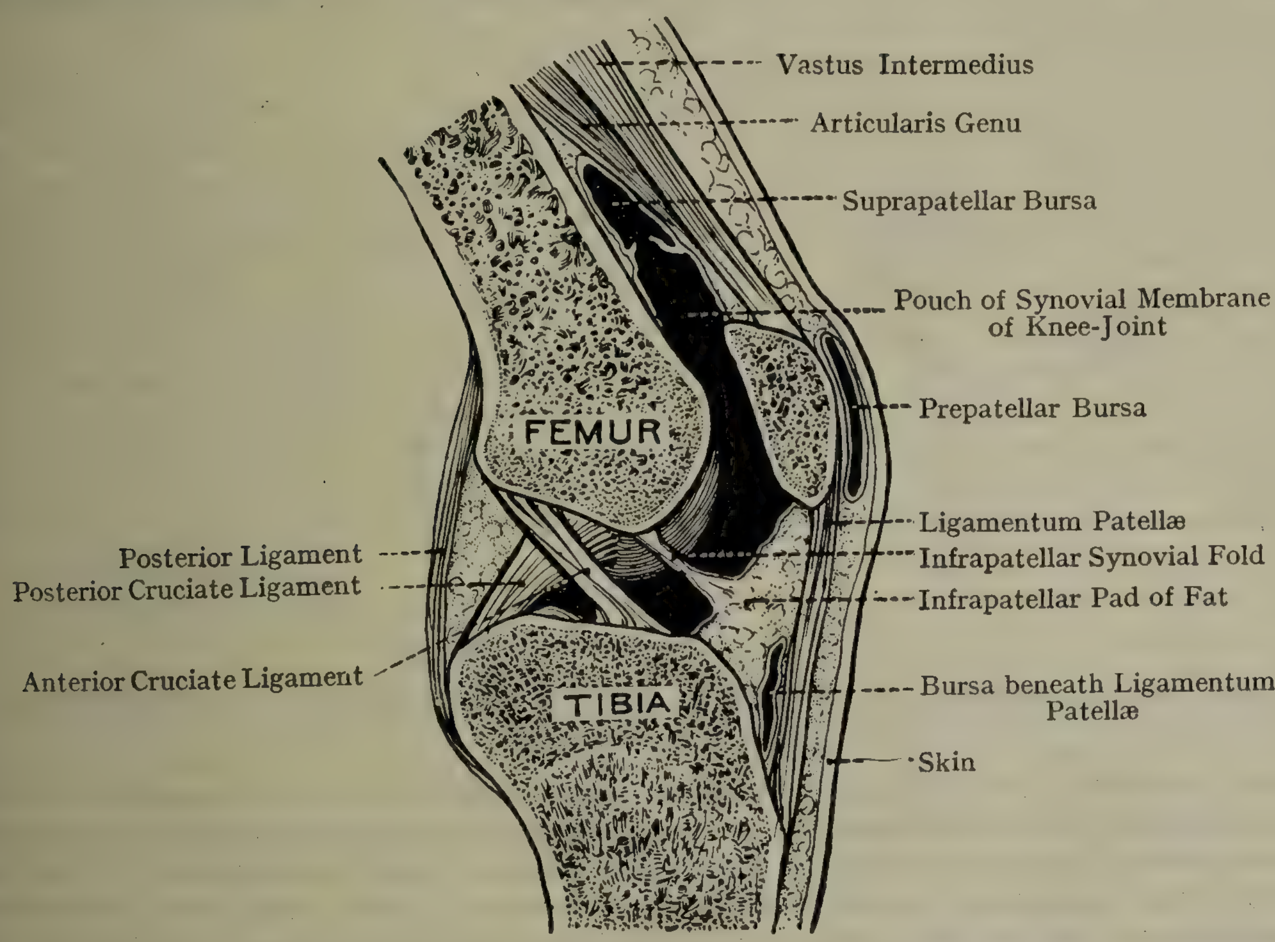


FIG. 384.—SAGITTAL SECTION OF THE RIGHT KNEE-JOINT VIEWED FROM THE OUTER SIDE.

Genicular branches from the medial popliteal nerve accompany the two medial genicular and the middle genicular branches of the popliteal artery. Genicular branches from the lateral popliteal nerve accompany the two lateral genicular arteries and the anterior tibial recurrent artery (p. 550). The terminal twigs of the three muscular branches of the femoral supplying the vastus lateralis, vastus intermedius, and vastus medialis respectively end in the joint, that derived from the nerve to the vastus medialis being the largest and most important (p. 574). The supply from the obturator is the genicular branch, the terminal branch of its posterior division (p. 580).

The **movements** taking place in the knee-joint are chiefly flexion and extension, with which gliding and rotation movements are associated.

The complicated movements occurring in extension and flexion of the knee-

joint are most easily understood by studying the sequence of events when th joint passes from the position of extreme flexion to that of extreme extensio the feet being firmly planted on the ground. In the fully flexed position th extreme hinder parts of the two condylar surfaces of the femur, each graspe by the corresponding semilunar cartilage, rest on the hinder parts of th articular surfaces of the tibia. As flexion commences the two condyles begi to roll parallel to each other in the cups provided by the semilunar cartilage which, being elastic structures, adapt themselves to the varying curvature of the two condyles. As the movement progresses the parallel rolling of th two condyles continues, and at the same time the semilunar cartilages sli forwards on the tibia, with the result that the contact surface of each condyl with the tibia and the transverse axis about which the rolling takes place als move forwards. This continues until the rolling of the lateral condyle is brough to a stop, and a groove which marks the junction of its articular surface wit the patellar surface comes into contact with the anterior edge of the semiluna

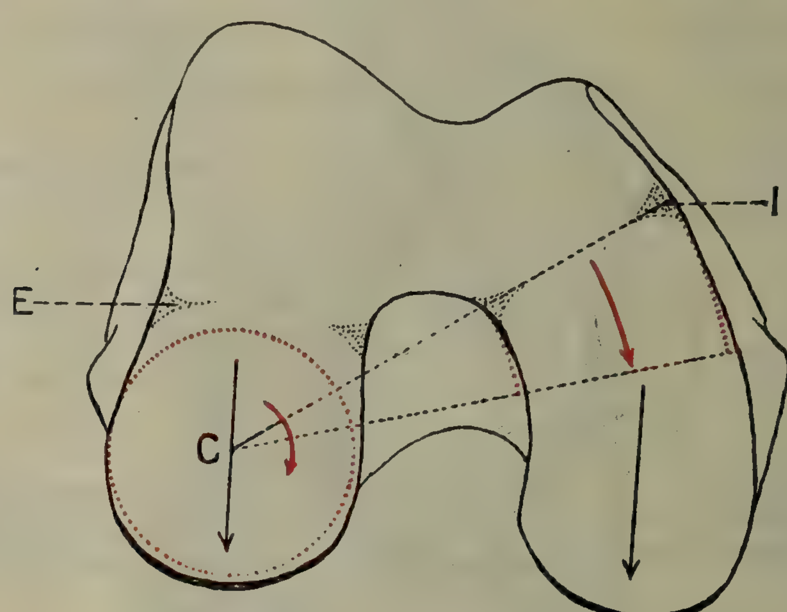


FIG. 385.—THE ARTICULAR SURFACE AT THE LOWER END OF THE FEMUR VIEWED FROM BELOW.

The black arrows indicate the direction of movement in the two condyles durin the greater part of extension; the red arrows show the direction of move- ment during the final stage, when the femur rotates inwards. E is th groove on the lateral condyle which is in contact with the lateral semiluna cartilage at end of first stage of extension; I is the groove on the media condyle in contact with the medial semilunar cartilage at the end of th final rotation; C a point on the vertical axis about which the final rotatio takes place.

cartilage. At this stage the rolling of the medial condyle is incomplete, as it articular surface is prolonged farther forwards than that of the lateral condyle. In the final stage of extension the femur rotates inwards. The lateral condyle pivots round about a vertical axis, while the medial condyle goes on rolling, but now wheels round the vertical axis, passing through the lateral condyle. The pivoting of the lateral condyle and the wheeling movement of the medial condyle are finally brought to a stop by the tension of all the strong ligaments about the joint. At the end of the final stage the groove marking the junction of the tibial articular surface of the medial condyle with the patellar surface comes into contact, in its turn, with the front edge of the medial semilunar cartilage. When the foot is off the ground the tibia rotates outwards on the femur in the final stage of extension, but the same relative displacement takes place between the two bones.

It is to be noted that the front part of the articular surface of the medial condyle is bent outwards, and is bounded on either side by two curved edges,

ach of which is a segment of a circle, of which the common centre is a point n the lateral condyle. This point indicates the position of the axis round vhich the lateral condyle pivots.

The inward rotation of the femur on the tibia, which marks the final stage f extension, is said to lock the knee-joint. When standing in the erect posture vith the knees fully extended the line of the centre of gravity falls in front of he axis of rotation of the joint, and will tend further to extend it, but this is revented by all the strong ligaments about the joint, the medial and lateral igaments, the cruciate ligaments, and the oblique posterior ligament all being on he stretch at the end of the movement. Further, in this position the grooves vhich mark the front limits of the condylar articular surfaces are firmly pressed gainst the anterior edges of the two semilunar cartilages. Such is the automatic rrangement whereby the erect posture can be maintained as far as the knee-oint is concerned, with a minimal expenditure of muscular energy.

Flexion Movements.—When bending the knees in the standing position an utward rotation of the femur must take place as a preliminary movement, he lateral condyle pivoting round on a vertical axis and the medial condyle ndergoing a wheeling movement. Before the femur can rotate outwards lexion must also take place at the hip-joint, in order to relax the ilio-femoral igament, the outer band of which would prevent outward rotation of the femur n the extended position of this joint. This preliminary movement of rotation s said to unlock the knee-joint. When it is completed, the two articular condylar surfaces in contact with the tibia are parallel with each other, and both commence to roll in their articular cups, at the same time sliding backwards with the two semilunar cartilages on the tibia. In other words, the movement is the exact converse of that occurring during the greater part of extension, and continues until full flexion is attained. Extreme flexion is usually limited by the meeting and compression of the soft masses on the back of the thigh and of the calf respectively, although the posterior cruciate ligament is said to be on the stretch.

Rotation.—In considering rotation it must be kept in mind that when the foot is on the ground the leg is fixed, and no rotation of the tibia can occur, but the femur can rotate on the tibia. When the foot is off the ground the leg can be rotated outwards and inwards on the thigh to a limited extent. Rotation movements of the tibia on the femur cannot take place when the joint is extended, and are most free when it is in the semiflexed position. The rotation of the tibia in the semiflexed position is one which takes place about a vertical axis between the articular surfaces, the inner tibial surface moving backwards and the outer surface moving forwards during medial rotation, the reverse movements taking place during lateral rotation. In either case the movement of the inner tibial surface is more extensive than that of the outer. The movements are of an altogether different kind to the rotations occurring at the end of extension and at the beginning of flexion. Inward rotation of the tibia is limited by the anterior cruciate ligament being put on the stretch, the movement tending to wind up the ligaments. In outward rotation the cruciate ligaments are unwound and relaxed; it is limited by the tension of the medial and lateral ligaments.

Movements of the Patella.—With the movements of flexion and extension the patellar or trochlear surface of the femur must glide upwards and downwards respectively on the posterior surface of the patella, the patella itself remaining practically stationary. When the joint is in the extended position the greater part of the patella is at a higher level than the trochlear surface, and its lowermost pair of facets only are in contact with it. As flexion proceeds the trochlear rises; the two intermediate patellar facets and later the uppermost pair, each in turn, come in contact with it. In extreme flexion the increasing projection forwards of the medial condyle tilts the patella outwards, and the inner vertical facet on its articular surface comes into contact with the semilunar facet on the outer aspect of the medial condyle.

When the knee-joint is flexed, a space towards the front of the joint opens up

between the articular surfaces. In this movement the infrapatellar synovial fold is drawn upwards, with the result that the conical pad of fat to which it is attached is pulled upwards and occupies the space. This is an automatic arrangement comparable with that of the ligament of head of femur (p. 593).

The **bursæ about the knee-joint** are very numerous, as the surrounding tendons come into closer relation with the bones taking part in the formation of the joints than is the case in most joints.

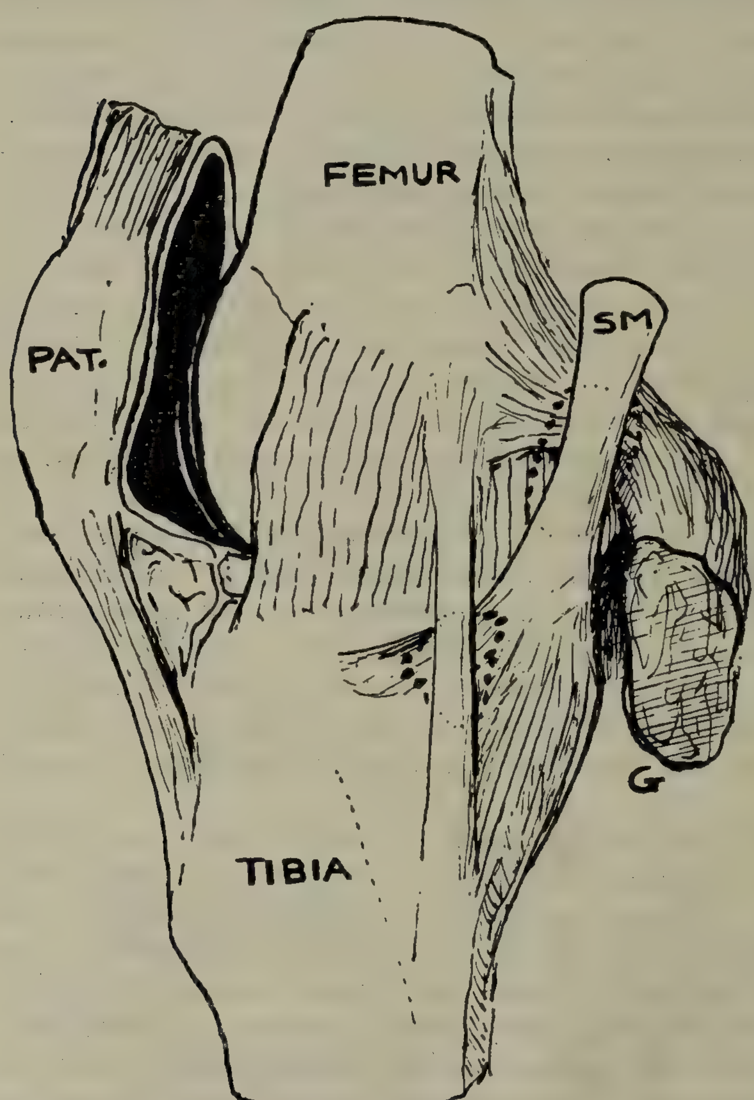


Fig. 386.—Plan of Insertion of Tendon (SM) of Semimembranosus on Medial Side of Tibia, Deep to Medial Ligament of Knee, with a Bursa (Dotted Line).

Above this bursa the tendon is in contact with medial head (G) of gastrocnemius, another bursa intervening, prolonged between the tendon lower down and condylar capsule.

On the Front of the Joint.—Above the level of the patella is the suprapatellar bursa, which lies deeply to the tendon of the quadriceps femoris, and in most cases communicates with the pouch of the synovial membrane, extending upwards in front of the lower part of the shaft of the femur. In front of the patella there are usually two bursæ, known as the prepatellar bursæ, one subcutaneous and the other subfascial. Below the level of the patella a subcutaneous bursa lies in front of the tubercle of the tibia and the lower part of the ligamentum patellæ, and a deeper one between the ligamentum patellæ and the upper smooth part of the tubercle by fat of the tibia. The latter bursa extends upwards, and is separated from the anterior aspect of the tibia, above the level of the tubercle.

On the back of the joint the largest and most important bursa, which usually communicates with the synovial cavity, lies deeply to the inner head of the gastrocnemius and the semimembranosus. A smaller bursa lies deeply to the outer head of the gastrocnemius.

On the inner aspect of the joint a large bursa, sometimes represented by two bursæ, intervenes between the medial ligament and the tendons of the sartorius, gracilis, and semitendinosus. Deep to the medial ligament is a bursa between the tendon of the semimembranosus and the upper lip of the horizontal groove on the medial epicondyle of the tibia in which the tendon lies.

On the outer side of the joint a bursa lies deeply to the tendon of the biceps, between it and the lateral ligament. A pouch of the synovial membrane ensheathes the tendon of the popliteus, separates it from the lateral ligament superficially, and from the lateral semilunar cartilage deeply. A prolongation of this synovial sheath extends upwards, and lies between the tendon of the popliteus and the lateral femoral condyle, while another prolongation follows the tendon as it passes through the capsular ligament, and, extending downwards, intervenes between it and the back of the upper end of the tibia.

SOLE OF THE FOOT.

Landmarks.—On the inner side of the foot, about an inch below the medial malleolus, the ridge-like projection of the sustentaculum tali may possibly be felt. In front of the sustentaculum tali is a very prominent projection caused by the tuberosity of the navicular bone, and between them a depression, occupied deeply by the tendon of the tibialis posterior and the plantar calcaneo-navicular ligament. This depression marks the position of the talo-navicular joint. The projection caused by the tuberosity of the navicular bone is one of the most important surgical landmarks in the foot. In front of the tuberosity of the navicular bone the medial cuneiform, the first metatarsal, and the marked prominence of the metatarso-phalangeal joint of the great toe can all be distinguished, in this order from behind forwards.

On the outer border of the foot at about its mid-point is an easily recognizable projection caused by the prominent tubercle on the outer side of the base of the fifth metatarsal bone. A point midway between this prominence and the tip of the lateral malleolus marks the position of the calcaneo-cuboid joint, which it may be noted is in the same transverse plane as the talo-navicular joint on the inner side of the foot.

The Plantar Arteries.—The lateral plantar artery crosses the foot twice, first passing obliquely forwards and outwards towards the outer side of the foot, and then, changing its direction, crosses to the inner side of the foot. The first part of the artery is indicated by a line drawn from a point midway between the medial malleolus and the projection of the heel to a point about a finger's breadth to the inner side of the tuberosity of the fifth metatarsal; the second part by a line drawn from the latter point to the proximal end of the first intermetatarsal space. The position of the medial plantar artery is indicated by a line drawn from a point midway between the medial malleolus and the projection of the heel to about the middle of the plantar aspect of the ball of the great toe.

Subcutaneous bursæ are usually found in situations where the foot is subject to the greatest pressure. These situations are more particularly the under side of the heel, the plantar and inner aspects of the metatarso-phalangeal joint of the great toe, and the plantar aspect

of the head of the fifth metatarsal bone. Occasionally bursæ are foun
on the outer side of the tuberosity of the fifth metatarsal and on th
tuberosity of the navicular bone.

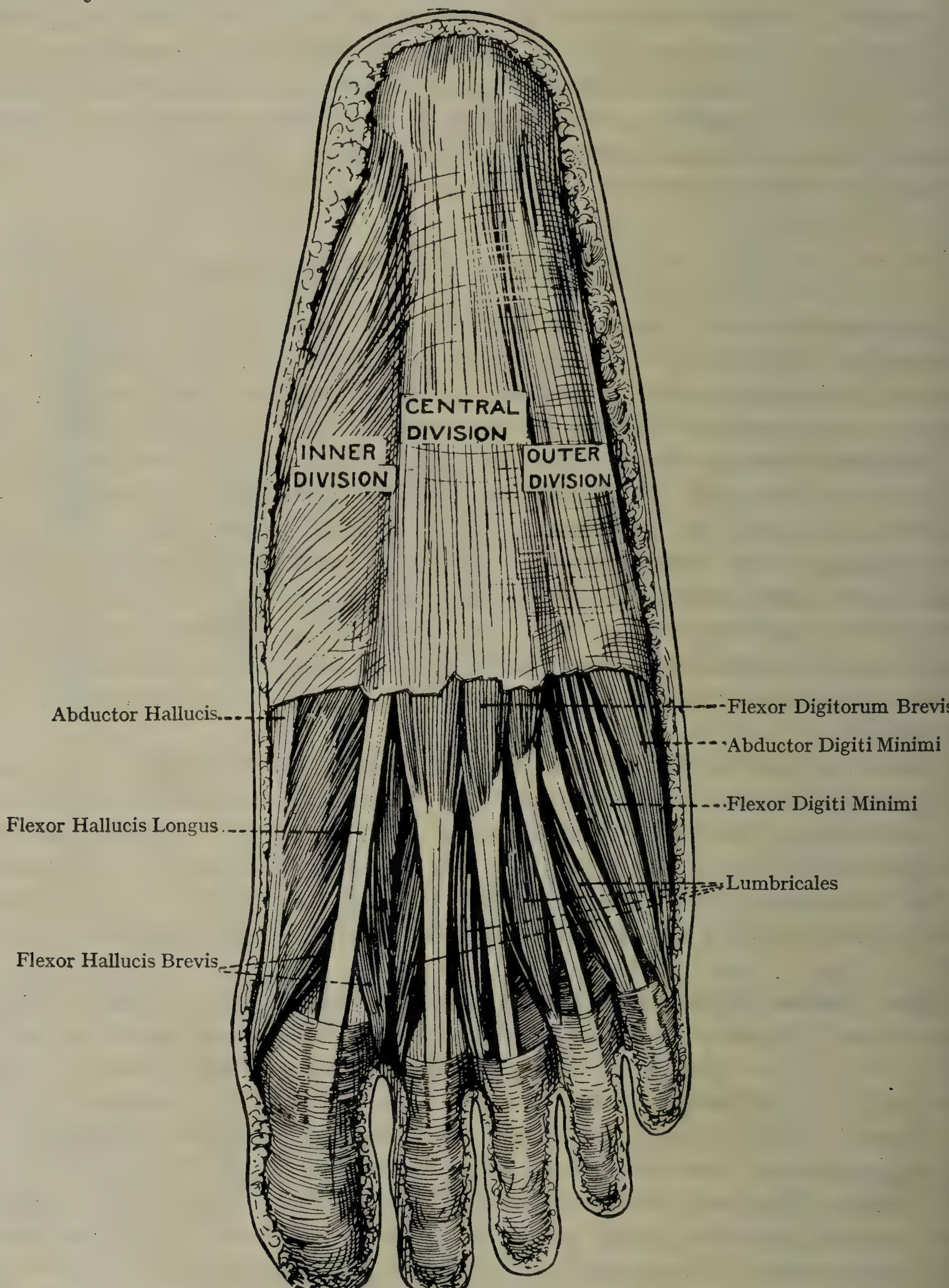


FIG. 387.—THE PLANTAR APONEUROSIS AND FIRST LAYER OF MUSCLES (IN PART).

The deep fascia of the sole, known as the **plantar aponeurosi** (Fig. 387), consists of three portions, a central, medial, and lateral. Th junctions of the former with the latter are indicated by two longi

udinal grooves. The central portion chiefly consists of longitudinal .bres, and is exceedingly thick and strong, while the two side portions, ı which transverse fibres predominate, are relatively thin. Between he plantar aponeurosis and the skin are numerous fibrous bands which ind the two together. The spaces between the fibrous bands are ccupied by masses of finely lobulated fat, representing the superficial ascia, which, in the sole, is thick, dense, and resistant.

The **central portion** covers the flexor digitorum brevis superficially, nd is triangular in outline. Behind it is very narrow, and is attached o the large inner tubercle at the hinder end of the plantar aspect of he calcaneum. As it passes forwards towards the toes it widens and ecomes thinner. Opposite the heads of the metatarsal bones it divides nto five digital processes. The direction of its fibres is chiefly longi-udinal, but towards the toes transverse fibres are superadded.

In the webs of the toes the transverse fibres form a more or less listinct band, the *superficial transverse ligament*, which bridges over he intervals between the digital processes and covers the digital rteries and nerves, together with the lumbrical muscles, superficially. Each digital process ends by becoming continuous with the fibrous lexor sheath; while some of its superficial fibres are attached to the kin. From each side of a digital process a lateral slip passes in deeply o join the deep transverse ligament, and thus completes the com-nencement of a tunnel in which the flexor tendons, as they pass on o a toe, are contained.

The central part of the plantar aponeurosis, by playing the part of a string o a bow, is an important factor in maintaining the longitudinal arch of the foot. The central part of the plantar aponeurosis and its digital processes, with their ateral slips, represent the tendons of a flexor of the proximal phalanges of the oes, a muscle which is well developed in many animals. The proximal part of he muscle is represented by the plantaris (p. 620).

The **lateral portion** invests the abductor digiti minimi muscle. At ts line of junction with the central portion is the lateral intermuscular eptum, which is prolonged deeply into the sole; laterally it is con-inuous round the outer border of the foot with the deep fascia of the lorsum. A strong band of this portion extends between the outer ubercle of the calcaneum and the tuberosity on the outer side of the ase of the fifth metatarsal bone. This band is sometimes replaced by nuscle fibres, the *abductor ossis metatarsi quinti*.

The **medial portion** invests the abductor hallucis muscle, and is continuous posteriorly with the flexor retinaculum. At its line of unction with the central portion is the medial intermuscular septum; nedially it is continuous round the inner border of the foot with the leep fascia of the dorsum.

The two **intermuscular septa,** medial and lateral, are situated on either side of the flexor digitorum brevis, between it and the abductor allucis on the one side and the abductor digiti minimi on the other. Each septum gives attachment to the two muscles between which it ies. The two septa are continuous deeply with the ligamentous and

tendinous structures clothing the plantar aspect of the tarsus and th interosseous fascia investing the metatarsal bones and the interosseou muscles.

The **cutaneous nerves** (Fig. 392) which supply the skin of the sol are the medial calcanean from the posterior tibial, and branches c the medial and lateral plantar nerves.

The **medial calcanean nerve** is a branch of the posterior tibial give off under cover of the flexor retinaculum. It passes through the liga ment, and a branch supplies the skin on the under side of the heel.

The plantar cutaneous branches of the medial plantar nerve appea in the groove between the abductor hallucis and flexor digitorum brevi They are distributed to the skin of the inner half of the sole.

The plantar cutaneous branches of the lateral plantar nerve appea in the groove between the flexor digitorum brevis and abductor digi minimi. They are distributed to the skin of the outer half of the sol

The skin on the outer side of the heel and the outer border of the foo is supplied by the sural nerve, that of the inner border of the foot b the saphenous, and distal to the metatarso-phalangeal joint of th great toe by the medial branch of the musculo-cutaneous nerve.

Cutaneous Arteries.—The skin of the heel is supplied by the media calcanean branches of the posterior tibial and of the lateral planta arteries, and by the lateral calcanean branch of the peroneal artery. Th skin covering the rest of the sole is supplied by branches of the later and medial plantar arteries, which accompany the cutaneous branche of the corresponding nerves.

Superficial Veins.—A close network of very small veins occupies th subcutaneous tissue of the sole. It is drained by vessels windin round the borders of the foot to join the dorsal plexus, and also by th plantar venous arcade, a vein crossing the distal part of the sole clos to the roots of the toes. The venous arcade receives small vein draining the toes, and joins the dorsal plexus by veins which win round the borders of the foot, and also by interdigital veins which pas directly upwards, between the toes, opposite the interdigital clefts.

Muscles.—The muscles of the sole are disposed in four layers.

The *first layer* (Fig. 388) consists of three muscles which lie deepl to the three portions of the plantar aponeurosis; the flexor digitoru brevis occupies a central position, and the abductors of the two margina toes, the abductor hallucis and the abductor digiti minimi respectivel lie on either side of it.

Abductor Hallucis (Fig. 388)—*Origin.*—From the inner side of th large inner tubercle on the plantar aspect of the calcaneum, and fro the lower border of the flexor retinaculum. Many of its fibres aris from the plantar aponeurosis covering it, and from the medial inte muscular septum.

Insertion.—By a tendon which blends with that of the inner hea the flexor hallucis brevis, with which it is inserted into the inner sid of the base of the proximal phalanx of the great toe.

Nerve-supply.—The medial plantar nerve.

Action.—Abducts the great toe, and flexes its metatarso-phalangeal oint.

Flexor Digitorum Brevis (Fig. 388)—*Origin.*—By a narrow tendon ttached to the apex of the large inner tubercle on the plantar aspect

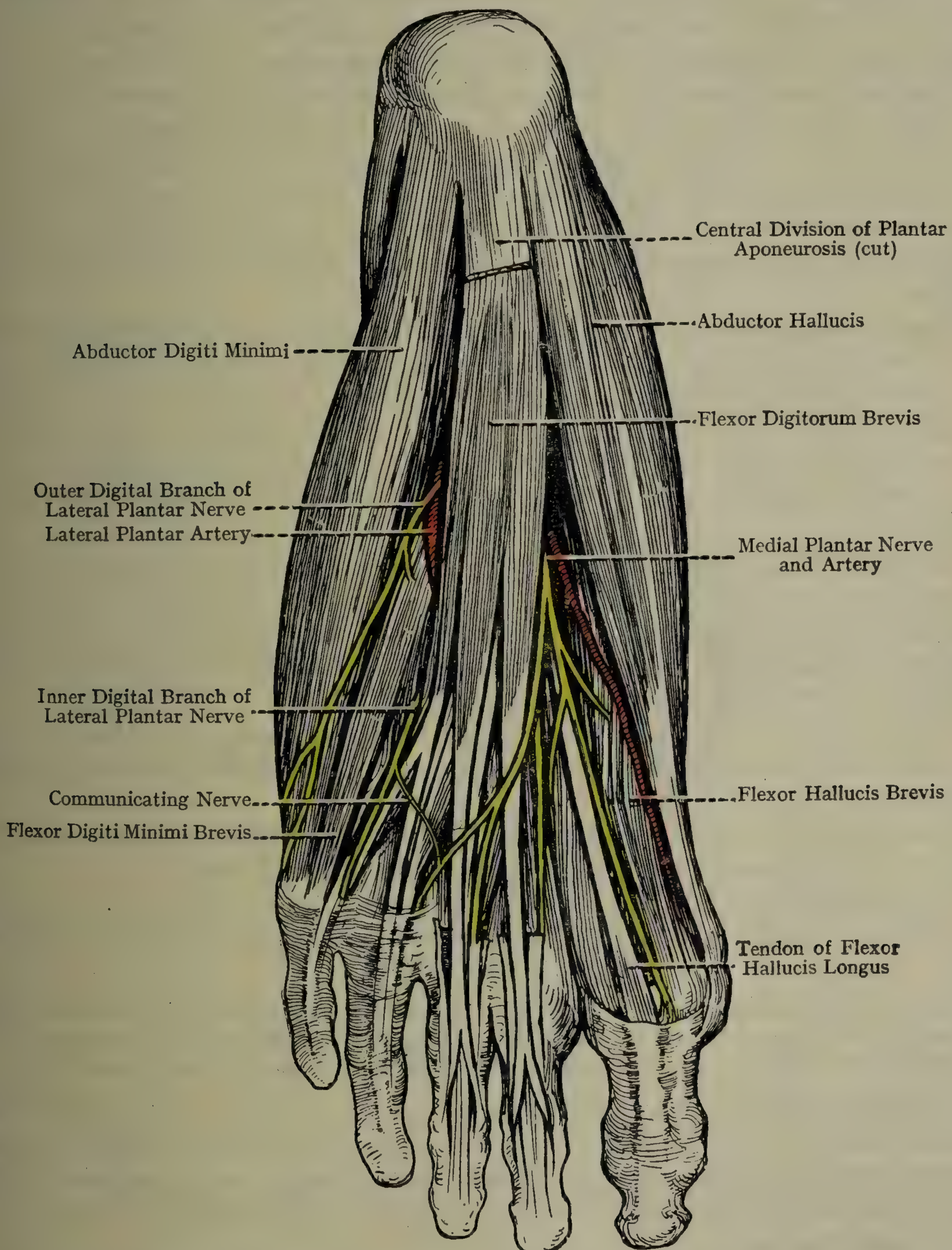


FIG. 388.—THE FIRST LAYER OF PLANTAR MUSCLES (LEFT FOOT).

of the calcaneum; most of its fibres arise from the deep surface of the central portion of the plantar aponeurosis, and from the two inter-muscular septa.

Insertion.—By four tendons attached to the four outer toes.

Nerve-supply.—The medial plantar nerve.

Action.—Flexes the intermediate phalanges of the four outer toes.

On the plantar surface of a toe each tendon is accompanied by a tendon of the flexor digitorum longus, which lies deeply to it, the two tendons being contained in a fibro-osseous canal lined by a synovial sheath. Opposite the base of the proximal phalanx the brevis tendon divides into two slips, which wind round on either side of, and unite on, the deep aspect of the longus tendon, which thus passes through it; hence the name *flexor perforatus* for the brevis muscle. At the distal end of the proximal phalanx the tendon splits again into two diverging slips, which are attached to the sides of the shaft of the intermediate phalanx. Each brevis tendon has a vinculum breve, which is reflected from its deep aspect to the distal end of the proximal phalanx.

The fibrous sheaths (vaginal ligaments) which, with the phalanges, form the fibro-osseous canals in which the flexor tendons are contained, have the same general arrangement as in the fingers (p. 492). The entrance to the proximal end of one of these canals is a short tunnel formed by a digital process of the plantar fascia superficially, by its two lateral slips on either side, and deeply by the deep transverse ligament.

Abductor Digiti Minimi (Fig. 388)—*Origin.*—From the small lateral tubercle on the plantar aspect of the os calcis, from the surface of bone in front of it, and from the outer side of the large medial tubercle. Many of its fibres are also attached to the plantar aponeurosis covering it, and to the lateral intermuscular septum.

The distal part of the muscle is mainly tendinous, and glides over the base of the fifth metatarsal bone, to which it is occasionally adherent.

Insertion.—The outer side of the base of the proximal phalanx of the little toe, in common with the flexor digiti minimi brevis.

Nerve-supply.—The lateral plantar nerve.

Action.—Abducts the little toe, and flexes its metatarso-phalangeal joint.

The abductor digiti minimi, especially towards its distal end, is often replaced by tendon to a greater or less extent. It has occasionally an additional slip of origin from the prominent tubercle at the base of the fifth metatarsal bone.

The *second layer* (Fig. 389) consists of the tendons of the two long digital flexors, the flexor digitorum longus and flexor hallucis longus respectively; and two sets of muscles, the flexor accessorius and the lumbricals, both associated with the tendon or tendons of the flexor digitorum longus.

The tendon of the flexor hallucis longus is prolonged from the groove on the inferior aspect of the sustentaculum tali directly forwards to the great toe, and lies towards the inner side of the foot. The tendon of the flexor digitorum longus, which in the hinder part of the sole is lying to the inner side of the tendon of the flexor hallucis longus, is directed obliquely forwards and outwards and crosses superficially

the tendon of the flexor hallucis longus, to which it is attached by a tendinous slip (p. 624). After crossing the flexor hallucis longus the tendon of the flexor digitorum longus subdivides into digital tendons, to which the lumbrical muscles are attached. Implanted into it from behind is the accessorius muscle.

The **flexor accessorius** arises by two heads.

Origin.—The **inner head,** which is broad and fleshy, arises from the internal concave surface of the calcaneum below the sustentaculum

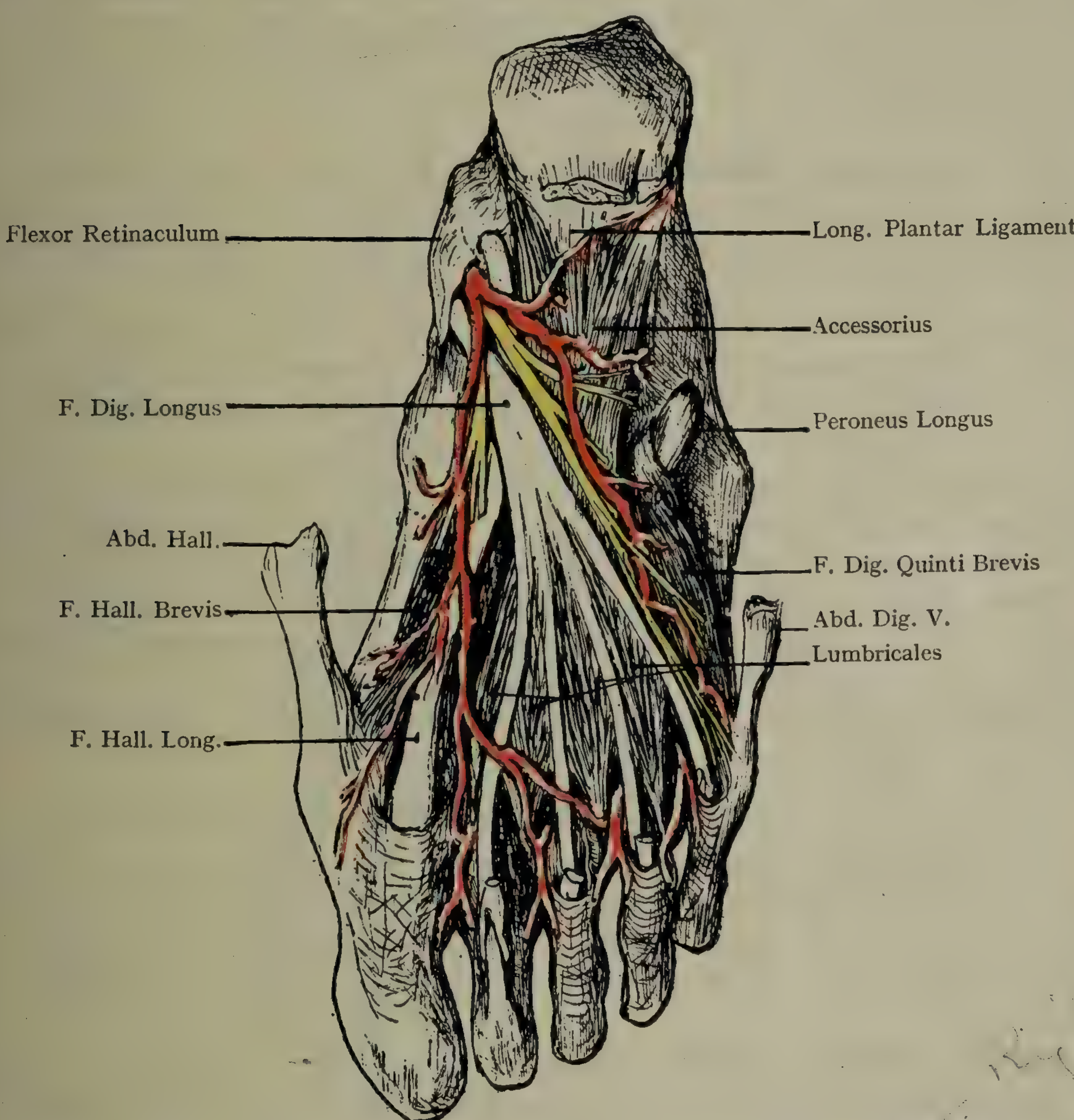


FIG. 389.—THE SECOND LAYER OF PLANTAR MUSCLES (LEFT FOOT).

tali. The **outer head,** narrow and tendinous, arises from the plantar aspect of the calcaneum immediately in front of the small lateral tubercle, but chiefly from the long plantar ligament, which here clothes the bone.

Insertion.—The posterior and deep aspects of the tendon of the flexor digitorum longus.

It may be attached to the plantar aspect of the tendon of the flexor digitorum longus, and in some cases embraces it.

Nerve-supply.—The lateral plantar nerve.

Action.—The muscle probably never contracts independently, bu always in conjunction with the flexor digitorum longus. Passin directly forwards from its origin to its insertion, it neutralizes th oblique pull of the flexor digitorum longus, which in flexing the toe would otherwise drag them inwards.

The accessorius is probably a part of the flexor digitorum longus which ha migrated into the foot. In support of this view it is interesting to note that th inner head of the muscle may occasionally be prolonged upwards into the leg The flexor digitorum longus is one of the muscles engaged in extending the foot and in full extension may be incapable of further contraction. It is possibl that in this position of the foot the accessorius is the chief agent concerned i flexing the toes.

The Lumbrical Muscles (Fig. 389) are four small muscles whicl occupy the distal part of the sole where they are found in associatio with the tendons of the flexor digitorum longus. They are remarkabl in that they have no direct attachment to the skeleton.

Origin.—They are all attached to the adjacent sides of the tw tendons of the flexor digitorum longus, between which they lie, witl the exception of the first or innermost, which arises from the inne side of the long flexor tendon of the second toe.

Insertion.—The tendons wind round on the inner side of the meta tarso-phalangeal joints of the four outer toes, and blend with th extensor expansion on the dorsal aspect of the proximal phalanx.

Nerve-supply.—The innermost or first lumbrical is supplied by th medial plantar nerve. The outer three lumbricals are supplied b the deep division of the lateral plantar nerve.

Action.—Flex the metatarso-phalangeal joints, and extend th interphalangeal joints.

The muscles are detached parts of the flexor digitorum longus.

The *third layer* (Fig. 390) consists of the short muscles of the tw marginal digits, with the exception of the two abductors, which wer found in the first layer. There are two muscles of the great toe a short flexor and an adductor; one muscle of the little toe, a shor flexor.

Flexor Hallucis Brevis (Fig. 390)—*Origin.*—From the planta surface of the cuboid, and from the prolongations of the tendon of th tibialis posterior to the intermediate and lateral cuneiform bones.

Insertion.—The muscle divides into two heads, each of which ends i a tendon. The tendon of the **inner head** is inserted on the inner sid of the base of the proximal phalanx of the great toe in common wit the abductor hallucis; that of the **outer head** into the outer side of th base of the same phalanx in common with both heads of adducto hallucis. The two tendons blend with the capsular ligament of th metatarso-phalangeal joint, and in this situation each tendon contain a large sesamoid bone.

Nerve-supply.—The medial plantar nerve.

Action.—Flexes the metatarso-phalangeal joint of the great toe.

Adductor Hallucis (Oblique Head) (Fig. 390)—*Origin.*—The plantar urfaces of the bases of the second, third, and fourth metatarsal bones, ut chiefly from the sheath of the peroneus longus tendon immediately ehind them.

Insertion.—The outer side of the base of the proximal phalanx of he great toe in common with the outer head of the flexor hallucis revis and the transverse head.

Nerve-supply.—The deep division of the lateral plantar nerve.

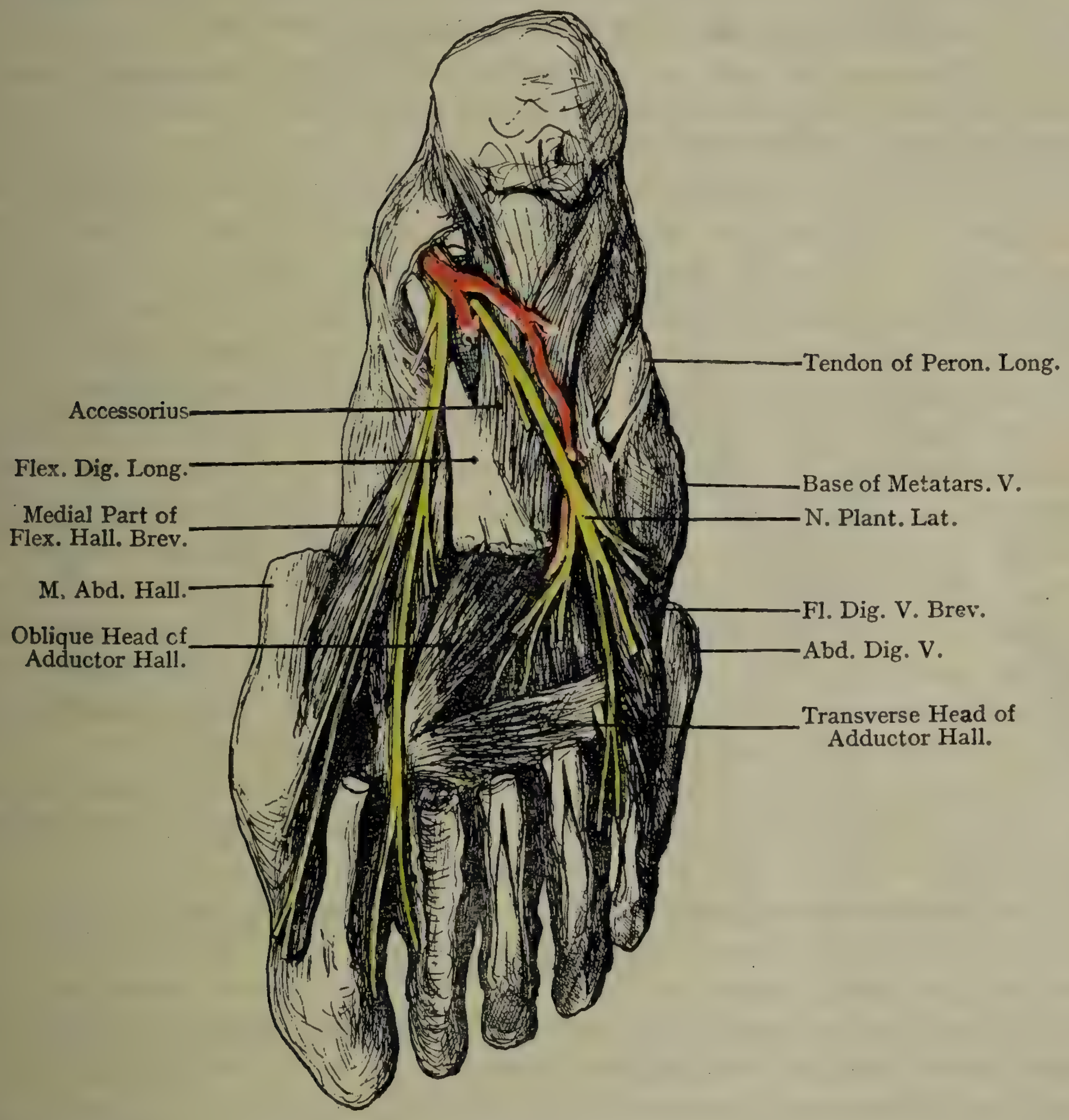


FIG. 390.—THE THIRD LAYER OF PLANTAR MUSCLES (LEFT FOOT).

Action.—Adducts the great toe, and aids in flexing its metatarso-halangeal joint.

The muscle is obliquely disposed on the outer side of the flexor allucis brevis.

Transverse Head (*Transversus Pedis*) (Fig. 390)—*Origin.*—By three lips attached to the deep transverse ligament, and to the plantar igaments of the metatarso-phalangeal joints opposite the distal ex-remities of the three outer metatarsal bones.

Insertion.—It passes transversely across the distal end of the

metatarsus, and ends in a tendon which is attached to the outer sid of the base of the proximal phalanx of the great toe in common wit the oblique head.

Nerve-supply.—The deep division of the lateral plantar nerve.

Action.—Adducts the great toe.

Flexor Digiti Minimi Brevis (Fig. 390)—*Origin.*—The base of th fifth metatarsal bone, but chiefly from the sheath of the tendon of th peroneus longus immediately behind it.

Insertion.—The outer side of the base of the first phalanx of th little toe in common with the abductor digiti minimi.

Some fibres may be attached to the shaft of the fifth metatarsal bone towarc its distal end. Such fibres represent an *opponens minimi digiti*, a musc normally present in the upper limb.

Nerve-supply.—The superficial division of the lateral plantar nerv

Action.—Flexes the metatarso-phalangeal joint of the little to The muscle is a small fleshy slip which lies upon the plantar surfac of the fifth metatarsal bone, under cover of the abductor digiti minim It is liable to be mistaken for a plantar interosseous muscle, as it lie in close contact with the most lateral plantar interosseous.

The **plantar triangle** (Fig. 390) is a muscular triangle in connectio with the third layer of muscles, the boundaries of which are as follows *Anterior* or *Base.*—Transverse head of adductor hallucis. *Medial.*– Oblique head of adductor hallucis. *Lateral.*—Flexor digiti minin brevis. *Floor.*—Some of the plantar and dorsal interosseous muscle invested by the interosseous fascia. *Roof.*—The long flexor tendor and the lumbrical muscles. *Contents.*—A part of the plantar arteri arch with some of its digital branches, especially the second and thir and a part of the deep branch of the lateral plantar nerve.

Fourth Layer.—The fourth layer consists of the interosseous muscle occupying the metatarsus, and the tendons of the peroneus longus an tibialis posterior on the plantar aspect of the tarsus.

The **interosseous muscles** (Fig. 391) are seven in number, and ar arranged in two groups—three plantar and four dorsal. The planta muscles are only seen in the sole, but the dorsal muscles are als visible on the dorsum of the foot. The plantar aspects of the muscle are covered by the thin interosseous fascia, which distally blends wit the deep transverse ligament (p. 671).

The three **plantar interossei** occupy the three outer intermetatars spaces, and are inserted into the three outer toes. They are terme numerically the first, second, and third, from within outwards.

Origin.—From the three outer metatarsal bones, where they ar attached to the inner sides of the sharp ridges on the plantar aspec of these bones. They also extend proximally on to the plantar aspec of the bases of the metatarsal bones, and on to the sheath of the tendo of the peroneus longus. Each of the three muscles arises from th metatarsal bone of the toe into which it is inserted.

Insertion.—By tendon which is attached to the inner side of the bas of the proximal phalanx of the toe, and further extends on to th

orsal aspect of the proximal phalanx, and there blends with the xtensor expansion.

The four **dorsal interossei** occupy the four intermetatarsal spaces, nd are termed numerically the first, second, third, and fourth, from vithin outwards. The first and second are both inserted into the econd toe, the third and fourth into the third and fourth toes respecively.

Origin.—Each muscle arises by two heads from the adjacent sides f the shafts of the two metatarsal bones between which it lies, but nore extensively from the metatarsal bone of the toe into which it is nserted.

The inner head of the first dorsal interosseous is small, and is limited n its attachment to the proximal end of the first metatarsal bone. This muscle also arises from a band which crosses the proximal end

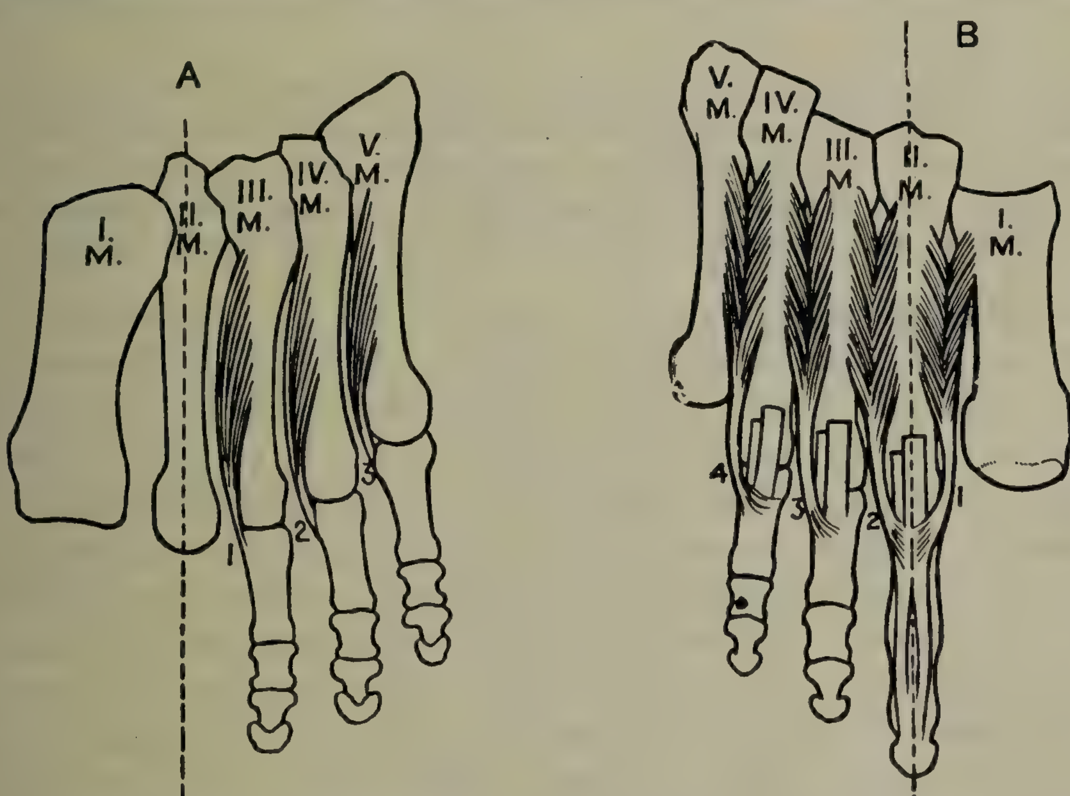


FIG. 391.—THE INTEROSSEOUS MUSCLES OF THE RIGHT FOOT.
A, plantar; B, dorsal.

of the first interosseous space, and arches across the deep plantar terminal branch of the dorsalis pedis artery. The third and fourth dorsal interossei extend proximally beyond the intermetatarsal spaces, and are attached to the sheath of the tendon of the peroneus longus.

Insertion.—Each muscle has a centrally placed tendon, on either side of which the obliquely disposed fibres of the two heads are implanted, the arrangement presenting a feather-like appearance. The central tendon is inserted distally to the base of the proximal phalanx. The first and second dorsal interossei are inserted on either side of the base of the proximal phalanx of the second toe; the third and fourth to the outer side of the base of the proximal phalanx of the third toe and of the fourth toe respectively.

Nerve-supply.—All the seven interosseous muscles are supplied by the lateral plantar nerve. The two muscles which occupy the fourth

interspace—namely, the third plantar and the fourth dorsal—are su plied by the superficial division of the nerve, the remainder by its de division.

Action.—The axial line of the foot, away from which and towa which the toes diverge and converge respectively, passes through t second toe (*cf.* hand, where the axial line passes through the mid finger). The three plantar interossei are adductors, pulling the thi outer toes inwards towards the line of the second toe. The four dor interossei are abductors, the first and second pulling the second toe either side of its own line, the third and fourth pulling the third a fourth toes outwards. The four dorsal interossei, together with t abductors of the two marginal digits (the abductor hallucis and t abductor digiti minimi), constitute a complete system of abducto pulling all the toes away from the axial line passing through the seco toe.

The extent of abduction and adduction of the toes brought about by t interosseous muscles is very small as compared with the corresponding mo ments in the hand. In the opinion of some anatomists the interosseous musc as a group are concerned in approximating the metatarsal bones, and there accentuate the transverse arch of the foot in the metatarsal region.

The two **plantar nerves,** medial and lateral, are the terminal branch into which the posterior tibial nerve divides behind the lateral malleol The lateral plantar is the larger of the two nerves, and accompani the medial plantar artery, the smaller of the two plantar arteries. T lateral plantar nerve accompanies the lateral plantar artery.

The **medial plantar nerve** (Fig. 390) has a more extensive cutan ous, but a more limited muscular, distribution than the lateral plant At its commencement it lies deeply to the flexor retinaculum. As passes into the sole it is covered superficially by the abductor halluc It extends forwards near the inner side of the foot, and lies deeply the interval between the abductor hallucis and the flexor digitoru brevis, with the medial plantar artery lying on its inner side.

Branches.—Muscular branches supply the abductor hallucis a flexor digitorum brevis.

Articular branches are distributed to tarsal and tarso-metatars joints.

Cutaneous branches become superficial between the abduct hallucis and flexor digitorum brevis, and are distributed to the sk of rather more than the inner half of the sole.

The medial plantar nerve ends by dividing into four **digital branche** Tracing them from within outwards, the **first** digital nerve is di tributed to the inner side of the great toe, and supplies a branch to t flexor hallucis brevis muscle. The **second** digital nerve supplies t first lumbrical muscle, and opposite the cleft between the great a second toes divides into two collateral digital nerves, which supp the adjacent sides of these two toes. The **third** digital nerve similar divides into two collateral branches, which supply the adjacent sid of the second and third toes. The **fourth** digital nerve communicat

th the digital branch of the lateral plantar nerve lying on its outer le, and ends by dividing into two collateral branches supplying the ljacent sides of the third and fourth toes. On the sides of the toes e nerves lie superficially to the digital arteries. They supply articular anches to the digital joints, and cutaneous branches to the plantar id dorsal surfaces of the toes. Finally, each terminates in two anches—one to the matrix of the nail, and the other to the pulp of e toe. The branches of the digital nerves are beset with numerous icinian bodies.

Summary of the Medial Plantar Nerve.—**Muscular** branches to four muscles: e flexor digitorum brevis, two muscles of the great toe (the abductor and the xor brevis), and the first lumbricalis. **Cutaneous** branches to the skin of the

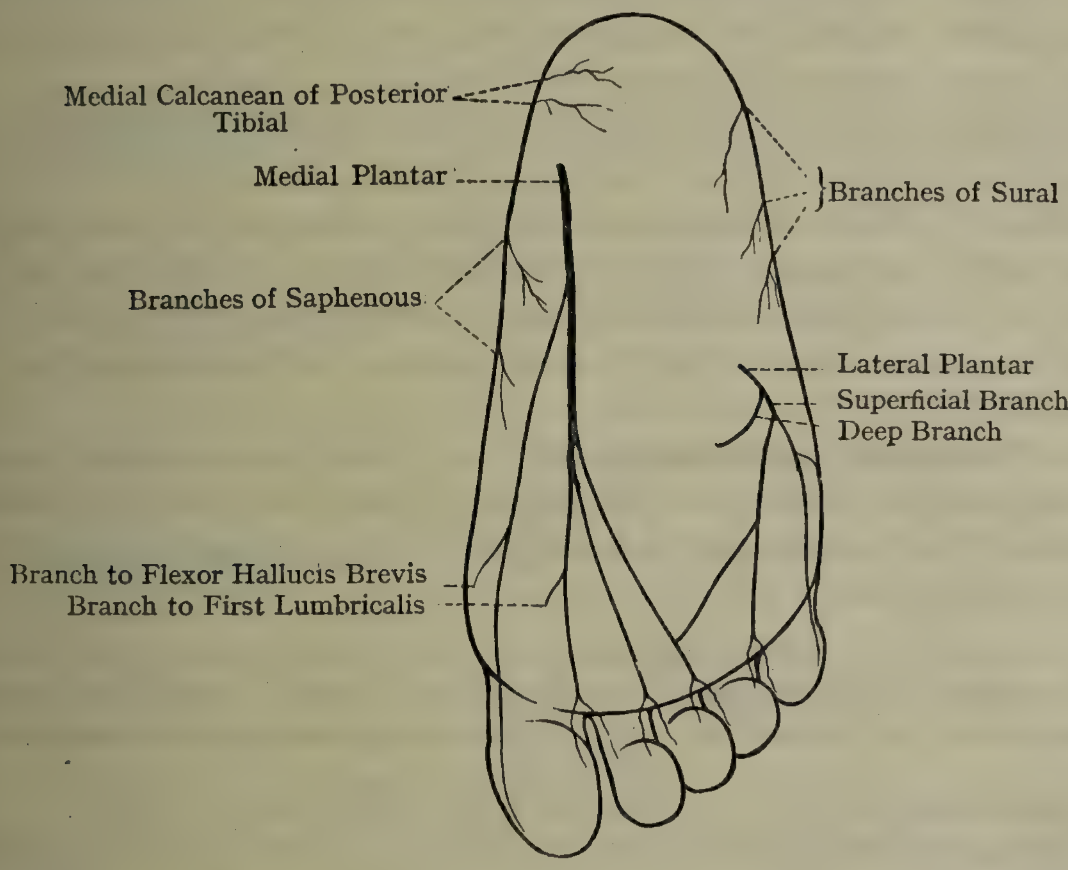


FIG. 392.—DIAGRAM OF THE NERVES OF THE FOOT (PLANTAR ASPECT).

iner half of the sole and of the inner three and a half toes. **Articular** branches the tarsal, metatarsal, and digital joints.

The distribution of the medial plantar nerve corresponds closely with that f the median nerve in the hand.

The **lateral plantar nerve** passes downwards from under cover of he flexor retinaculum, and gains the inner side of the hinder part of he sole, where it lies deeply to the abductor hallucis. Thence it crosses he foot, passing obliquely forwards and outwards towards the rominent base of the fifth metatarsal bone. In this part of its course lies between the flexor digitorum brevis superficially and the flexor ccessorius deeply, and is accompanied by the lateral plantar artery, which lies to its outer side. Finally, it lies deeply in the interval etween the flexor digitorum brevis and the abductor digiti minimi, where it divides into two terminal branches, superficial and deep.

The Branches of the Trunk.—*Muscular* to the flexor accessoriu and the abductor digiti minimi; *articular* to the calcaneo-cuboid joint *cutaneous* branches become superficial between the flexor digitorun brevis and the abductor minimi digiti to supply the skin of the oute half of the sole; and two *terminal* branches.

Of the two **terminal branches,** the **superficial branch** divides int two digital nerves, outer and inner. The **outer digital nerve** is dis tributed to the outer side of the little toe, and also supplies the flexo digiti minimi brevis and the interosseous muscles of the fourth inter space (the fourth dorsal and third plantar). The **inner digital nerv** communicates with the most lateral digital branch of the media plantar nerve, and divides into two collateral digital branches, whicl supply the adjacent sides of the third and fourth toes. In their cours and distribution the digital branches of the superficial division of th lateral plantar nerve resemble those of the medial plantar.

The **deep branch** crosses the foot from the outer side towards th inner side, and lies deeply in the plane between the third and fourt layers of muscles. On its deep aspect are the bases of the metatarsa bones and the interosseous muscles, superficially to it are the obliqu head of adductor hallucis, and in the plantar triangle (p. 650) the flexo tendons, together with the lumbrical muscles. It accompanies th plantar arterial arch.

Branches.—**Muscular branches** supply all the interosseous muscle (with the exception of the two occupying the fourth interosseou space); the outer three lumbricales and the adductor hallucis, and tw muscles of the great toe.

The nerve to the second lumbricalis passes forwards deeply to the transvers head of adductor hallucis, winds round the distal edge of this muscle, and finall takes a recurrent course to enter the deep aspect of the lumbrical muscle.

Articular branches supply the tarsal and metatarsal joints.

Minute **perforating branches** pass upwards through the proxima ends of the intermetatarsal spaces, and join the interosseous branche of the anterior tibial nerve.

Summary of Lateral Plantar Nerve.—**Muscular** branches to the flexor acces sorius, the two short muscles of the little toe, all the interossei, the outer thre lumbricales, and the adductor hallucis. **Cutaneous** branches to the skin of th outer half of the sole and of the outer one and a half toes. **Articular** branches t the tarsal, metatarsal, and digital joints. **Perforating** branches join the inter osseous nerves on the dorsum of the foot.

The distribution of the lateral plantar nerve closely corresponds with tha of the ulnar nerve in the hand.

Plantar Arteries.—The medial and lateral plantar arteries are th terminal branches into which the posterior tibial divides under cove of the flexor retinaculum. The medial plantar is much the smalle of the two. Each vessel is accompanied by the corresponding planta nerve.

The **medial plantar artery** (Fig. 390) first passes downwards deeply to the abductor hallucis, and then passes directly forwards near the

ıner side of the foot, lying deeply in the interval between the abductor allucis and flexor digitorum brevis. It is accompanied by the medial lantar nerve, which lies on its outer side. It usually ends by anastoıosing with the first dorsal metatarsal artery on the inner side of the reat toe.

Branches.—In addition to **muscular** branches which supply the ıuscles on the inner side of the foot, and **cutaneous** branches which ecome superficial between the abductor hallucis and flexor digitorum revis, and supply the skin of the inner half of the sole, it gives off he following branches:

Articular to the joints on the inner side of the foot.

A variable number of small **superficial digital branches** which ccompany the digital branches of the medial plantar nerve, and ivide into collateral branches which supply the toes.

These digital branches are very variable and frequently absent. When resent, they anastomose with the digital branches of the plantar arch.

The medial plantar artery communicates with the medial tarsal ranches of the dorsalis pedis artery by twigs which wind round the nner border of the foot deeply to the abductor hallucis.

The **lateral plantar artery** (Fig. 393) is much larger than the medial lantar. It ends at the proximal end of the first intermetatarsal space y joining the deep plantar of the dorsalis pedis artery.

At its commencement it lies on the inner side of the calcaneum, being overed superficially by the abductor hallucis. Thence it passes bliquely forwards and outwards across the hinder part of the sole owards the prominent base of the fifth metatarsal bone on the outer ide of the foot. In this the **first** or **superficial part** of its course it ies between the first and second layers of muscles, the flexor digitorum revis covers it superficially, the flexor accessorius is on its deep aspect; t is accompanied by the lateral plantar nerve, which lies on its inner ide. Gaining the interval between the flexor digitorum brevis and he abductor digiti minimi, its direction suddenly changes, and it rosses the foot for a second time. It winds round the outer edge of he flexor accessorius, and crosses the base of the metatarsus from the uter side of the foot towards the inner, lying deeply between the third nd fourth layers of muscles. In this the **second** or **deep part** of its ourse the proximal ends of the metatarsal bones and the interosseous nuscles are on its deep aspect; the oblique head of adductor hallucis nd, in the plantar triangle (p. 650), the flexor tendons with the lumbricales are superficial to it. It is accompanied by the deep branch of the lateral plantar nerve. It ends at the proximal end of the first intermetatarsal space, where it joins the terminal branch of the dorsalis pedis artery, which here passes downwards from the dorsum of the foot into the sole. The second or deep part of the lateral plantar artery, together with the dorsalis pedis artery, complete the **plantar arch.**

Branches of the First Part.—**Muscular** branches to the muscles with which it comes into relation. Two or three **branches** traverse the

abductor hallucis muscle and ramify over the heel, where they ana-tomose with the medial calcanean branch of the posterior tibial arter and the lateral calcanean branches of the peroneal artery. **Cutaneou** branches become superficial between the abductor digiti minimi an

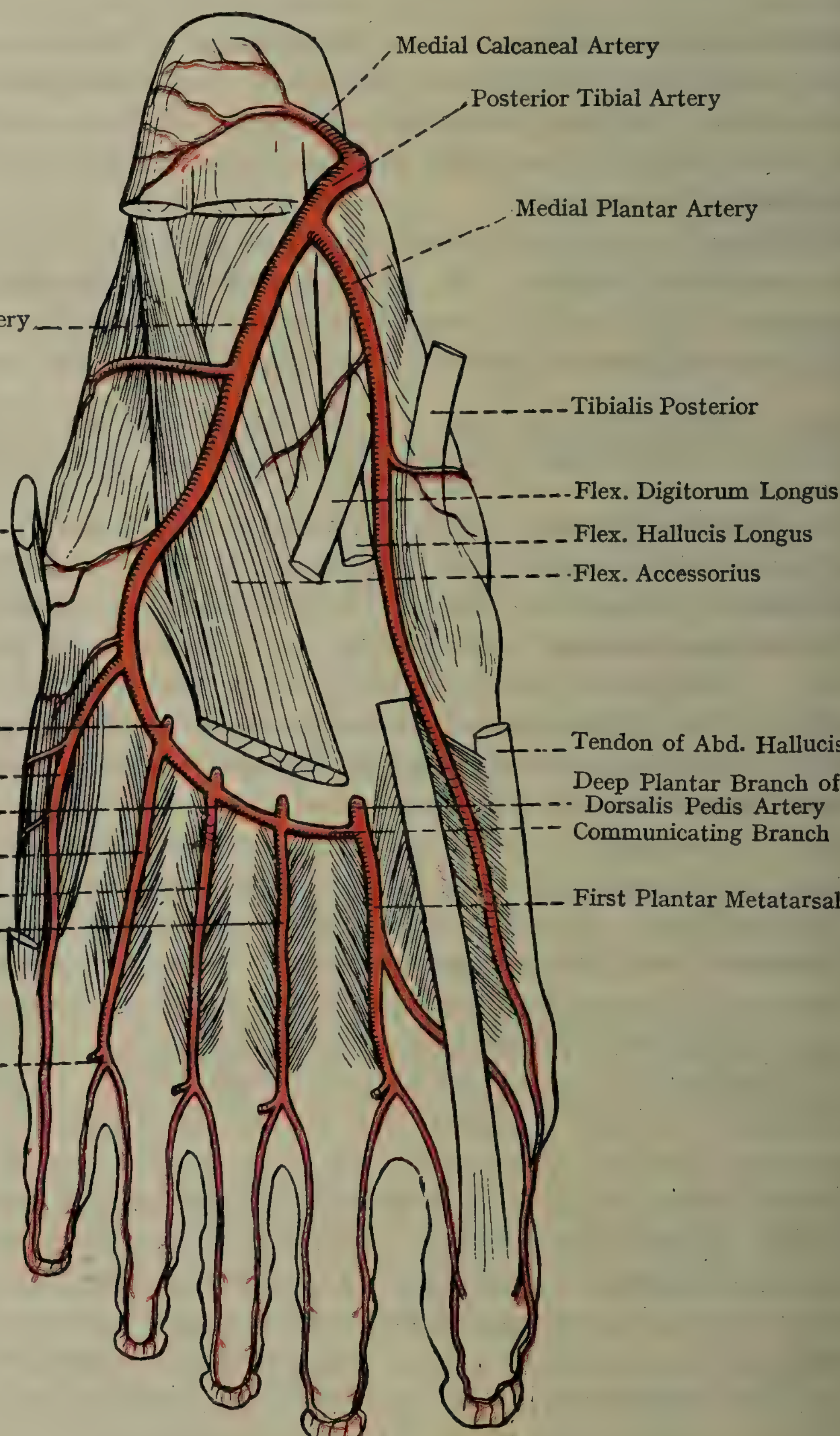


FIG. 393.—THE PLANTAR ARTERIES (LEFT FOOT) (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

flexor digitorum brevis. They supply the skin of the outer half o the foot.

Small twigs wind round the outer border of the foot, and anasto-mose with the tarsal and arcuate branches of the dorsalis pedis artery

The **plantar arch** (Fig. 393) is an arterial arcade which results from the junction of the deep part of the lateral plantar with the dorsalis pedis artery. The convexity of the arch is towards the toes.

Branches of the Plantar Arch.—**Articular branches** arise from the concavity of the arch, and pass backwards to supply the tarsal joints.

Three **perforating arteries** pass upwards through the proximal ends of the three outer intermetatarsal spaces, and between the two heads of the corresponding dorsal interosseous muscles. On the dorsum of the foot they join the dorsal metatarsal branches of the arcuate artery.

Four **digital arteries** arise from the convexity of the arch. The **first** crosses the fifth metatarsal bone and the flexor digiti minimi brevis; it is distributed to the outer side of the little toe. The **second, third, and fourth** pass forwards in the three outer intermetatarsal spaces, where they lie on the interosseous muscles. They pass deeply to the transverse head of adductor hallucis, and divide near the clefts of the toes into collateral digital arteries. The second supplies the adjacent sides of the fourth and fifth toes; the third is similarly distributed to the third and fourth toes; the fourth to the second and third toes.

The first and second digital arteries often arise from the plantar arch by a common trunk.

The two arteries, one on either side of the toe, supply branches to the skin and the fibrous sheaths of the tendons. They are connected together, on the plantar aspects of the phalanges, by transverse communications, from which branches to the synovial sheaths, the flexor tendons, and the interphalangeal joints are derived. Dorsal branches pass to the dorsal aspect of the toe, and anastomose with the dorsal digital arteries. The largest dorsal branches form an arterial arcade at the root of the nail, numerous branches of which supply the nail bed. The two arteries end by joining one another on the distal phalanx to form an arch from which branches are distributed to the pulp of the toe.

The **first plantar metatarsal artery** passes forwards in the first intermetatarsal space, where it lies on the first dorsal interosseous muscle and deeply to the oblique head of adductor hallucis. It divides into two branches; one passes inwards deeply to the tendon of the flexor hallucis longus and the flexor hallucis brevis, and is distributed to the inner side of the great toe. The other divides into two collateral digital arteries, which supply the adjacent sides of the great and second toes.

The arteries of the foot are much more constant than those of the hand.

Varieties.—The **medial plantar artery** is sometimes very small, and may end in the flexor hallucis brevis. In other cases it is large, and may replace the arteria princeps hallucis, and furnish the digital branches for both sides of the great toe and the inner side of the second toe. In rare cases the medial plantar artery communicates with the lateral plantar, with which it forms a superficial plantar arch. In such cases the digital arteries arise from this arch.

The **lateral plantar artery** may be diminished in size to such an extent that it may take no share in forming the plantar arch. Such deficiency is compensated for by enlargement of the plantar branch of the dorsalis pedis artery.

The perforating branches of the plantar arch are sometimes enlarged, and furnish the dorsal interosseous arteries on the dorsum of the foot.

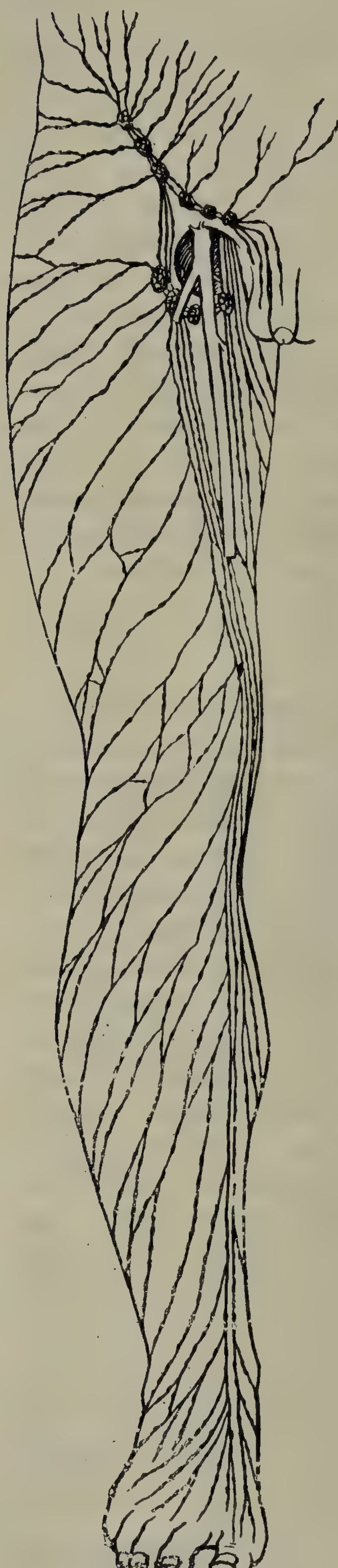


FIG. 394.—SUPERFICIAL LYMPHATICS OF THE LOWER LIMB.

Lymphatic Vessels of the Lower Limb.

The lymphatic vessels of the limb are disposed two sets, superficial and deep. The two sets are n to be regarded as absolutely independent one of tl other, as in certain situations they freely communica with each other. It may be taken as a general ru that the lymphatic trunks which drain the superfici parts of the limb follow the chief subcutaneous vein while the deep vessels follow the main arteries of tl limb.

Superficial Lymphatics.—On the dorsum of tl foot is a network of vessels into which the lymphati of the toes drain, and which also receives the supe ficial lymphatics of the plantar region, some of whi reach it by passing upwards in the interdigital space others by winding round the margins of the foo This dorsal plexus is drained by two sets of larg lymphatic vessels which follow the long and sho saphenous veins respectively. The vessels followi the short saphenous vein receive tributaries draini the outer side and back of the leg; they eventual join the popliteal glands (p. 551). Those followi the long saphenous vein receive vessels from the inn side and front of the leg, and in the region of tl knee are joined by some of the efferent vessels of tl popliteal glands. Above the knee they receive mo of the superficial lymphatic vessels of the thigh, a end in the medial set of superficial inguinal glan (p. 358). Some of the superficial lymphatic vessels the upper part of the thigh and those of the glute region join the superficial inguinal glands direct (p. 358).

The **deep lymphatics** on the dorsum of the fo follow the dorsalis pedis artery, those in the so accompany the two plantar arteries. They are co tinuous with vessels which accompany the lar arteries of which the foot arteries are branches. the leg three chief sets of lymphatic vessels accor pany the two tibial and the peroneal arteries. Tl anterior tibial set receives the deep lymphatics fro the dorsum of the foot and the front of the leg; the join the anterior tibial gland, the efferent vessels which pass to the popliteal glands (p. 551). Tl posterior tibial set receives the deep lymphatics the sole of the foot, and together with the perone set drain the back of the leg; they join the poplite glands (p. 551). Some of the efferent vessels of tl popliteal glands join the superficial lymphatics accor panying the long saphenous vein; most of the ascend and join the deep lymphatic vessels whic accompany the femoral artery, drain the deep par of the thigh, and end in the deep inguinal glands.

The efferent vessels of the inguinal glands, bot superficial and deep, are described on p. 358. Tl deep lymphatics of the buttock accompany the i ferior and superior and gluteal arteries, pass throu the greater sciatic notch, and join the internal ili glands.

THE TIBIO-FIBULAR JOINTS.

Between the upper and lower ends of the tibia and fibula are uperior and inferior tibio-fibular joints. Intermediately is an extended yndesmosis between the shafts of the two bones, which are connected ogether by the interosseous membrane.

Superior Tibio-fibular Joint.—In this joint the articular surface on the upper aspect of the head of the fibula is applied to that on the nferior aspect of the external tuberosity of the tibia. The joint is surrounded by a capsular ligament in which **anterior** and **posterior** igaments may be distinguished. The fibres of the two ligaments pass obliquely upwards and inwards from the head of the fibula to the lateral condyle of the tibia. The anterior ligament is intimately associated with the tendon of the biceps, which contributes materially to the strength of the joint. The tendon of the popliteus lies superficially to the posterior ligament.

The **synovial cavity** is usually independent of that of the knee-joint, but sometimes communicates with it indirectly by means of a small deficiency in the posterior ligament, whereby the synovial membrane is continuous with the synovial sheath of the tendon of the popliteus (p. 641).

Nerve-supply.—The lateral inferior genicular and recurrent genicular branches of the lateral popliteal nerve.

Movements.—Slight gliding movements in the plane of the articular surfaces.

Inferior Tibio-fibular Joint.—The opposed surfaces of the lower ends of the tibia and fibula are for the most part rough, and are connected together by an interosseous ligament. The extreme lower parts of the two surfaces, for a distance of from 1 to 2 mm. only, are in contact with each other, and are coated with hyaline cartilage. The very limited joint cavity is continuous with that of the ankle-joint. The ligaments are anterior inferior and posterior inferior tibio-fibular, interosseous, and transverse tibio-fibular.

The **anterior inferior tibio-fibular ligament** (Fig. 398) is thick and strong, and passes obliquely downwards and outwards from the tibia to the fibula. It is related in front to the peroneus tertius, and behind to the interosseous ligament.

The **posterior inferior tibio-fibular ligament** (Fig. 396) is thicker and stronger than the anterior. It also passes obliquely downwards and outwards from the tibia to the fibula.

The **interosseous ligament** consists of short fibres, which pass very obliquely from the rough triangular surface at the lower ends of the tibia to the corresponding surface of the fibula. It is continuous above with the interosseous membrane. Anteriorly and posteriorly its lower part is related to the anterior and posterior inferior tibio-fibular ligaments.

The **transverse ligament** (Fig. 395) lies deeply to the posteri
ligament, and fills in a slight interval between the lower ends of th
tibia and the fibula. It forms the posterior limit of the inferior tibi
fibular joint cavity, is in contact with the talus below, and is continuou
with the interosseous ligament above. It completes the upper articula
surface of the ankle-joint. It is remarkable for containing yello
elastic fibres, which account for its yellowish colour.

Nerve-supply.—The anterior tibial nerve.

The **movements** are very limited, a slight amount of gliding taking pla
between the cartilage-clad articular surfaces. When the ankle-joint is flexe
the two malleoli are forced apart by the talus, and the transverse ligament is p
on the stretch. In this position a fat-laden fold of synovial membrane occupi
the interval between the articular surfaces. When the ankle-joint is extend
a narrower part of the talus is interposed between the two malleoli (p. 368
The resiliency of the elastic transverse ligament now comes into play, pul

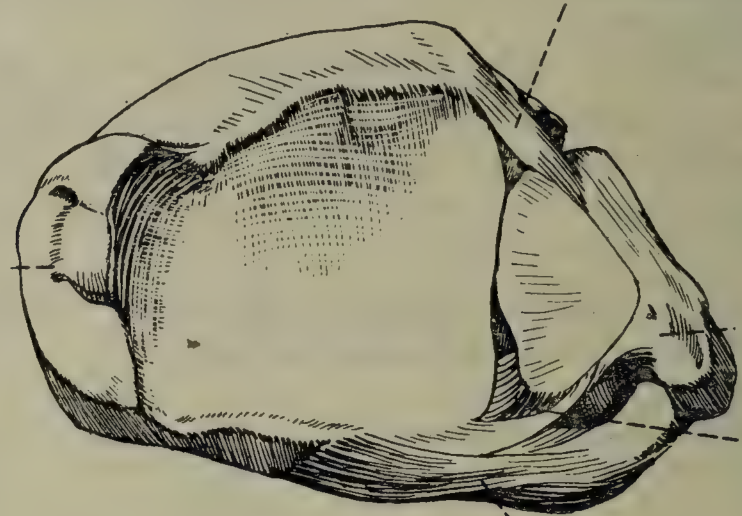


FIG. 395.—THE UPPER ARTICULAR SURFACES OF THE ANKLE-JOINT VIEWED FROM BELOW.

the lower ends of the tibia and fibula together, and keeps the two malleoli close
applied to the lateral aspects of the talus, while the other ligaments of the joi
(anterior, posterior, and interosseous) are relaxed.

Intermediate Tibio-fibular Syndesmosis.—The **interosseous mem
brane** extends from the lateral border or interosseous ridge of th
tibia to the antero-medial border or interosseous ridge of the fibul
The direction of the fibres is chiefly downwards and outwards fro
the tibia to the fibula, but a few pass in the opposite direction. A
its upper end is an opening with a concave lower margin for the passag
of the anterior tibial vessels and the efferent lymphatic vessels of th
anterior tibial gland. Below it is continuous with the interosseou
ligament, and has a small opening for the passage of the peroneal vessels
All the extensor muscles on the front of the leg are attached to it
anterior surface; the tibialis posterior is attached to its posterior surface

Nerve-supply.—The interosseous branch of the nerve to the popliteu
muscle (p. 550).

THE ANKLE-JOINT.

The articular surfaces of the joint are furnished by the tibia, fibula, nd talus. The lower ends of the tibia and fibula provide a mortice-ke socket, formed by the inferior articular surface of the tibia together vith the transverse ligament above, and the articular surfaces of the wo malleoli on either side (Fig. 395). Into this socket the upper part f the talus fits like a wedge. The convex upper surface of the astrag-lus is applied to the inferior surface of the tibia, while the two lateral urfaces of the bone are in contact with the two malleoli (Fig. 396). 'he upper articular surface of the talus is wider in front than behind,

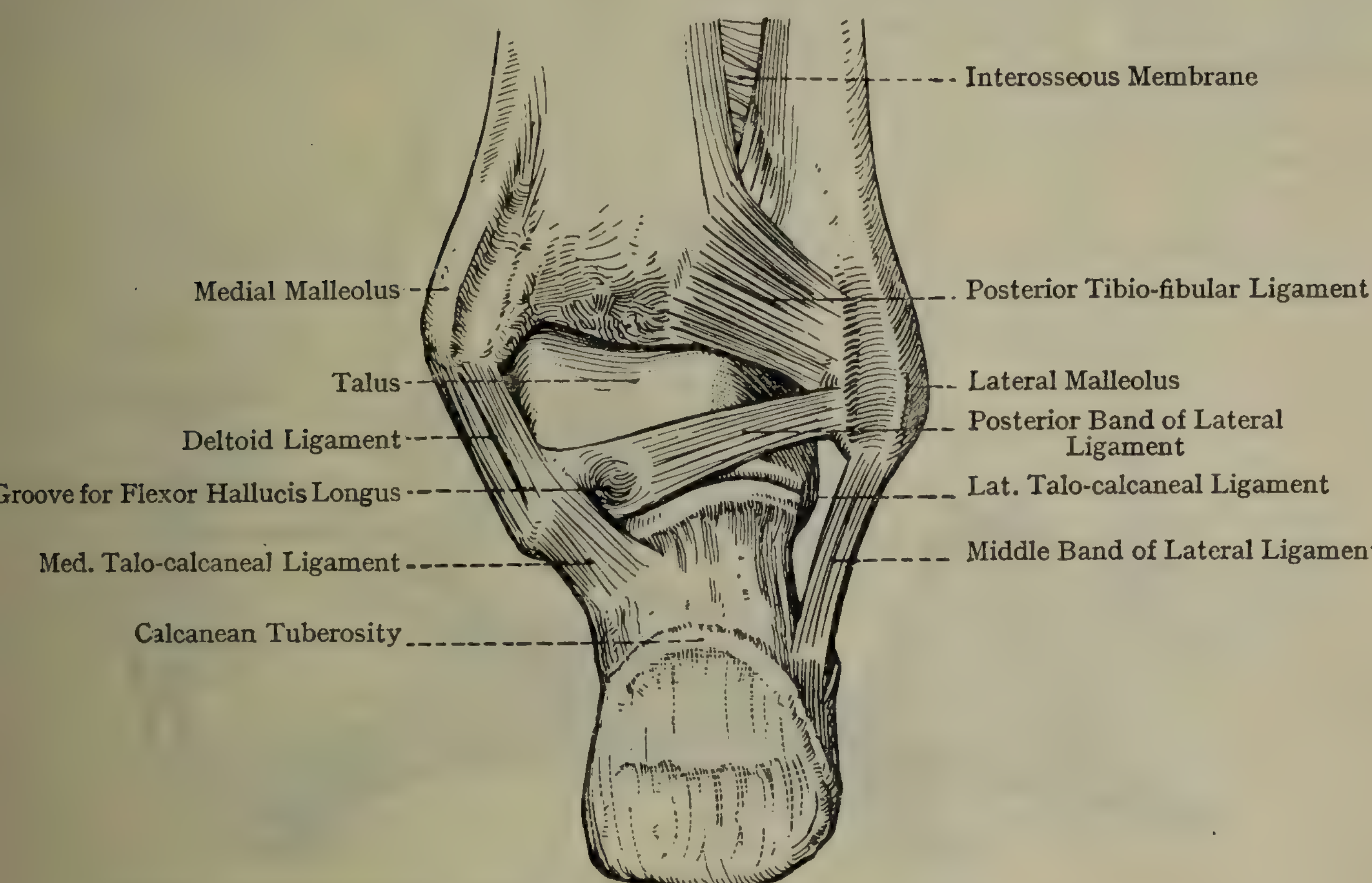


Fig. 396.—The Right Ankle-Joint (Posterior View).
The posterior ligament has been removed.

ınd on its outer bevelled edge the transverse ligament of the inferior ibio-fibular joint plays in the flexion and extension movements of the joint. The joint is surrounded by a capsular ligament in which an anterior, a posterior, and two lateral ligaments may be distinguished.

The **anterior ligament** is exceedingly thin, consisting of not much more than a few scattered fibres which clothe the synovial membrane. Above it is attached to the anterior margin of the lower end of the tibia and to the anterior inferior tibio-fibular ligament, below to the talus immediately in front of its upper articular surface.

The **posterior ligament** is also very thin, and chiefly consists of transverse fibres. It is attached above to the posterior aspect of the lateral malleolus medial to the peroneal groove, the posterior inferior tibio-fibular ligament, and the posterior margin of the inferior surface

of the tibia. Below it is attached to the posterior margin of the upp articular surface of the talus.

The **medial ligament** (Fig. 397) is also known inappropriately as tl **deltoid ligament.** It is thick, flat, and quadrangular. Above it attached to the lower margin of the medial malleolus. The anteri fibres are comparatively thin, and pass obliquely downwards ar forwards to the tuberosity of the navicular bone and the plant calcaneo-navicular ligament; the middle fibres are vertical, and a attached below to the sustentaculum tali; the posterior fibres, sho and thick, incline downwards and backwards to the talus, and exter backwards as far as the inner tubercle on the posterior aspect of tl bone. In addition, there is a deep band of fibres which are attache to the tip of the medial malleolus above and the inner side of tl talus below.

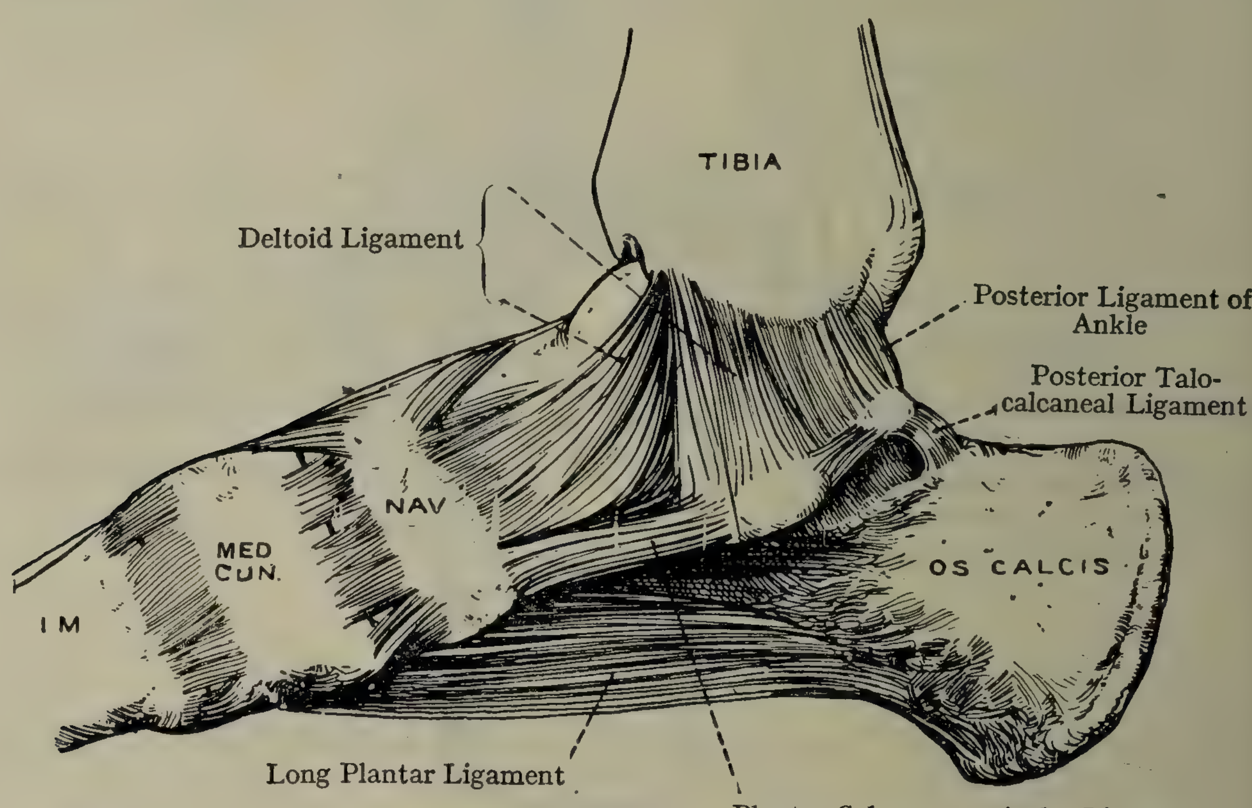


FIG. 397.—LIGAMENTS OF THE RIGHT FOOT (MEDIAL ASPECT).

The **lateral ligament** consists of three distinct bundles—anterio middle, and posterior.

The *anterior talo-fibular ligament* (Fig. 398) extends forwards an slightly inwards from the lower part of the anterior border of tl lateral malleolus to the outer surface of the neck of the talus.

The *calcaneo-fibular ligament* (Fig. 398) is the longest of the thre It is attached above to the tip of the lateral malleolus, from which passes obliquely downwards and backwards to a tubercle on the out surface of the calcaneum behind and above the peroneal tubercle.

The *posterior talo-fibular ligament* (Fig. 396) is the strongest an thickest of the three. It is attached to the malleolar fossa, which immediately behind the articular facet on the inner surface of th lateral malleolus. Thence it passes almost directly inwards to th outer tubercle on the posterior aspect of the talus.

The **synovial membrane** is loose, and lines the deep surfaces of the ligaments. It also invests pads of fat at the front and back of the joint, where synovial folds project between the articular surfaces of the talus and tibia to a greater or less extent according to the position of the joint. It is also prolonged upwards, and lines the anterior and posterior ligaments of the inferior tibio-fibular joint.

Relations of the Ankle-Joint.—*In front,* from within outwards, are the tendons of the tibialis anterior, extensor hallucis longus, extensor digitorum longus, and peroneus tertius, with the anterior tibial vessels and nerve lying between the extensor hallucis longus and extensor digitorum longus. *Behind,* from within outwards, are the tendons of

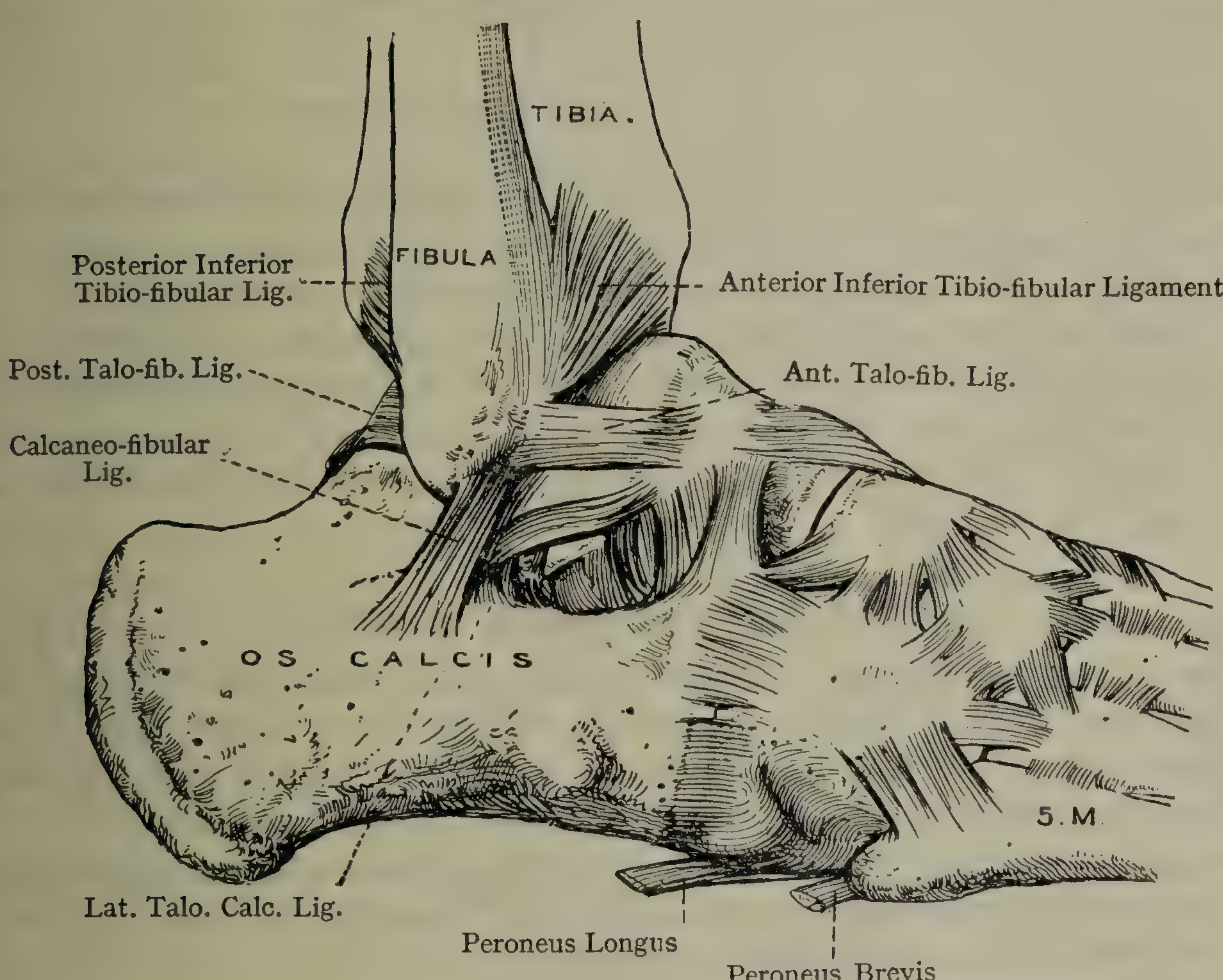


FIG. 398.—LIGAMENTS OF THE RIGHT INFERIOR TIBIO-FIBULAR, ANKLE, TARSAL, AND TARSO-METATARSAL JOINTS (LATERAL ASPECT).

the tibialis posterior, flexor digitorum longus, and flexor hallucis longus, with the posterior tibial vessels and nerve lying between the flexor digitorum and flexor hallucis longus. More superficially, and separated from the joint by a considerable amount of fat, are the tendo-calcaneus and the tendon of the plantaris. *Laterally* the peroneal tendons are superficial to the calcaneo-fibular ligament. *Medially* the tendons of the tibialis posterior and flexor digitorum longus cross the deltoid ligament superficially.

Nerve-supply.—The anterior and posterior tibial nerves.

Movements.—The chief movements at the ankle-joint are flexion and extension. It is important to remember that the habitual position of the foot is at right angles to the leg, and is really one of hyperextension. Consequently, bending the foot or diminishing the angle between it and the leg (flexion) is

brought about by the extensor muscles on the front of the limb, while tl flexor muscles are concerned in straightening the foot or widening the ang between it and the leg (extension). In the extended position, when the narrow part of the articular surface of the talus occupies the tibio-fibular socket, very limited amount of lateral movement is possible. In flexion the broa anterior part of the superior articular surface of the talus is carried backwar into the narrow posterior part of the tibio-fibular socket, and lateral moveme is then impossible. Flexion is chiefly limited by the posterior parts of the tw lateral and deltoid ligaments, and extension by the anterior parts of the ligaments. The range of movement in flexion and extension is about 90 degree and takes place round a transverse axis passing through the body of the talus.

In the standing posture the line of the centre of gravity falls in front of tl axis of movement at the ankle-joint. There is thus a tendency to flex the join which is counteracted by contraction of the calf muscles.

THE JOINTS OF THE FOOT.

The joints of the foot are tarsal, tarso-metatarsal, intermetatarsa metatarso-phalangeal, and interphalangeal.

The tarsal joints may be further subdivided into:

1. Posterior tarsal joints, between the talus and calcaneum.

2. Mid-tarsal joints, between the talus and calcaneum behin and the navicular and cuboid in front.

3. Anterior tarsal joints, between the navicular, the three cune forms, and the cuboid.

The Posterior Tarsal Joints.

Talo-calcaneal Joints.—Between the talus above and the calcaneu below are two joints, anterior and posterior. The joints are separate from each other by the interosseous ligament, which fastens the tw bones together and is a ligament common to the two joints.

The *posterior talo-calcaneal joint* is surrounded by a capsular liga ment in which special thickenings are known as the interosseou posterior, medial, and lateral ligaments.

The **interosseous ligament** is the strongest and most importan ligament connecting the talus to the calcaneum. It is attached to th interosseous grooves on the opposed surfaces of the two bones. It i very strong, and consists of both vertical and oblique fibres. Laterall it is intimately associated with the stem of the extensor retinaculu (p. 603).

The **posterior talo-calcaneal ligament** (Fig. 397) extends from th outer tubercle on the back of the talus to the adjacent part of th calcaneum. It is a short but relatively broad band.

The **medial talo-calcaneal ligament** (Fig. 396) passes from the inne tubercle on the back of the talus to the hinder end of the sustentaculu tali of the calcaneum.

The **lateral talo-calcaneal ligament** (Fig. 398) is a short narrow ban which extends obliquely downwards and backwards from the oute surface of the talus immediately below the fibular facet to the adjacen part of the calcaneum. It is situated deeply to, but is slightly farthe

rwards than, the middle fasciculus of the lateral ligament of the nkle-joint.

The *anterior talo-calcaneal joint* plays an important part in the lo-calcaneo-navicular joint, with which it will be considered.

Mid-Tarsal Joints.

The **talo-calcaneo-navicular joint** is the largest and most important f all the tarsal joints. The articular surfaces consist of the more or ss spherical head of the talus, which fits into a cup provided by the rticular surface on the upper aspect of the calcaneum, in front of the nterosseous groove, and the concave articular surface on the posterior urface of the navicular bone. The articular cup is completed by two gaments, the calcaneo-navicular part of bifurcated ligament and the lantar calcaneo-navicular ligament, which bind the two bony contituents of the cup together.

The **plantar calcaneo-navicular ligament** (*spring ligament*), or, as it hould be more properly called, the infero-medial calcaneo-navicular gament, fills in a triangular interval between the calcaneum and the avicular bone, and completes the floor of the cup (Fig. 399). It also xtends upwards on the inner aspect of the joint. It is attached behind o the sustentaculum talis, and in front to the plantar surface, to the uberosity, and slightly to the dorsal surface of the navicular bone. he upper surface of the lower part of the ligament is thickly coated vith hyaline cartilage, and impresses a well-defined triangular area n the head of the talus; this area is intermediate in position between he articular surfaces for the calcaneum and the navicular bone Fig. 399). The upper or inner part of the ligament is a curved fibrous and closely applied to the head of the talus and forms the inner wall f the articular cup. The superficial aspect of the ligament is closely elated to the tendon of the tibialis posterior. Some of the anterior ibres of the deltoid ligament of the ankle-joint are attached to it Fig. 397).

The **bifurcated ligament** (Fig. 399) is attached behind to the upper urface of the front part of the calcaneum. It divides into two bands: he outer passes forwards to the cuboid; the inner, or *calcaneo-navicular art*, passes obliquely forwards and inwards to the navicular bone. It ompletes the outer wall of the articular cup for the reception of the ead of the talus.

The head of the talus is retained in its articular cup by two ligaments, which fasten the talus to the calcaneum and to the navicular one respectively.

The former is the talo-calcanean *interosseous ligament*, which completes the joint behind and separates it from the posterior talo-calcanean joint (p. 664).

Medial and lateral talo-calcanean ligaments, sometimes described in connection with the anterior talo-calcanean joint, are only collateral parts of the nterosseous ligament, with which they are continuous.

The latter is the **dorsal talo-navicular ligament,** a thin fibrous shee on the dorsal or upper aspect of the joint. It is attached behind t the upper surface of the head of the talus close to the edge of th articular surface, from which it sweeps downwards and forwards t the upper surface of the navicular bone. Its collateral margins ar adherent to each side of the bifurcated ligament. The interosseou and the dorsal talo-navicular ligaments form together an almost com plete capsule surrounding the joint.

From the foregoing description it may be realized that the anterior tal calcanean joint is a part of the general talo-calcaneo-navicular joint, and shoul not be described independently.

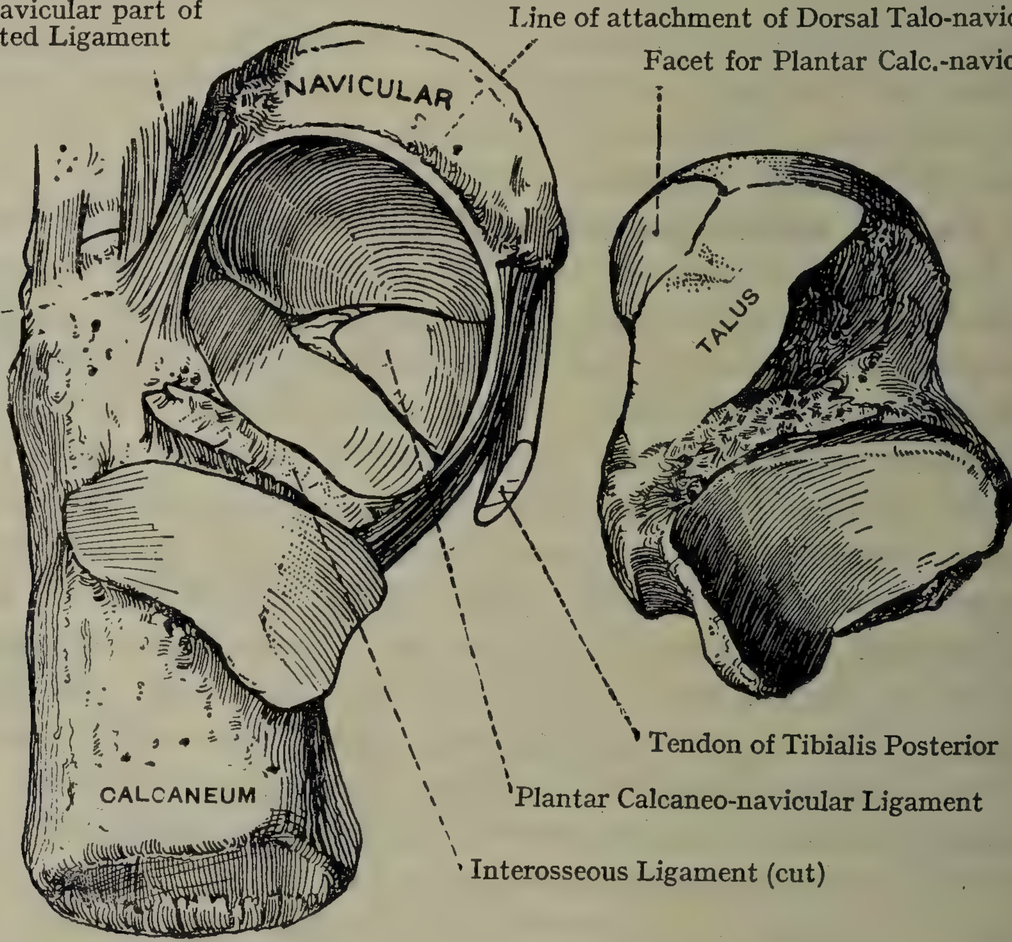


FIG. 399.—THE PLANTAR CALCANEO-NAVICULAR LIGAMENT OF THE LEFT FOOT (SUPERIOR VIEW).

The **calcaneo-cuboid joint** is the outer of the two mid-tarsal joints In this joint the articular surface on the anterior aspect of the cal caneum is applied to the posterior articular surface of the cuboid the opposed surfaces are somewhat saddle-shaped. The ligament connecting the calcaneum and the cuboid are dorsal calcaneo-cuboid calcaneo-cuboid part of bifurcated ligament, and two plantar.

The **dorsal calcaneo-cuboid ligament** (Fig. 398) is a flattened banc which passes between the adjoining surfaces of the calcaneum anc cuboid. Some of its lateral fibres are attached to the outer surface o the calcaneum.

The **calcaneo-cuboid part of bifurcated ligament** (Fig. 399) passe forwards from the calcaneum, and is attached to the supero-media aspect of the cuboid.

The two plantar ligaments are known as the long and the short. The latter is almost completely under cover of the former.

The **long plantar ligament** (Fig. 370) is by far the longest ligament in the foot. It clothes and is adherent to all the plantar surface of the calcaneum in front of the two tubercles at the hinder part of the bone. From the calcaneum it passes on to the plantar aspect of the cuboid, where it is adherent to the prominent ridge behind the peroneal groove. It passes forwards across the groove, and finally subdivides into slightly diverging bands, which are attached to the bases of the second,

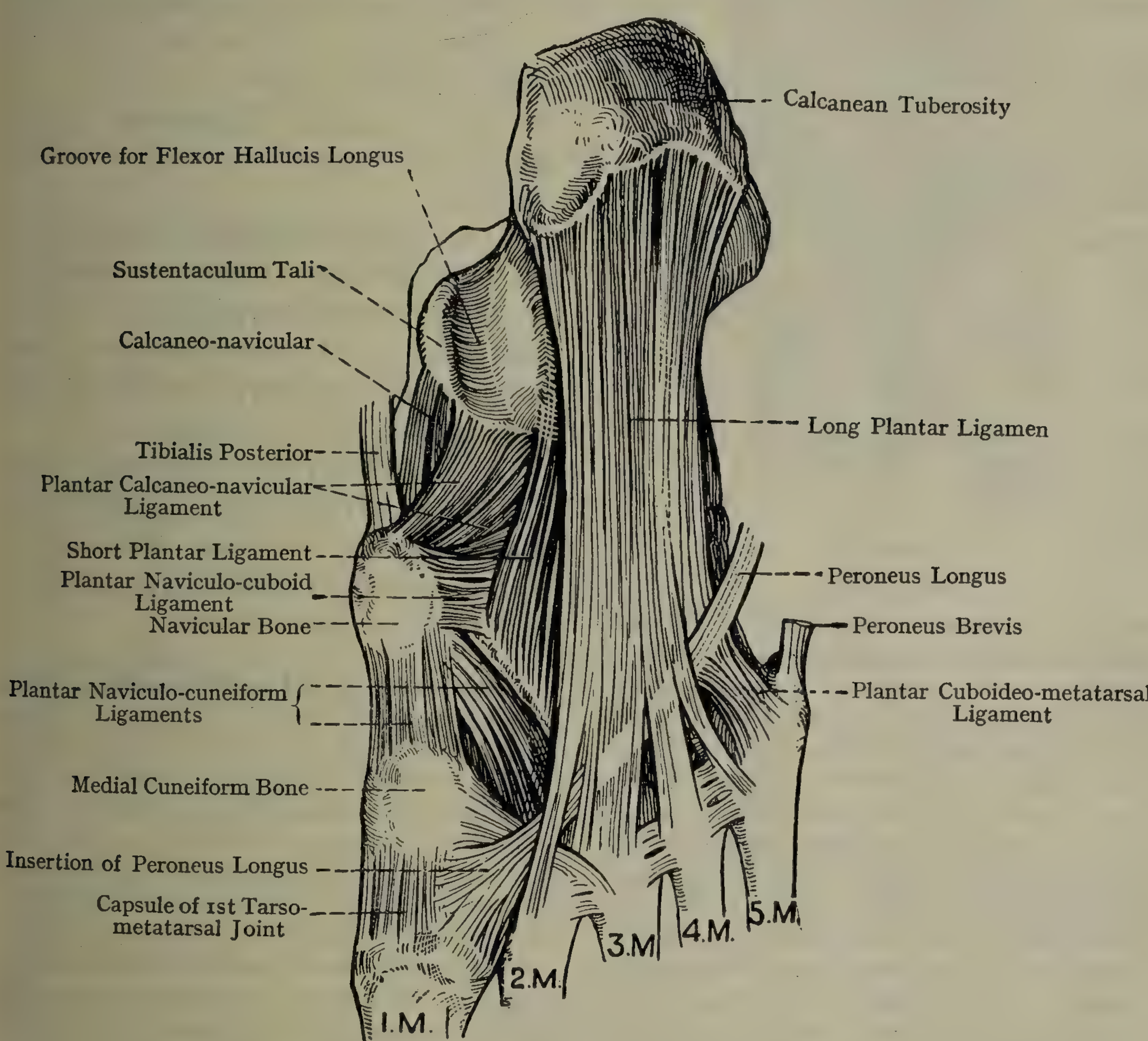


FIG. 400.—LIGAMENTS OF THE RIGHT FOOT (PLANTAR ASPECT).

third, and fourth metatarsal bones. The ligament converts the peroneal groove into a canal in which the tendon of the peroneus longus is contained.

The **short plantar ligament** is the shorter and thicker of the two plantar ligaments, and its fibres are more obliquely disposed. It extends forwards from the tubercle at the front end of the plantar surface of the calcaneum to the cuboid, where it is attached to the ridge forming the posterior limit of the peroneal groove and the surface of bone behind it.

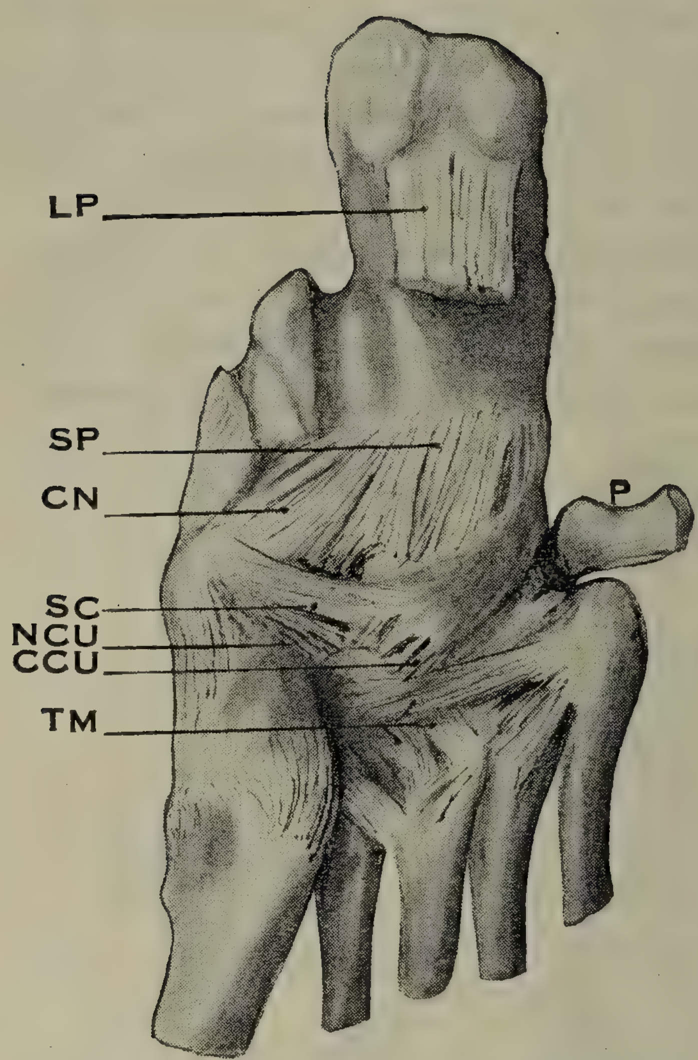


Fig. 401.—Deeper Ligaments in the Sole.

The long plantar ligament (LP) has been removed, with other superficial bands, and peroneus longus tendon (P) turned aside. Short plantar (SP) and calcaneo-navicular (CN) fibres are seen, and other bands of the longitudinal group anterior to the navicular, in the form of naviculo-cuneiform and cuneiform-metatarsal; some of these fibres (NCU) are very oblique. Transverse fibres are in the anterior tarsal region. Cubo-navicular (SC), cubo-cuneiform (CCU), and intercuneiform bands comprise these. In front of them is the tarso-metatarsal region, with corresponding ligaments (TM); one of these bands runs transversely between the cuneiforms and the fifth metatarsal, and is evidently part of the transverse arch mechanism, although it is actually tarso-metatarsal.

The Naviculo-cuboid Ligaments—The navicular and the cuboid which are only occasionally in contact with each other, are bound together by three strong ligaments—dorsal, plantar, and interosseous. The dorsal and plantar ligaments are more or less transverse.

The **dorsal ligament** (Fig. 398) is triangular with its base on the cuboid.

The **plantar ligament** (Figs. 400 and 401) is very often double.

The **interosseous ligament** is very strong and thick. It consists of short fibres, which, as a rule completely fill the interval between the adjacent surfaces of the two bones.

The cuboid and the navicular are very firmly knit together by these ligaments, and the movements between them are so slight as to be inappreciable.

Movements at the Mid-tarsal Joints.—The cuboid and navicular, carrying the distal part of the foot with them, move as one bone, and with a considerable amount of freedom, on the rounded head of the talus and the anterior articular surface of the calcaneus. Slight movements of extension and flexion take place in association with movements of the ankle-joint. Extension occurs when the ankle is flexed, the opposite movement when it is extended. The chief movements are adduction and abduction, whereby the foot is carried inwards and outwards, and rotation movements, whereby the foot is everted and inverted. Slighter displacements in the two talo-calcanean joints take a share in these movements.

Anterior Tarsal Joints.

The **cuneo-navicular joint** is the joint between the navicular behind and the three cuneiforms in front. It is provided with dorsal, plantar, and medial ligaments.

The **dorsal ligaments,** three in number, pass obliquely forwards and outwards from the navicular to the three cuneiforms.

The **plantar ligaments** have the same general direction as the dorsal, but are more closely packed together.

The **medial ligament** is very thick and strong. It extends from the tuberosity of the navicular bone to the inner surface of the medial cuneiform. It is usually continuous above and below with the innermost dorsal and plantar ligaments.

Intercuneiform and Cuneo-cuboid Joints.—The three cuneiform bones and the cuboid are bound together by dorsal, interosseous, and plantar ligaments.

The **three dorsal ligaments** are relatively narrow transverse bands which connect the four bones together.

The **three interosseous ligaments** (Fig. 402) are very thick and strong. They consist of short fibres, which connect the non-articular areas of the adjacent surfaces of the four bones.

The **plantar ligaments** are two in number. One very thick band extends obliquely forwards and outwards from the medial to the intermediate cuneiform. The other is a weaker band which passes obliquely forwards and inwards from the cuboid to the lateral cuneiform.

The **movements** which take place in the anterior tarsal joints are very limited and are confined to slight gliding movements. They confer elasticity to the anterior part of the tarsus, and are also associated with alterations which occur in the arches of the foot.

The Tarso-metatarsal Joints.

The joint line between the tarsus and metatarsus slopes obliquely across the foot, the inner end being about three-quarters of an inch farther forwards than the outer. This line is interrupted opposite the second metatarsal bone, the base of which is wedged into a mortice-like socket provided by the three cuneiform bones (Fig. 402).

Between the tarsus and metatarsus are three distinct joint cavities (Fig. 402): A **medial** between the medial cuneiform and the first metatarsal; an **intermediate** between the three cuneiforms and the second and third metatarsals; a **lateral** or **cuboideo-metatarsal** between the cuboid and the fourth and fifth metatarsals.

The joints are provided with dorsal, plantar, and interosseous ligaments.

The **medial tarso-metatarsal joint,** between the medial cuneiform and the first metatarsal, has a capsular ligament which is somewhat deficient laterally, and is stronger below and medially than elsewhere. Its upper and lower parts are usually distinguished as plantar and dorsal ligaments.

The Dorsal Ligaments.—The second metatarsal is provided with three dorsal ligaments, which converge from the three cuneiform bones on to its base. The bases of the three outer metatarsals are fastened to the lateral cuneiform and to the cuboid by one dorsal ligament in each case.

The **plantar ligaments** are less regular than the dorsal. An obliqu band passes obliquely outwards and forwards from the medial cunei form to the bases of the second and third metatarsals. The inter mediate cuneiform and the second metatarsal, the lateral cuneiforn and the third metatarsal, the cuboid and the two outer metatarsals are all connected together by single bands. The plantar ligament are supplemented by the long plantar ligament, which is usuall attached to the bases of the second, third, and fourth metatarsa bones, and by tendinous slips of the tendon of the tibialis posterior which are also attached to the bases of the second, third, and fourtl metatarsals (p. 622).

The **interosseous ligaments** are three in number, two of them bein attached to the second metatarsal bone.

The *medial* is the thickest and strongest. It extends obliquel forwards and outwards from the outer side of the medial cuneiforn

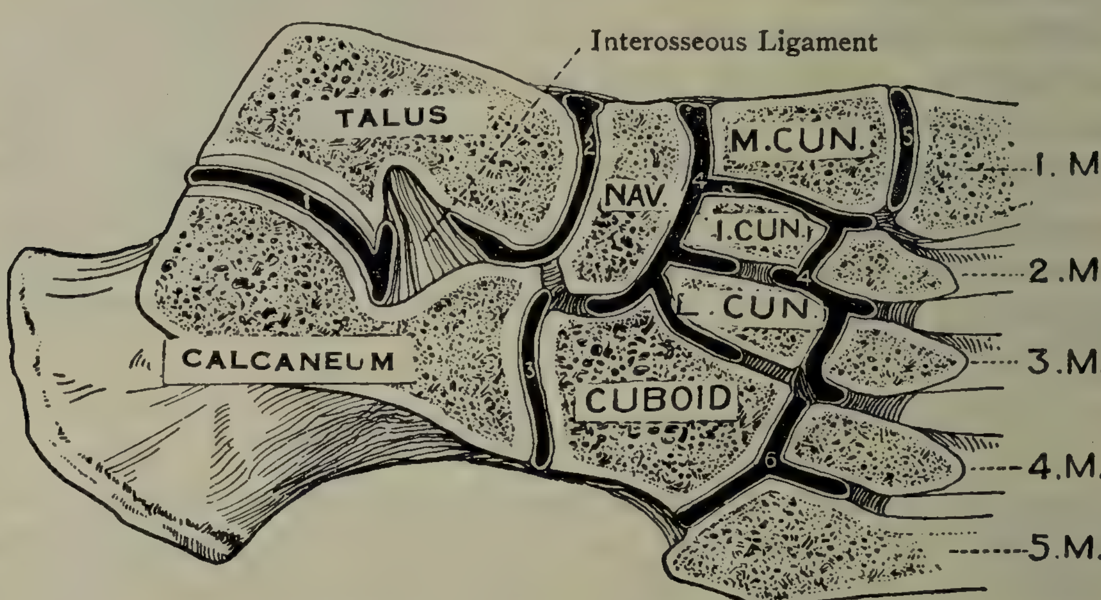


FIG. 402.—THE SYNOVIAL CAVITIES OF THE TARSAL AND TARSO-METATARSAL JOINTS.

to the adjacent side of the base of the second metatarsal. The *inter-mediate*, the weakest and least constant, extends from the lateral cuneiform to the outer surface of the base of the second metatarsal The *lateral* extends from the lateral cuneiform to the outer side of the base of the third metatarsal.

The interosseous ligaments, with the exception of the internal, are variable Occasionally weak interosseous bands pass from the lateral cuneiform or the cuboid to the fourth metatarsal.

Of all the metatarsals, the second is most firmly fastened to the tarsus. Its base is wedged into the socket provided by the three cuneiform bones, and it is held in place by a larger number of ligaments than any other metatarsal bone.

Nerve-supply.—The anterior tibial and the two plantar nerves.

The **movements at the tarso-metatarsal joints** are slight movements of flexion and extension which occur in changes affecting the arches of the foot. Slight lateral movements may take place in the first and the two outer metatarsals, which are more movable on the tarsus than the second and third. The second metatarsal bone is almost immovable on the tarsus.

The Intermetatarsal Joints.

The bases of all the metatarsal bones, with the exception of the rst, are closely approximated, and the joints between them are rovided with dorsal, plantar, and interosseous ligaments.

In rare cases a joint exists between the first and second metatarsal bones.

The **dorsal** and **plantar ligaments,** in each case three in number, re transverse bands which unite the adjoining bases of the four outer ietatarsal bones together. The dorsal ligaments are thin, while the lantar are relatively much thicker and stronger.

The **interosseous ligaments** are three dense and very strong fibrous ands, which are nearer to the plantar ligaments than to the dorsal. 'hey connect the rough non-articular lateral surfaces of the metaarsal bases together (Fig. 402).

The **synovial cavities** are continuous with those of the tarso-metaarsal joints. Those between the second and third and between the hird and fourth metatarsal bones are continuous with the middle arso-metatarsal joint cavity; that between the fourth and fifth metaarsal bones is continuous with the cuboideo-metatarsal cavity Fig. 402).

The **movements** are very slight gliding movements, which are associated vith variations in the arches of the foot.

Crossing the plantar aspects of the heads of *all* the metatarsal ones, and connecting them together, is the **deep transverse ligament f foot.** It is adherent deeply to the capsular ligaments of the metaarso-phalangeal joints. Opposite a metatarso-phalangeal joint its uperficial aspect has a cartilage-lined groove in which the flexor endons are lodged. The disposition of the deep transverse ligament f foot is very similar to that of the deep transverse ligament of palm, ut the latter links together the four inner metacarpal bones only, and loes not include that of the thumb.

The Tarsal and Tarso-metatarsal Synovial Cavities.—These are isually **six** in number (Fig. 402): (1) Posterior talo-calcaneal; (2) talo-alcaneo-navicular; (3) calcaneo-cuboid; (4) a large complicated joint avity common to the cuneo-navicular joints, the joints between the ndividual cuneiform bones, the cuneo-cuboid joint, and the middle arso-metatarsal joint; (5) medial tarso-metatarsal; (6) lateral tarso-netatarsal or cuboideo-metatarsal.

Occasionally the middle tarso-metatarsal or the cubo-cuneiform joint cavities are independent, in which case there may be **seven** or even **eight** synovial cavities.

The Metatarso-phalangeal Joints.

The articular surfaces are the narrow convex articular surfaces of the heads of the metatarsal bones, which are prolonged more extensively on to the plantar aspect of the bone than on to the dorsal, and the ovoid shallow cups at the proximal ends of the phalanges.

Each joint is provided with three ligaments—a capsular, and tw collateral. The *capsular ligament* is continuous on its plantar surfac with the deep transverse ligament of foot. On its deep aspect is a li of fibro-cartilage which projects into the joint, and deepens the socke of reception for the head of the metatarsal bone. The *collateral liga ments* are thick resistant bands. The dorsal part of the *capsula ligament* is exceedingly thin and weak; it is closely adherent to th extensor tendon.

The metatarso-phalangeal joint of the great toe is peculiar in tha there are two sesamoid bones embedded in the plantar ligament i the situations where the short muscles of the great toe are adheren to it.

The *movements* are chiefly those of flexion and extension.

Collateral movements, owing to the very narrow articular surfaces on th heads of the metatarsal bones, are very limited. In the metacarpo-phalange joints, where the articular surfaces on the heads of the metacarpal bones ar broader, collateral movements are much less restricted.

The Interphalangeal Joints.

These joints are like the metatarso-phalangeal joints, and ar provided with similar ligaments. The plantar ligament is a thic fibro-cartilaginous plate which is grooved superficially for the flexo tendons, and has a deep lip projecting into the joint and deepening th socket of reception for the rounded head of the more proximal phalanx

The movements are those of flexion and extension. These move ments are limited, and in some of the joints voluntary extension move ments are impossible.

THE ARCHES OF THE FOOT.

The bones of the foot are so disposed that, as a whole, they are built togethe in the form of two arches, a longitudinal and a transverse.

The **longitudinal arch** is most obvious when the foot is viewed from the inne side (Fig. 397). From this point of view the talus is at the summit of the arch the calcaneum provides a short, more vertical, posterior pillar, while a lon anterior pillar is formed by the navicular, medial cuneiform, and the meta tarsal bone of the great toe, which together slope obliquely downwards an forwards. The arch gradually flattens out towards the outer side of the foo and from this point of view (Fig. 398) the cuboid is at the summit of the arch the posterior pillar is again the os calcis, which, however, passes backwards wit only a slight inclination downwards; the anterior pillar is the fifth metatarsa the proximal end of which is only at a slightly higher level than the distal.

When the distal end of the tarsus and the proximal end of the metatarsu are viewed from below, they are seen to be concave from side to side. Thi concavity, or **transverse arch** of the foot, is due to the wedge-shaped form of th component bones, and is deepest towards the inner side. It is important t notice that the transverse arch involves bones which are also concerned i forming the anterior pillar of the longitudinal arch.

The posterior pillar of the longitudinal arch is formed by one bone, th calcaneum. The anterior pillar presents the greatest contrast to the posterior Nearly all the tarsal bones and all the metatarsals take a share in its formation It splays out from the summit of the arch to the distal end of the metatarsus Further, it is arched from side to side, and flattens out towards the outer side o

he foot. The posterior pillar may be defined as the shorter, more vertical, nd rigid pillar; the anterior as the longer, more oblique, and highly elastic illar.

The arches render the foot a very elastic basis of support and a highly efficient rgan of progression. In the standing position the larger component of the ody weight, transmitted from the tibia to the talus, passes through the calaneus to the heel; the smaller component through the longer anterior pillar o the ball of the foot, which corresponds in position to the distal end of the etatarsus. The superincumbent weight, which chiefly impinges on the inner ide of the foot, tends to flatten the arches and to thrust the head of the astragalus ownwards between the upper ends of the two pillars of the longitudinal arch. 'he plantar calcaneo-navicular ligament keeps the upper ends of the two pillars n approximation, and supports the head of the talus from below. In this respect

FIG. 403.—SAGITTAL SECTION OF ANKLE AND FOOT PASSING THROUGH THE GREAT TOE.

1, plantar calcaneo-navicular ligament; 2, inner sesamoid bone.

he plantar calcaneo-navicular ligament is the most important ligament in the oot. The longitudinal arch is also maintained by the tendons of the long lexor muscles, which pass into the sole from behind the medial malleolus, the ibialis posterior being the most important (p. 622); by the flexor digitorum revis; by the long plantar ligament; and by the plantar aponeurosis (p. 642), which plays the part of a string to a bow, and prevents undue separation of he lower ends of the two pillars. In walking, the heel is first raised from the ground by the powerful calf muscles, the posterior pillar playing the part of an rm of a lever. Being rigid and composed of one bone, the calcaneum, there is no loss of effective power, as would ensue if the posterior pillar had movable omponents. The weight of the body is then gradually thrown forwards through he anterior pillar on to the toes. As this pillar is elastic and slight gliding isplacements take place between its component parts, this movement is effected smoothly and evenly.

CHAPTER XI

THE ABDOMEN

MALE PERINEUM.

Landmarks.—The ischial tuberosity can be felt on either side, as we
as the ischio-pubic ramus; but the sacro-tuberous ligament cannot b
felt, on account of the thickness of the lower border of the gluteu
maximus. The posterior margin of the pubic symphysis and th
tip of the coccyx are both to be felt, the former, however, only on dee
pressure.

The perineum practically corresponds with the outlet of the pelvi
and is somewhat lozenge-shaped, having the subpubic angle in fron
the tip of the coccy
behind, and the ischia
tuberosity on eithe
side. It is convenientl
divided into two part
by a line connectin
the ischial tuberositie
each division being tri
angular. The anterio
constitutes the uro
genital division, thi
being the perineum
proper, and the pos
terior the anal division
The skin of the uro
genital division present
an antero-posterior me
dian elevation, called
the perineal raphé
which extends over th
posterior and anterior surfaces of the scrotum, and along the unde
surface of the penis, indicating the bilateral origin of these parts
The position of the deeply-placed perineal body is indicated by takin
a point in this raphé about an inch in front of the anus.

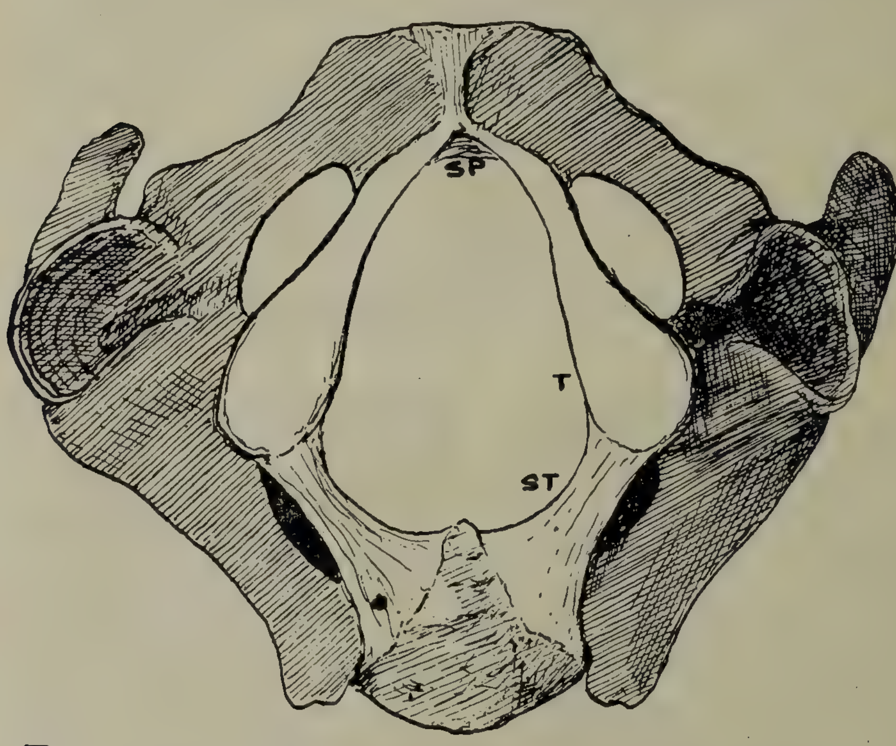


FIG. 404.—LOWER APERTURE OF MALE PELVIS.
SP, subpubic ligament; ST, sacro-tuberous ligament; T, tuber ischii.

The **anus** is the external opening of the anal canal. It is situate
posterior to a line connecting the front parts of the ischial tuberosities
and about $1\frac{1}{2}$ inches from the tip of the coccyx. A delicate white lin
surrounds the anus where the skin and mucous membrane meet; i
indicates the interval between the external and internal sphincte

ıuscles (Hilton). The position of each ischio-rectal fossa is indicated y a slight depression between the anus and ischial tuberosity.

Deep Boundaries of the Perineum—*Anterior.*—The subpubic angle ıd the inferior pubic ligament. *Posterior.*—The coccyx. *Lateral.*—rom behind forwards, the inferior border of the sacro-tuberous ligaıent, the ischial tuberosity, and the ischio-pubic ramus.

Ischio-rectal Division.

Cutaneous Nerves.—These are (1) the **perineal branch** from the ›wer part of the anterior primary division of the fourth sacral, and ;) the **inferior hæmorrhoidal nerve,** a branch of the pudendal. The ›rmer supplies the skin between the tip of the coccyx and the anus, ıe latter the skin around the anus as far out as the ischial tuberosity.

Fascia.—The superficial fascia of this division is rich in fat, and is rolonged into the ischio-rectal fossa, where it forms an elastic pad on hich the pelvic floor rests.

Ano-coccygeal Body.—This is a collection of fibrous and muscular ssue situated between the coccyx and anal canal, the muscular ement being contributed by the levatores ani and sphincter ani ıuscles. Its importance lies in the fact that it gives support to the ıal canal.

Muscles.—The muscles in this division are the corrugator cutis ani, ›hincter ani externus, levator ani, and coccygeus.

Corrugator Cutis Ani (Ellis).—This muscle is represented by a very elicate sheet of involuntary muscular fibres, which pass in a radiating ıanner from the submucous tissue of the anal aperture to be inserted ıto the surrounding skin.

Action.—(1) To throw the skin around the anus into wrinkles; and ;) to invert the mucous membrane of the lower end of the anal canal fter it has been everted during defæcation.

For the **levator ani** and **coccygeus,** see pp. 947 and 948.

Sphincter Ani Externus—*Origin.*—The tip of the coccyx and the ɛin over it.

Insertion.—The greater part of the muscle is inserted into the erineal body. The more superficial fibres, however, are inserted ıto the skin, and a certain amount of decussation takes place across ıe middle line.

Nerve-supply.—The part of the muscle between the coccyx and ıe anus is supplied by the perineal branch of the fourth sacral, the emainder by the inferior hæmorrhoidal and the muscular branch of the erineal nerve, both of which are derived from the pudendal.

Action.—To keep the anal aperture closed, at the same time proucing a wrinkled condition of the skin.

The muscle is situated immediately beneath the skin, and is liptical. Behind and in front of the anus it is single, but around ıat aperture it is arranged in two symmetrical halves, which are ıtimately connected with the middle portions of the levatores ani.

Ischio-rectal Fossa.—This is a deep fossa which is situated o either side between the ischium and rectum. It measures nearl $2\frac{1}{2}$ inches in depth, 2 inches from before backwards, and 1 inch fro side to side. In transverse section it is triangular, the base bein directed downwards and the apex upwards. The **outer wall,** which vertical, is formed by the lower part of the obturator internus musc covered by the obturator fascia. The **inner wall,** which is oblique, formed by the lower part of the rectum, the anal canal, the levato ani muscle covered by the anal fascia, and the sphincter ani externu The **base** is formed by the skin and fascia, which extend between th

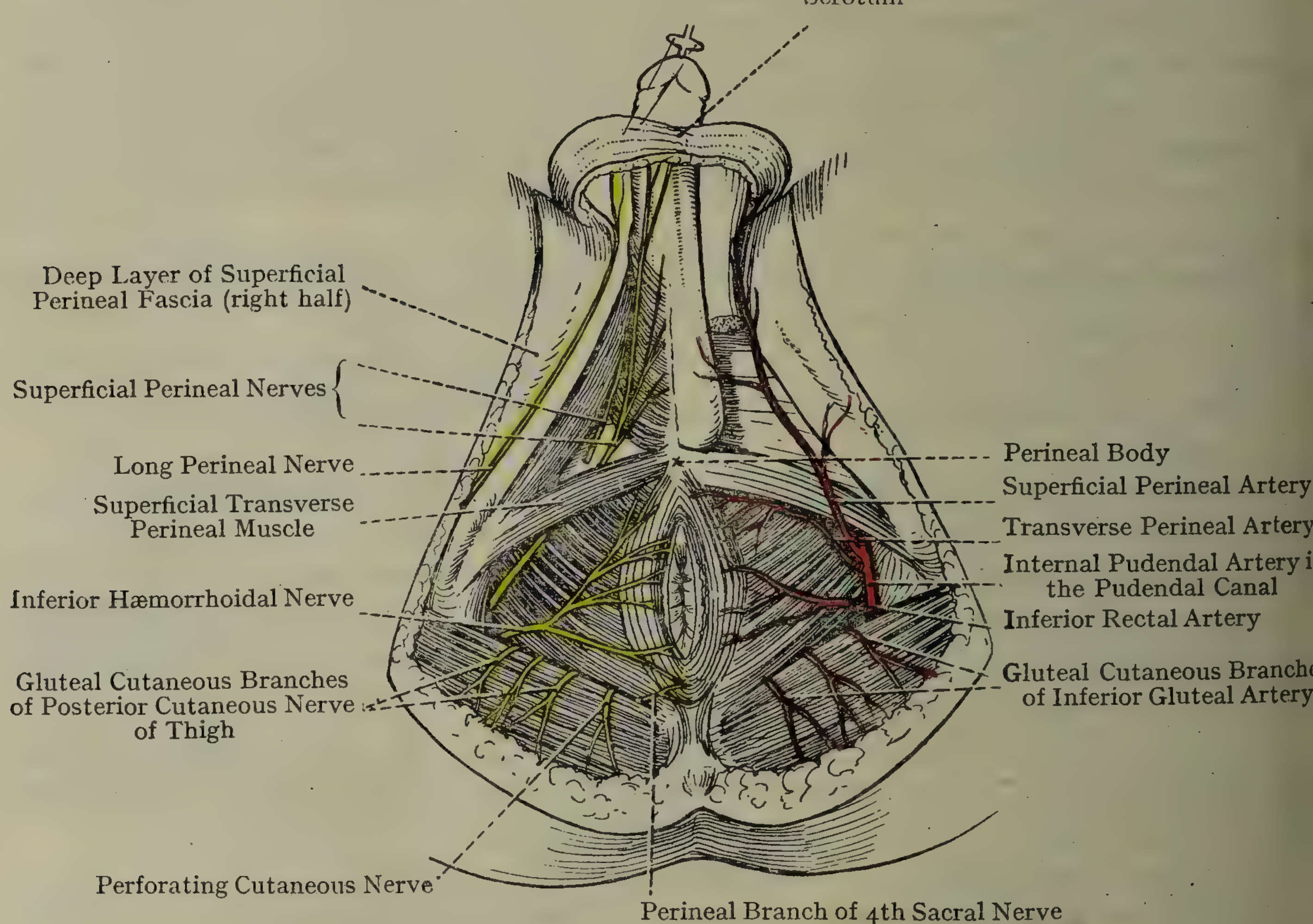


Fig. 405.—Dissection of the Male Perineum.

On the left side the bulbo-spongiosus has been removed and the crus penis cut.

ischial tuberosity and anus. The **roof** is just below the *white line* where the anal fascia springs from the obturator fascia. *Anteriorl* the fossa is partially limited by the deep layer of superficial perinea fascia as it is reflected round the posterior border of the superficia transverse perineal muscle on its way to join the base of the perinea membrane. Above this junction there is a forward prolongation o the fossa, called the *anterior diverticulum,* which extends almost t the symphysis pubis; it lies between the superior layer of the perinea membrane and the inferior surface of the anterior part of the levato ani muscle, and is limited by the prostate gland and pubo-prostati ligament medially, and by the ischio-pubic ramus laterally. *Posteriorl*

he fossa is partially limited by the margin of the sacro-tuberous igament and the lower border of the gluteus maximus muscle. Be-ween these two structures it is prolonged backwards for a short listance in the form of a *posterior diverticulum*, which extends outwards owards the ischial tuberosity, and inwards towards the upper part f the coccyx.

Position of Contents.—The internal pudendal vessels and the erineal and dorsal nerve of penis, branches of the pudendal nerve, lie n the pudendal canal, which runs along the outer wall $1\frac{1}{2}$ inches above he lower part of the ischial tuberosity. The inferior rectal vessels nd nerve cross the fossa transversely from the outer wall to the anal anal. The perineal vessels and nerves, branches respectively of the nternal pudendal vessels and of the perineal branch of the pudendal erve, lie for a short distance, as they run forwards, in the front part f the fossa, where they anastomose and form connections with branches f the inferior rectal vessels and the inferior hæmorrhoidal nerve. At he back part of the fossa, winding round the lower border of the gluteus naximus, the gluteal cutaneous branches of the posterior cutaneous erve of thigh and the inferior gluteal artery, as well as the perforating utaneous branch from the sacral plexus, are to be seen.

The fossa is filled with loose fat, which also extends into the anterior nd posterior diverticula.

This fat is badly supplied with bloodvessels, and its vitality is therefore low. s a consequence, an ischio-rectal abscess is of not infrequent occurrence. When n abscess forms, the pus has a tendency to discharge itself in two directions—amely, through the skin forming the floor of the fossa, and through the wall of he anal canal about $\frac{1}{2}$ inch above the anus. If the discharge is effected in either r both of these two ways a *fistulo in ano* is the result.

The severe pain which accompanies an ischio-rectal abscess is due to pressure pon the following nerves: (1) the inferior hæmorrhoidal; (2) the two superficial erineal nerves; and (3) the gluteal cutaneous branches of the posterior cutaneous erve of thigh.

Uro-genital Division.

Superficial Fascia.—The superficial fascia resembles that over the ower part of the anterior wall of the abdomen in being divisible into wo layers, which are called the superficial layer and the deep layer.

The **superficial layer** contains a granular variety of fat which is n sharp contrast with the lobulated fat of the ischio-rectal division. When followed backwards it forms on either side the floor of the schio-rectal fossa. At the middle line it is continuous with the corre-sponding layer of the opposite side. Laterally it passes freely over the ischio-pubic ramus, and is continuous with the superficial fascia of the inner side of the thigh. Anteriorly it passes into the scrotum, where it joins the deep layer. The resultant fascia, now free from adipose tissue, contains involuntary muscular tissue, and forms the dartos muscle. The superficial layer represents the superficial fascia of the anterior abdominal wall.

The **deep layer (Fascia of Colles)** is membranous and strong.

Laterally it is attached to the anterior everted lip of the inner bord of the ischio-pubic ramus as far back as the ischial tuberosity, in mediately outside the attachment of the crus penis. *Medially* th fascia of one side is continuous with that of the other at the midd line. *Posteriorly* the fascia turns round the posterior border of eac superficial transverse perineal muscle, and joins the base of the perine membrane. *Anteriorly* it passes into the scrotum, where it joins th superficial layer, the two forming the dartos muscle.

The deep layer of superficial perineal fascia represents the dee fascia of the anterior abdominal wall. It forms in the erect positic the floor of a space called the **perineal pouch.** This pouch is partiall subdivided into two compartments by an incomplete septum, whic extends upwards from the deep or superior surface of the deep lay of superficial perineal fascia to be attached to the overlying perine membrane. This septum is only complete at the back; elsewhere is very imperfect.

When air is blown beneath the back part of the deep layer of supe ficial perineal fascia on one side of the middle line, the perineal pouc of that side and the corresponding half of the scrotum become di tended. As more air is blown in, the pouch of the opposite side an the corresponding half of the scrotum also become distended.

It is into the perineal pouch that urine is extravasated in rupture of the ureth in the perineum. In such cases the urine cannot pass into either ischio-rect fossa, its backward course being arrested at the posterior borders of the superfici transverse perineal muscles, where the deep layer of superficial perineal fascia, a whole, turns round to join the base of the perineal membrane. Neither ca the urine make its way down the inner side of the thigh, its passage in th direction being stopped at the ischio-pubic ramus, to which the deep layer c superficial perineal fascia is attached. The only course, therefore, which is ope to the extravasated urine is forwards into the scrotal wall and on to the peni in each case beneath the dartos muscle, whence it passes upwards along th spermatic cord to the anterior wall of the abdomen, in which situation it li beneath the deep fascia.

The deep layer of superficial perineal fascia covers the followin structures: the crura penis, covered by the ischio-cavernosus muscle the bulb of the penis, covered by the bulbo-spongiosus muscles; th superficial transverse perineal muscles; the superficial perineal vesse of each side; the two superficial perineal nerves and the long perine nerve; the terminal branches of the deep division of the perineal branc of the pudendal nerve to the superficial perineal muscles, the bul and urethra; the terminal branches of the dorsal penis branch of th pudendal nerve to the corpus cavernosum and penis; and the inferi layer of the perineal membrane.

Muscles—Transversus Perinæi Superficialis (Fig. 406)—*Origin.*— The ramus of the ischium superficial or deep to the ischio-cavernosus.

Insertion.—The perineal body.

Nerve-supply.—The deep division of the perineal branch of th pudendal nerve.

Action.—To draw back and fix the perineal body, and so to aid he action of the bulbo-spongiosus.

The muscle is directed obliquely inwards and forwards, being ccompanied by the transverse perineal artery, and being crossed uperficially or deeply by the superficial perineal nerves. It forms he base of a triangle, the other two sides being formed by the bulbo-pongiosus and ischio-cavernosus muscles.

Ischio-cavernosus (**Erector Penis**)—*Origin.*—(1) The inner aspect f the ischial tuberosity; and (2) the inner border of the ramus of the schium on either side of the crus penis.

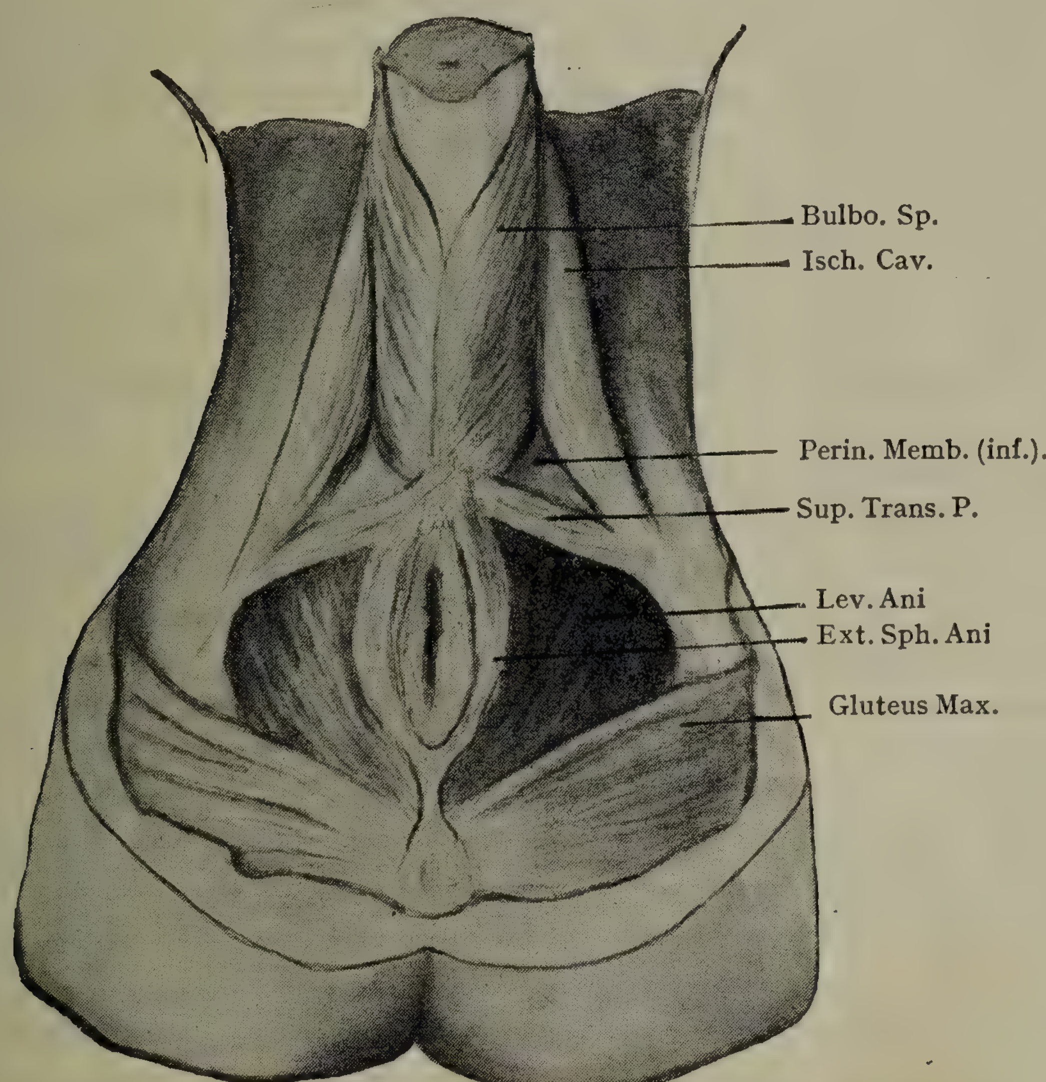


FIG. 406.—SUPERFICIAL DISSECTION TO SHOW PERINEAL MUSCLES AND ISCHIO-RECTAL FOSSA.

Insertion.—The under surface of the fibrous sheath of the crus enis in its front part, and the outer and upper surfaces of the fibrous heath of the corpus cavernosum penis, in which latter situation it is ontinuous with the fascial investment of the penis and with the uspensory ligament of that organ.

Nerve-supply.—The deep division of the perineal branch of the udendal nerve.

Action.—The muscle compresses the crus penis against the ischio-ubic ramus, and, by retarding the return of venous blood, it helps o maintain the penis in a state of erection. It also contributes to the naintenance of erection by compressing the dorsal vein of the penis.

The anterior and outer part of the muscle is sometimes detached, and form a separate muscle, called the **compressor venæ dorsalis penis.** This arises fro the descending ramus of the pubis, and terminates in an aponeurotic expansio which joins its fellow of the opposite side over the dorsal vein of the penis.

Bulbo-spongiosus (Fig. 406) (**Accelerator or Ejaculator Urinæ**)– *Origin.*—(1) The perineal body; and (2) the median raphé, which continued forwards from that point towards the symphysis pubis.

Insertion.—The muscle, as regards its insertion, is convenientl divided into three parts—namely, the chief part, the anterior par and the posterior part.

Chief Part.—The fibres of this part ascend between the crus pen and the side of the bulb, to be inserted into the median raphé on th upper surface of the bulb, where they meet the fibres of the corre sponding part of the opposite muscle.

Anterior Part.—The fibres of this part as they pass forward diverg in the form of a V and are inserted partly into the outer surface of th fibrous sheath of the corpus cavernosum penis in front of the ischic cavernosus, and partly by means of a tendinous expansion into th fascial investment of the penis, beneath which the dorsal vein of th penis lies; they are sometimes regarded as forming a separate muscle– the **constrictor radicis penis.**

Posterior Part.—The fibres of this, which is also the deepest par surround like a close-fitting cap the hemispheres of the bulb, and ar inserted into the dorsal surface of the bulb immediately in front o the point of entry of the urethra.

Nerve-supply.—The deep division of the perineal branch of th pudendal nerve.

Action.—(1) The chief part of the muscle, acting with its fellow compresses the bulb. These portions of the two muscles therefor come into play at the end of micturition, when they expel the las drops of urine from this part of the urethra. A further action is t contribute to the maintenance of erection of the penis by compressin the veins of the bulb. (2) The anterior part compresses the dorsa vein of the penis, and so contributes to the maintenance of erection (3) The posterior part, when in action, will compress not merely th hemispheres of the bulb and their bloodvessels, but also the urethr and the ducts of the bulbo-urethral glands.

The chief portions of the bulbo-spongiosus muscles complete surround the bulb, and may be regarded as forming a sphincter muscle

Sphincter (Compressor) Urethræ—*Origin.*—From the inner borde of the inferior ramus of the pubis, lying behind or above the inferio layer of the perineal membrane.

Insertion.—Near the middle line the muscle divides into two layers which, passing above and below the membranous part of the urethra are inserted into median raphés, thus constituting a sphincter muscle The lower layer, which is by far the better developed, ensheathe also the bulbo-urethral glands. The posterior fibres of the muscle which lie close to the base of the perineal membrane, are sometime

regarded as a separate muscle—the **deep transverse muscle of the perineum.**

Nerve-supply.—The dorsal nerve of the penis.

Action.—(1) To constrict the membranous part of the urethra. The muscle comes into play at the end of micturition, and assists the bulbo-spongiosus in emptying the urethral canal. (2) To contribute to the maintenance of erection of the penis by compressing the veins from the corpora cavernosa and bulb. (3) To compress the bulbo-urethral glands, and so aid in the expulsion of their secretion.

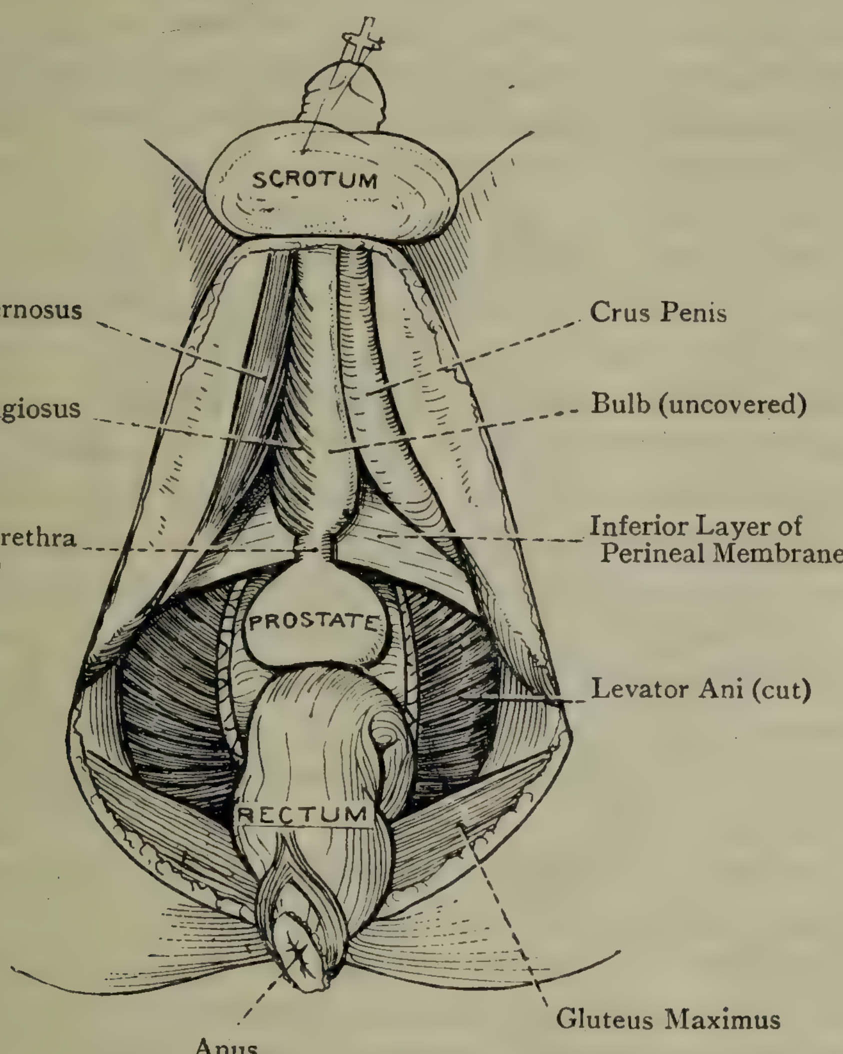


FIG. 407.—DEEP DISSECTION OF THE MALE PERINEUM.
The rectum has been turned back.

The sphincter urethræ muscle lies between the two layers of the perineal membrane. Close to its attachment to the ischio-pubic ramus it contains within its substance the internal pudendal vessels and the dorsal nerve of the penis.

Perineal Body (Central Tendinous Point).—Nearly 1 inch in front of the anus there is a short transverse tendinous septum about $\frac{1}{2}$ inch long. At its centre it presents a thickening, to which the name of *perineal body* is given. The muscles which meet at this point are as follows: (1) the sphincter ani externus, coming from behind; (2) the bulbo-spongiosus, coming from before; (3) the superficial transverse perineal muscles, coming from either side; and (4) the levatores ani, coming from above. The pointed process at the centre of the base

of the inferior layer of the perineal membrane is also attached to the perineal body.

Bulb of the Penis.—This is the first part of the corpus spongiosum penis, and is so named from its presenting a bulbous enlargement. It measures about 1½ inches in length, and about ¾ inch in breadth at its posterior part. Its posterior extremity rests upon the inferior layer of the perineal membrane, and extends as far back as the perineal body, where it lies nearly 1 inch in front of the anus. This part extends fully ¼ inch farther back than the bulbous part of the urethra. It here presents on its under surface, in the middle line, a faint groove indicative of its having been formed by the union of two symmetrical parts. The bulb is invested by a fibrous sheath derived from the circumference of the urethral opening in the inferior layer of the perineal membrane, superficial to which lie fibres of the bulbo-spongiosus muscles. Each lateral wall of the bulb is pierced by the duct of the bulbo-urethral gland, which opens on either side of the middle line upon the floor of the bulbous part of the urethra fully 1 inch in front of the inferior layer of the perineal membrane.

Crus Penis (Crus Corporis Cavernosi Penis).—This is the posterior attached portion of the corpus cavernosum penis. It occupies and is attached to a broad groove which, beginning near the ischial tuberosity, winds spirally round the inner border of the ischio-pubic ramus superficial to the inferior layer of the perineal membrane. Inferiorly and laterally it is covered by the ischio-cavernosus and lies beneath the deep layer of superficial perineal fascia. The deep artery of the penis, having pierced the inferior layer of the perineal membrane, enters the deep surface of the crus, to be continued forwards in the centre of the corpus cavernosum.

Deep Perineal Triangle—Boundaries—*Lateral.*—The crus penis covered by the ischio-cavernosus muscle. *Medial.*—The bulb of the penis, covered by the bulbo-spongiosus muscle. *Posterior*, or *Base.*—The superficial transverse perineal muscle. The *floor* is formed by the deep layer of superficial perineal fascia, with the superficial perineal vessels and nerves. In the undisturbed position of the parts the area of the triangle is concealed by the approximation of the bulbo-spongiosus and ischio-cavernosus muscles. When, however, these muscles are held apart there is seen lying deeply in the area the inferior layer of the perineal membrane.

Inferior Ligament of Symphysis Pubis (Arcuate Ligament).—This is a thick band which lies at the antero-superior part of the pubic arch. It is attached superiorly to the lower part of the fibro-cartilaginous disc, and laterally to the adjacent parts of the inner lips of the inferior pubic rami. It is about ¼ inch in depth, and is slightly arched.

Transverse Ligament of Perineum.—This band extends transversely between the inferior pubic rami two or three lines below the inferior ligament of symphysis. Inferiorly it is closely connected with the truncated apex of the inferior layer of the perineal membrane. Be-

:ween its upper border and the inferior ligament there is the opening or the backward passage of the dorsal vein of the penis.

Perineal Membrane (Triangular Ligament) (Fig. 408).—This ligament ›ccupies the pubic arch, which it fills, except at its antero-superior part, vhere it is replaced by the inferior and transverse perineal ligaments. :t is composed of two distinct layers, called inferior (perineal) and ;uperior (pelvic). These two layers are united by their bases, but :lsewhere they are separated by an interval of about ½ inch, in which he membranous part of the urethra in the male, and the vagina and ırethra in the female, along with other structures to be presently :numerated, lie.

The **inferior layer** is also called the **deep perineal fascia.** It is riangular, the apex being truncated. The *apex* is closely connected

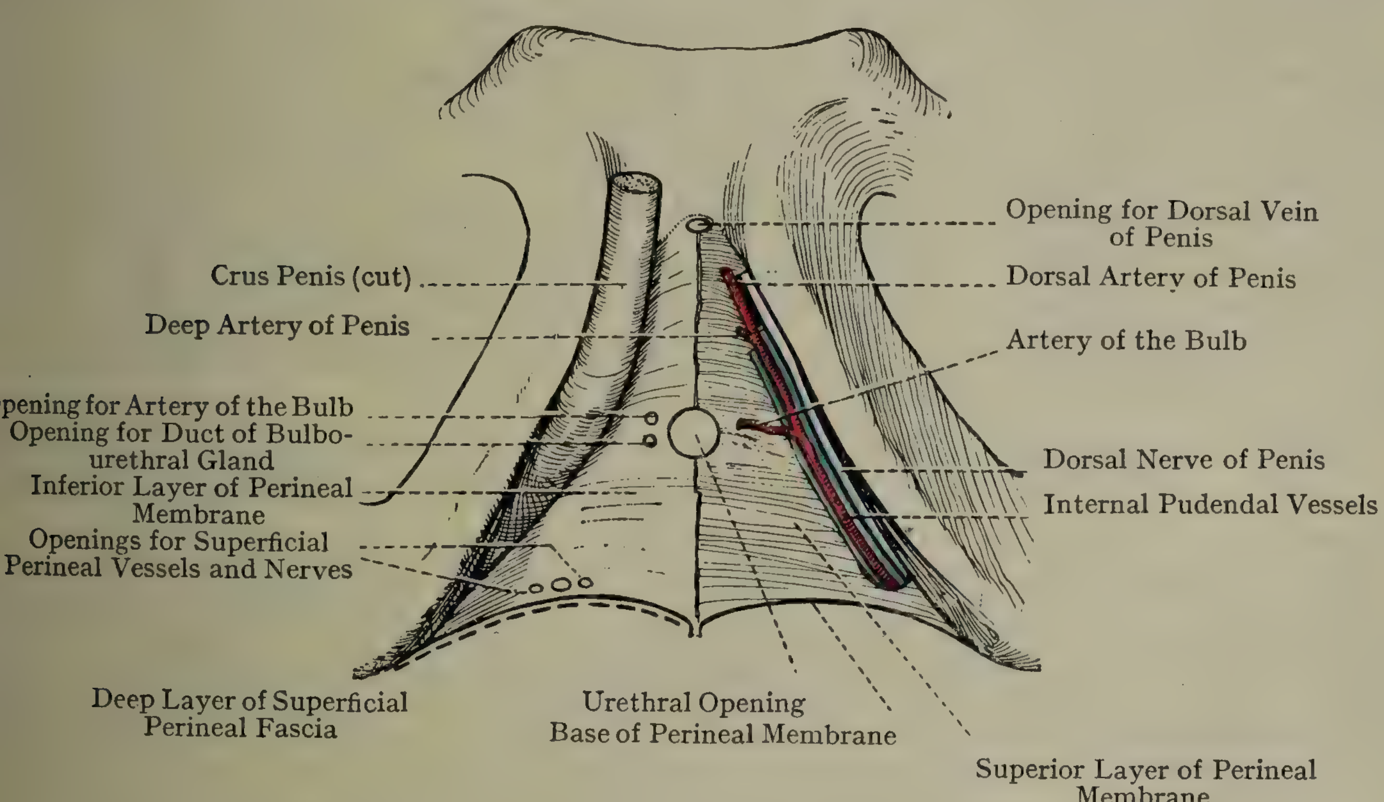


FIG. 408.—THE PERINEAL MEMBRANE.
The antero-inferior layer has been removed on the left side.

vith the transverse perineal ligament, which may be regarded as a ›art of it. Each *lateral margin* is attached behind or to the posterior :dge of the inner border of the ischio-pubic ramus, on which it extends ıs far back as the ischial tuberosity, lying between the attachments ›f the crus penis and ischio-cavernosus anteriorly and the sphincter ırethræ posteriorly. In this direction it measures fully 2 inches. The *base* is directed downwards and backwards, and is joined by the ›ase of the postero-superior layer and the deep layer of superficial ›erineal fascia. In the middle line the base is projected into a slight ›rocess, which is connected with the perineal body. On either side of his median process the base presents a concave margin where it sweeps lownwards and outwards to the ischial tuberosity. The length of the nferior layer in the middle line is about 1½ inches. Its fibres are :hiefly disposed transversely. The structures which pierce this layer

are as follows: the urethra, the arteries of the bulb, the deep arteries of the penis, the dorsal arteries and the dorsal nerves of the penis, the superficial perineal vessels and nerves, and the ducts of the bulbo-urethral glands.

Urethral Opening.—This aperture is situated in the middle line fully 1 inch below the pubic angle. From the circumference of the opening an extension is given off, which forms a fascial investment for the bulb.

Openings for the Arteries of the Bulb.—These are situated one on either side of the urethral opening.

Openings for the Deep Arteries of the Penis.—These are found near the lateral attached border, under cover of the crus penis, about 1 inch below the level of the pubic angle.

Openings for the Dorsal Arteries and Nerves of the Penis.—These are two in number on either side, and are situated far forward, near the pubic angle, and close to the inferior pubic ramus, the opening for the artery being medial to that for the nerve. It is to be noted that the dorsal vein of the penis has a special opening, which is situated in the median line between the inferior and transverse perineal ligaments.

Openings for the Superficial Perineal Vessels and Nerves.—These are situated on either side, in the base at the line of junction with the deep layer of superficial perineal fascia.

Openings for the Ducts of the Bulbo-urethral Glands.—Each of these is situated on either side of the urethral aperture a little behind and below the opening for the artery of the bulb.

Chief Relations—*Antero-inferior.*—The bulb of the penis and the crura penis, covered by their respective muscles, the superficial transverse perineal muscles, and the deep layer of superficial perineal fascia. *Postero-superior.*—The membranous part of the urethra, the bulbo-urethral glands, and the sphincter urethræ muscle.

The **superior layer** is weak, and is formed by the parietal pelvic fascia. It lies about $\frac{1}{2}$ inch above and behind the inferior layer, and extends inwards to the urethra from the back of each ischio-pubic ramus, where it lies behind the sphincter urethræ muscle. Anteriorly it blends with the sheath of the prostate posteriorly; its base joins that of the inferior layer. At each ischio-pubic ramus it is continuous with the parietal pelvic fascia. When it arrives at the urethra it changes its course, and passes backwards over the anterior border of the levator ani muscle to blend with that portion of the visceral pelvic fascia which ensheathes the prostate gland. Antero-inferiorly it is in contact with the membranous part of the urethra and sphincter urethræ muscle, whilst postero-superiorly it is related to the anterior fibres of the levator ani of each side, and forms the floor of the anterior diverticulum of the ischio-rectal fossa. The structures which pierce this layer are as follows: the urethra in the male, and the vagina and urethra in the female; and the internal pudendal vessels and dorsal nerves of the penis.

Urethral Opening.—This is often a mere cleft, in which case the superior layer may be described as being arranged in two symmetrical

halves. At this opening or cleft it becomes continuous superiorly with the capsule of the prostate gland.

Openings for the Internal Pudendal Vessels and Dorsal Nerves of the Penis.—These are situated close to the base, on either side, near the ischial ramus.

Much of the difficulty which the student experiences in understanding the anatomy of the perineum is due to the fasciæ or so-called ligaments which divide the region into compartments. These fasciæ are to be regarded as due to the strain thrown upon the connective tissue which everywhere surrounds here, as elsewhere, muscles, blood-vessels, glands, and other structures. In the perineum the connective tissue is particularly exposed to strain owing to its position and the support which it is called upon to give to various structures, some of which pass through it, and several of which are subject to considerable variations in size. Naturally individual differences are met not merely in the development of these fasciæ, but also in the relation which they bear to the vessels and nerves. The student is advised to obtain a clear general idea of the course of the various vessels and nerves, and of their respective branches, and to remember that they are but little, if at all, deflected from a direct course to their destination.

Structures between the Layers of the Perineal Membrane.—These are as follows:

1. The membranous portion of the urethra in great part.
2. The bulbo-urethral glands.
3. The sphincter urethræ muscle.
4. The internal pudendal arteries, each lying close to the ischio-pubic ramus in the sphincter urethræ muscle, and each giving off the following branches: (*a*) the artery of the bulb, which in turn gives off the artery to Cowper's gland; (*b*) the deep artery of the penis; and (*c*) the dorsal artery of the penis.
5. A plexus of veins which receives its tributaries from the crus (corpus cavernosum) and bulb, and in which the internal pudendal venæ comites take their origin.
6. The deep lymphatics of the penis and urethra.
7. The dorsal nerves of the penis, each of which lies lateral to the corresponding internal pudendal artery.

Bulbo-urethral Glands (Cowper's).—These glands are two in number, right and left. They are situated between the two layers of the perineal membrane, where they lie above the bulb and behind the membranous portion of the urethra, one on either side of the median line. Each gland is a firm, round, and lobulated mass about the size of a small pea. Both glands are ensheathed by the lower layer of the sphincter urethræ muscle, and within this there is the special fibrous capsule which has an admixture of plain muscular tissue. The glands belong to the class of racemose or acino-tubular glands, and each is composed of several lobules. The alveoli or acini are lined with columnar cells. The ducts are two in number, right and left. They are lined with cubical epithelium, and their walls contain plain muscular tissue.

Each duct pierces the inferior layer of the perineal membrane on either side of the urethral opening a little behind and below the artery of the bulb. The duct then pierces the side of the bulb, and opens upon the floor of the bulbous part of the urethra fully 1 inch in front of the inferior layer of the perineal membrane. Each gland receives a branch from the artery of the bulb.

The bulbo-urethral glands are developed from the epithelial lining of the urogenital sinus.

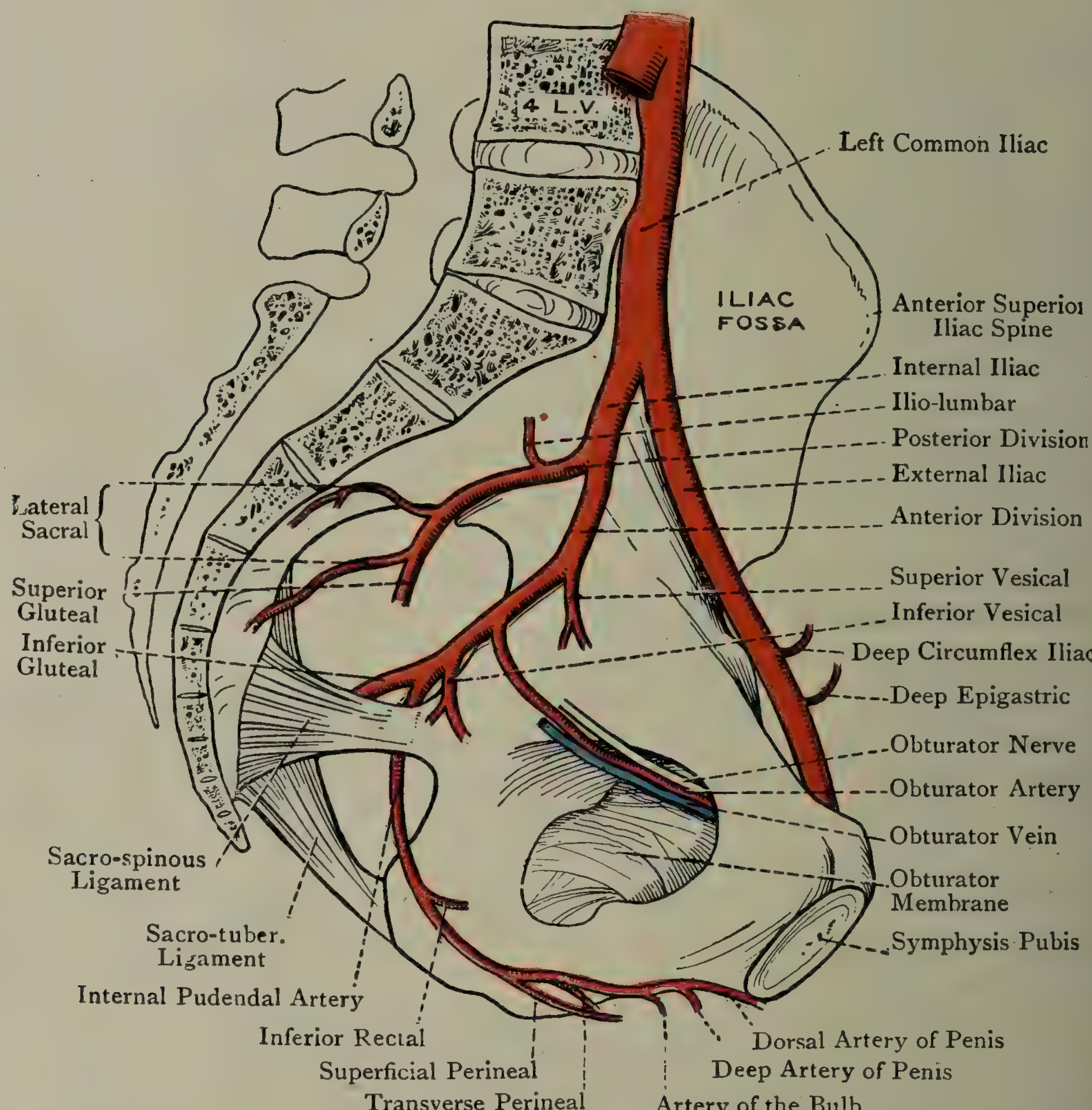


Fig. 409.—Plan of Left Internal Iliac Artery.

Internal Pudendal Artery.—This vessel is one of the terminal branches of the anterior division of the internal iliac, the other and larger terminal branch being the inferior gluteal. Lying at first within the pelvis, the artery passes downwards over the pyriformis muscle and sacral nerves, having the inferior gluteal artery usually behind it, and it emerges from the cavity through the lower compartment of the greater sciatic foramen. It then crosses the back of the spine of the ischium, after which it passes through the lesser sciatic foramen, and so enters the ischio-rectal division of the perineum. The vessel now courses along the outer wall of the ischio-rectal fossa,

'here, contained in the pudendal canal, it lies about $1\frac{1}{2}$ inches above he lower part of the ischial tuberosity. On approaching the anterior art of the fossa the artery gradually becomes more superficial, and, fter leaving the fossa, it enters the interspace between the two ıyers of the perineal membrane by piercing the superior layer close ɔ its base and near the ischial ramus. It now passes forwards and pwards, embedded in the sphincter urethræ muscle, and lying close ɔ the ischio-pubic ramus, where it is comparatively superficial. Iaving given off the artery of the bulb about $\frac{1}{2}$ inch above the base of he perineal membrane, the vessel finally divides, about 1 inch below he subpubic angle, into its two terminal branches, the deep and dorsal rteries of the penis.

In considering the relations and branches of the internal pudendal rtery it is convenient to divide the vessel into four parts—first, second, hird, and fourth.

The **first part** represents the intrapelvic portion of the vessel, and 'ill be found described on p. 925.

The **second part** is the portion of the vessel which lies upon the ack of the spine of the ischium. For a description of it see p. 539.

The **third part** is the part of the vessel which lies on the outer 'all of the ischio-rectal fossa. It is here contained in the pudendal anal, and is situated about $1\frac{1}{2}$ inches above the lower part of the schial tuberosity. For its relation see the pudendal canal.

Branches.—These are as follows: the inferior rectal, the superficial erineal, and the transverse perineal.

The **inferior rectal (hæmorrhoidal) artery** arises, either singly or ı two or three branches, from the internal pudendal immediately after : has taken up its position in the pudendal canal. The branches pass ıwards to the anal canal through the loose fat which fills the ischio-ectal fossa. They are distributed to the external sphincter, levator ni, wall of the anal canal, and superficial structures of the ischio-ectal division of the perineum, and they anastomose with the middle nd superior rectal arteries and the inferior rectal branches of the pposite side.

The **superficial perineal artery** arises from the internal pudendal at he anterior part of the ischio-rectal fossa. It pierces the base of he inferior layer of the perineal membrane, and passes superficial ɔ (sometimes on the deep surface of) the superficial transverse perineal ıuscle. Its subsequent course is forwards under cover of the deep ıyer of superficial perineal fascia, on the floor of the deep perineal riangle, in company with the superficial perineal nerves. On approach-ıg the scrotum it divides into several long slender branches, which upply the back of the scrotum and anastomose with the external udendal branches of the femoral artery.

The **transverse perineal artery,** as a rule, arises in common with he superficial perineal, of which it is sometimes regarded as a branch. t may, however, arise directly from the internal pudendal immediately ı front of the origin of the superficial perineal. It is directed inwards

and forwards to the perineal body, lying superficial to the superfici transverse perineal muscle, and beneath the deep layer of superfici perineal fascia. It supplies the muscles which meet at the perine body, and anastomoses with its fellow of the opposite side.

The Pudendal (Alcock's) Canal.—This canal is situated in the out wall of the ischio-rectal fossa, and is formed by the obturator fasci Its contents from below upwards are as follows: (1) the perineal divisic of the pudendal nerve; (2) the third part of the internal pudendal arte with its venæ comites; and (3) the dorsal nerve of the penis.

The **fourth part** of the internal pudendal artery lies between tl two layers of the perineal membrane. It enters this interspace b piercing the superior layer of that membrane close to its base ar near the ischial ramus. It is embedded in the sphincter urethr muscle, and is comparatively superficial. As it lies near the ischi pubic ramus it has a vena comes on either side of it, and the dors nerve of the penis is lateral to it.

Branches.—These are as follows: the artery of the bulb, the dee artery of the penis, and the dorsal artery of the penis.

The **artery of the bulb** arises from the internal pudendal about ½ inc above the base of the perineal membrane, and passes transversel inwards in the substance of the sphincter urethræ muscle. On ap proaching the urethra it turns forwards, and, having pierced tl sphincter urethræ, it passes through an opening in the inferior lay of the perineal membrane at the side of the urethral aperture. then enters the bulb, and is continued onwards in the corpus spo giosum as far as the glans penis, the erectile tissue of which parts supplies. It anastomoses with its fellow of the opposite side and wit the dorsal arteries of the penis; whilst between the two layers of tl perineal membrane the artery furnishes a branch to the bulbo-urethr gland of the corresponding side.

The **deep artery of the penis** is one of the two terminal branches the internal pudendal, and is somewhat larger than the dorsal arter of the penis, which is the other terminal branch. It arises abou 1 inch below the subpubic angle, and piercing the sphincter urethr muscle and the inferior layer of the perineal membrane close to th ischio-pubic ramus, enters the crus on its inner surface. Giving a fe branches backwards, it is continued forwards in the centre of the corpu cavernosum as far as the distal end of that body, the erectile tissue which it supplies.

The **dorsal artery of the penis** is the continuation of the intern pudendal. For a very short distance it lies between the two laye of the perineal membrane embedded in the sphincter urethræ muscl Piercing this muscle and the inferior layer of the membrane near it upper part, it ascends between the crus and the symphysis pubi Its subsequent course is between the two layers of the suspensor ligament of the penis, and then along the dorsum of the organ, wher it has the centrally-placed dorsal vein on its inner side and the dors nerve of the penis on its outer. On arriving at the neck of the peni

ends in branches for the supply of the glans and prepuce, anastomosing th its fellow of the opposite side and the arteries of the bulb. In its urse along the dorsum of the penis the artery gives off many branches, me of which supply the skin and anastomose with the superficial ternal pudendal of the femoral, while others pierce the fibrous sheath the corpus cavernosum to supply its erectile tissue, these latter iastomosing with the deep artery of the penis.

Varieties of the Internal Pudendal Artery—1. **Trunk.**—The vessel is occasionly of small size, and may terminate in the artery of the bulb, or in the superial perineal artery. In these cases an **accessory pudendal artery** is present, iich supplies the deficiencies. This vessel usually arises from the first or trapelvic part of the internal pudendal, though it may spring from an inferior sical artery. Its course is forwards along the side of the bladder, then along e side of the prostate gland to the perineal membrane, which it pierces above e membranous part of the canal, and so reaches the root of the penis. The cessory pudendal furnishes the deep artery of the penis and the dorsal artery of e penis, and in some cases the artery of the bulb.

2. **Artery of the Bulb.**—Sometimes two arteries are present on one side; metimes the artery is absent on one side; and sometimes it is of very small ze. A much more important variety of this artery affects its origin. It may ise from the third part, at the front of the ischio-rectal fossa, reaching the bulb om behind. In these cases the artery cannot escape division in the operation lateral lithotomy. In other cases it may arise from an accessory pudendal tery, when it will lie farther forwards than usual.

3. **Dorsal Artery of the Penis.**—This vessel may arise from the obturator tery in the obturator canal, or from one of the external pudendal branches of e femoral artery.

Veins.—Lying in each sphincter urethræ muscle there is a plexus veins, which receives its tributaries from the corresponding corpus ivernosum and one half of the corpus spongiosum and bulb. The **tternal pudendal venæ comites** arise on either side from this plexus, id accompany the internal pudendal artery as far back as the upper order of the spine of the ischium, one lying on either side of the essel. Here they join to form one trunk, which enters the pelvis irough the lower compartment of the greater sciatic foramen, and rminates in the internal iliac vein. They receive as tributaries the ansverse perineal, superficial perineal, and inferior rectal veins, as ell as a few veins from the gluteus maximus and lateral rotator muscles. he **inferior rectal (hæmorrhoidal) veins** take their origin in a plexus f veins which is situated immediately underneath the mucous memrane of the anal canal. Having pierced the external sphincter muscle, iey cross the ischio-rectal fossa through its loose fat and, being ultiiately reduced to two or three in number, join the internal pudendal enæ comites.

It is to be noted that, though there are two dorsal arteries, there only one dorsal vein, which takes the following course: after leaving ie dorsum of the penis it passes through an opening between the inrior and transverse perineal ligaments, where it communicates on ither side with the venous plexuses from which the internal pudendal eins take their origin. Having entered the cavity of the pelvis, it

divides into two branches, right and left, which join the prostat plexus of veins.

Lymphatics.—The **superficial lymphatics** of the perineum, includi those of the anus, pass to the superficial *inguinal glands*, which l immediately below the inguinal ligament, while the **deep lymphati** accompany the internal pudendal vessels through the ischio-rectal fos and buttock into the pelvis and pass to the *internal iliac glands*.

Pudendal Nerve.—The pudendal nerve is one of the termin branches of the sacral plexus, and derives its fibres from the ventr division of the second, the lower branch of the third, and the upp

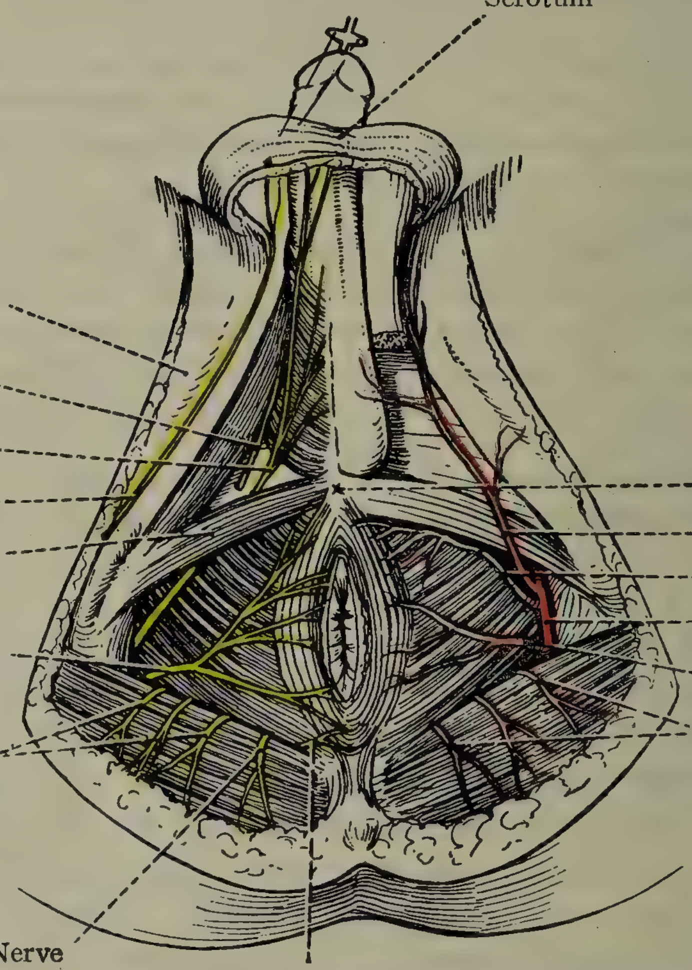


FIG. 410.—DISSECTION OF THE MALE PERINEUM.

On the left side the bulbo-spongiosus has been removed and the crus penis cut.

branch of the fourth sacral nerves, the majority of its fibres bein derived from the lower branch of the third. Leaving the pelvi through the lower compartment of the greater sciatic foramen, th nerve crosses the sacro-spinous ligament near its attachment to th spine of the ischium, lying under cover of the gluteus maximus an on the inner side of the internal pudendal vessels. It then passe through the lesser sciatic foramen, and so enters the pudendal cana in the outer wall of the ischio-rectal fossa. Immediately after doin so, it divides into three branches—namely, inferior hæmorrhoidal perineal, and dorsal nerve of the penis.

The **inferior hæmorrhoidal nerve,** which may have an independent -igin from the sacral plexus, passes inwards across the ischio-rectal ›ssa to the region of the anus, and is distributed to the external ›hincter muscle and the skin around the anus.

The **perineal nerve** is a large branch which passes forwards in the udendal canal, being the lowest of its contents. It ultimately divides ıto superficial and deep branches.

The *superficial branches* are two in number, and are called the *ıteral* and *medial scrotal nerves.* Both nerves, having emerged from ıe pudendal canal into the ischio-rectal fossa, pass forwards and ierce the base of the inferior layer of the perineal membrane. They ıen run forwards with the superficial perineal artery under cover of ıe deep layer of superficial perineal fascia, and on approaching ıe back of the scrotum they divide into long slender cutaneous ranches.

In the anterior division of the perineum the two superficial perineal erves communicate freely, and are accompanied by the **long perineal erve** (of Soemmering), which is a branch of the posterior cutaneous erve of the thigh. This nerve, having pierced the fascia lata about inch in front of the ischial tuberosity, passes inwards over the ischio-ubic ramus and through the deep layer of superficial perineal fascia. t then runs forwards and inwards beneath this fascia to the scrotum, ying on the ischio-cavernosus muscle, close to the ischio-pubic ramus, upplying the skin of the scrotum, and communicating with the ateral posterior scrotal nerve.

The *deep branch of the perineal nerve* furnishes offsets which, with ›ne exception, are muscular in their distribution, and supply the ınterior part of the external sphincter, the anterior part of the levator ıni, the superficial transverse perineal, the ischio-cavernosus, and the ›ulbo-spongiosus. The non-muscular branch, called the nerve of the ›ulb, pierces the bulbo-spongiosus muscle and the wall of the bulb, o be distributed to the erectile tissue of the corpus spongiosum and he mucous membrane of the spongy part of the urethra.

The **dorsal nerve of the penis** is at first contained in the pudendal anal, where it lies above the internal pudendal vessels. Having merged from that canal, it pierces the superior layer of the perineal nembrane near its base. It then passes forwards and upwards, with he fourth part of the internal pudendal artery, between the two ayers of the perineal membrane, in which situation it lies on the outer ide of the internal pudendal vessels, and close to the ischio-pubic ramus, being embedded in the sphincter urethræ muscle. Its subsequent course is similar to that of the dorsal artery of the penis, which it accompanies. On the dorsum of the penis, where it lies lateral to the dorsal artery, it is continued as far as the glans, where it ends in branches for the glans and prepuce. As the nerve lies between the two layers of the perineal membrane, it gives branches to the sphincter urethræ muscle, and it also furnishes the nerve of the corpus cavernosum. This latter nerve, having pierced the sphincter urethræ and

inferior layer of the perineal membrane, enters the crus and is continue forwards in the corpus cavernosum to supply its erectile tissue. A the nerve passes along the dorsum of the penis, it supplies numerou cutaneous branches.

Structures divided in Left Lateral Lithotomy.—The structures divided in th operation are as follows: (1) the skin; (2) the subcutaneous layer of the super ficial fascia; (3) the deep layer of the superficial fascia or the fascia of Colles (4) the transverse perineal vessels; (5) the superficial transverse perineal muscle (6) the inferior hæmorrhoidal nerve and the inferior rectal vessels; (7) the basa part of the inferior layer of the perineal membrane; (8) the sphincter urethr muscle and the plexus of veins embedded in it; (9) the membranous part of th urethra; (10) the superior layer of the perineal membrane; (11) the anterior fibre of the levator ani muscle; (12) a portion of the left lateral lobe of the prostat gland, with its capsule and some of the veins of the prostatic plexus; and (13) th prostatic urethra.

Structures to be avoided.—The structures to be avoided are as follows: (1) th rectum; (2) the internal pudendal vessels as they lie in the pudendal canal (3) the artery of the bulb; and (4) the common ejaculatory duct.

FEMALE PERINEUM.

The female perineum is divided into three regions—uro-genita perineum proper (as defined by the obstetrician), and anal. The uro genital division is situated at the anterior part, and comprises th pudendum and uro-genital cleft. The perineum proper is situate between the posterior part of the uro-genital cleft and the anus. Th anal division is situated as in the male.

Uro-genital Division.

The uro-genital division contains the external uro-genital organs These collectively constitute the *pudendum muliebre* or **vulva,** an comprise the following parts: the mons pubis; labia majora; labi minora; clitoris; vestibule; external urethral orifice; vaginal orifice including the hymen of the carunculæ hymenales; frænulum pudendi vestibular fossa; bulbs of the vestibule; and the greater vestibula glands.

The **mons pubis (Veneris)** is an eminence situated in front of an above the upper part of the symphysis pubis. It is produced by a collection of adipose tissue, the skin over which is more or less freel provided with hair after the age of puberty.

The **labia majora** are two thick, round folds of skin, which ar directed from before backwards, with a slight inclination downwards The length of each is about 3 inches. Posteriorly they become thin and fading away lose themselves in the anterior part of the perineum proper, about 1 inch in front of the anus. The junction to which th name of the **posterior commissure** has been given is of rare occurrence Anteriorly they retain their thick, round character, and become con tinuous with the mons pubis, forming the so-called **anterior com missure.** Each labium majus has two surfaces, outer and inner. Th

kin covering the outer convex surface is somewhat dark in colour, ke that of the scrotum, and contains numerous sebaceous glands of rge size. It is also more or less freely provided with hair after the ge of puberty, except towards the posterior part. The inner flat urface forms the lateral boundary of the uro-genital cleft, and touches hat of the opposite side. The skin covering this surface is smooth nd free from hair, and presents the openings of the ducts of sebaceous lands. Each labium majus contains adipose and areolar tissues, and small amount of dartos tissue. The ligamentum teres uteri of each ide loses itself in this labium, and superficial and deep fasciæ from he lower part of the anterior abdominal wall also enter it. The ssure between these labia is called the **uro-genital cleft (rima pudendi)**, nd is almost horizontal, its direction being antero-posterior. The

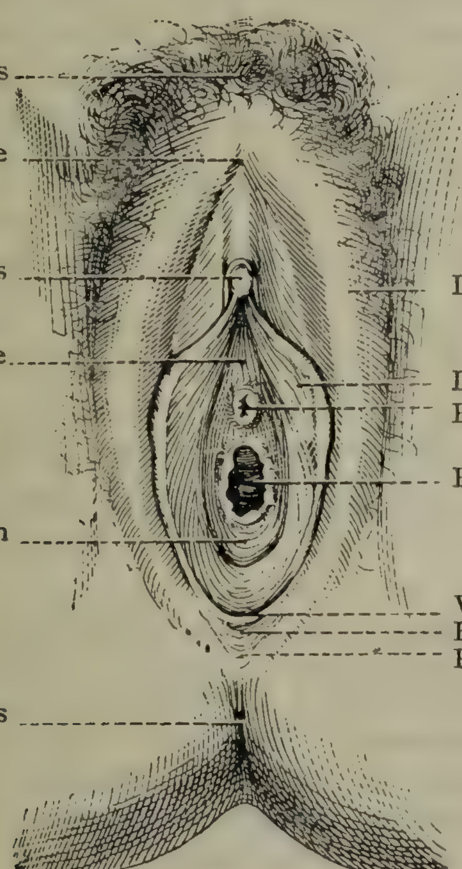


FIG. 411.—THE EXTERNAL GENITAL ORGANS OF THE FEMALE.

lood-supply and nerve-supply of the labia majora correspond with hose of the scrotum.

The *lymphatics* arise from a rich network in each labium majus, these net-orks being connected with each other across the median line. The *efferent* essels pass to the superficial *inguinal glands*. Some vessels are said to cross he median line and terminate in the glands of the opposite side.

The **labia minora (nymphæ)** are two narrow, more or less pendulous olds of integument, which are situated in the uro-genital space, each ying internal to the corresponding labium majus. They become con-inuous with each other anteriorly, in the region of the clitoris, a hort distance from the anterior commissure, in a manner to be presently lescribed. From this point they diverge as they pass backwards, and o form the lateral boundaries of the space called the vestibule. Each

terminates posteriorly by blending with the inner surface of the corre sponding labium majus, or in some cases by becoming continuous wit its fellow, forming the frenulum labiorum. Each labium minus ha two surfaces, outer and inner, and two borders, superior and inferio The outer surface is in contact with the inner surface of the labiur majus of the same side, and the inner surface touches that of the oppo site labium minus. Each surface is covered by a modified form of skir that on the inner surface being extremely delicate, and being some what like mucous membrane. The true mucous membrane, howeve only commences at the inner side of the base or superior attache border of the labium minus. The labia minora, previous to thei union anteriorly, divide each into two laminæ. The upper and large lamina passes over the clitoris, and becomes continuous with that c the opposite side, thus forming a cap for that organ, called the **prepuc of clitoris.** The lower and smaller lamina passes below the clitori where it also becomes continuous with that of the opposite side. A the line of junction of the two lower laminæ they are attached to th under surface of the clitoris, thus forming the **frenulum of clitori** The labia minora are destitute of both hair and fat, but they contai sebaceous glands. They sometimes attain a large degree of develop ment, in which cases they project through the uro-genital cleft. I some African women they become so much developed as to reach dow to the knees. When this occurs they form what has been called th Hottentot apron. The labia minora are homologous with the floo of the spongy part of the urethra, the skin of the penis, and the prepuc in the male.

Development of the Labia.—The opening of the uro-genital sinus extend ventrally on to the base of the *genital eminence*. The opening is bordered by th **labio-scrotal folds,** which also extend to the eminence. These folds, enlargin slightly, become the **labia minora;** the labia minora thus extend to the lowe aspect of the eminence, which becomes the **clitoris.** The **labia majora** are modi fications of the **genital swellings,** which *in the male* become the *scrotum*. Th fusion of the labio-scrotal folds in the male converts what is, in the female, th vestibule of the vulva into the *spongy urethra,* and the laterally placed genit swellings, meeting over the closed folds, constitute the scrotum.

The **clitoris** is situated in the uro-genital cleft a little behind th anterior commissure, and is composed of two corpora cavernosa an a glans. Each **corpus cavernosum** occupies, by means of a *crus*, groove which winds spirally round the inner border of the ischio-pubi ramus, the crus being covered by the ischio-cavernosus or erecto clitoridis muscle, and lying superficial to the inferior layer of th perineal membrane. The two corpora cavernosa unite by their inne flattened surfaces, and so form the body of the clitoris, which is abou $1\frac{1}{2}$ inches long. The septum, which is interposed at the line of junctio of the corpora cavernosa, is interrupted by vertical clefts, and is calle the *commissure of bulb* (septum pectiniforme). The dorsal surface o the clitoris at its upper end is attached to the front of the symphysi pubis by a small suspensory ligament, and the distal end of the orga

; capped by an imperforate glans. The *glans*, which caps the corpora avernosa, is composed of erectile tissue, and is extremely sensitive. t is provided with a prepuce and a frenulum, both of which are continous with the labia minora. The organ is composed of erectile tissue.

The clitoris is the homologue of the penis, from which it differs in he following respects: (1) the only part of a corpus spongiosum which : possesses is the glans (the part of the corpus spongiosum of the male which lies between the bulb and the glans penis being represented in he female by the *pars intermedia* of the bulb of the vestibule; (2) it oes not contain the female urethra; and (3) its component parts are nuch smaller than those of the penis. In reality the clitoris is a liminutive penis, minus the corpus spongiosum and the urethra. It is leveloped from the **genital eminence.**

Lymphatics.—The lymphatics of the *prepuce* of the clitoris accompany those of the labia majora, and pass to the superficial *inguinal glands.*

The lymphatics of the *glans clitoridis* run on the dorsum of the clitoris towards he front of the symphysis pubis, where they form a network. The vessels which emerge from either side of this network have the following destinations: 1) Some pass to the *deep inguinal glands,* and thence through the femoral canal o the *internal chain* of the *external iliac glands*; and (2) others traverse the nguinal canal and terminate in the *lowest gland* of the *outer chain* of the *external liac glands.*

The lymphatics of the *corpora cavernosa* pass to the *internal iliac glands* on either side.

The **vestibule** is the space which is enclosed by the labia minora, and s so called because it is the ' porch ' of the vagina. It is triangular, the apex, which is in front, being formed by the glans clitoridis, the lateral boundaries by the labia minora, and the base by the frenulum labiorum. It is 2 inches or more in length, and presents a smooth surface covered by a mucous membrane of stratified squamous epithelium. Half-way along the vestibule in the middle line, and immediately in front of the external orifice of the vagina, is a slight prominence with somewhat irregular margins. Upon this prominence the **external urethral orifice** is situated at a point 1 inch behind the clitoris. The irregular prominence serves as a guide to this opening.

The vestibule represents the remains of the uro-genital sinus.

The **external orifice of the vagina** is an antero-posterior cleft, having an elliptical shape when partially dilated. The portion of the vagina close above it is the narrowest part of the passage. For the description of the vagina, see Female Pelvis.

The **hymen** in its normal condition is a thin semilunar fold of mucous membrane which is stretched across the posterior third, or half, of the external orifice of the vagina. Its concave border, which is free, is directed forwards and upwards. Sometimes the hymen completely surrounds the circumference of the orifice, an aperture being left in its centre. In other cases it stretches over the entire opening, but is perforated by apertures which give it a cribriform appearance. In rare cases it is an entire membrane, completely shutting off the vaginal canal from the uro-genital cleft, and it is then spoken of as an

imperforate hymen. In some cases, even in the virgin, it is entire absent.

The hymen begins to appear about the fifth month of intra-uterine life a fold of mucous membrane at the point where the vagina opens into the u genital sinus.

The **carunculæ hymenales (myrtiformes)** are small elevations whi represent the remains of the hymen after its rupture. Though call *carunculæ* (fleshy), they are really mucous excrescences.

The **frenulum labiorum (fourchette)** is a crescentic fold formed the union posteriorly of the two labia minora. It is not always reco nizable, and is best marked in early life.

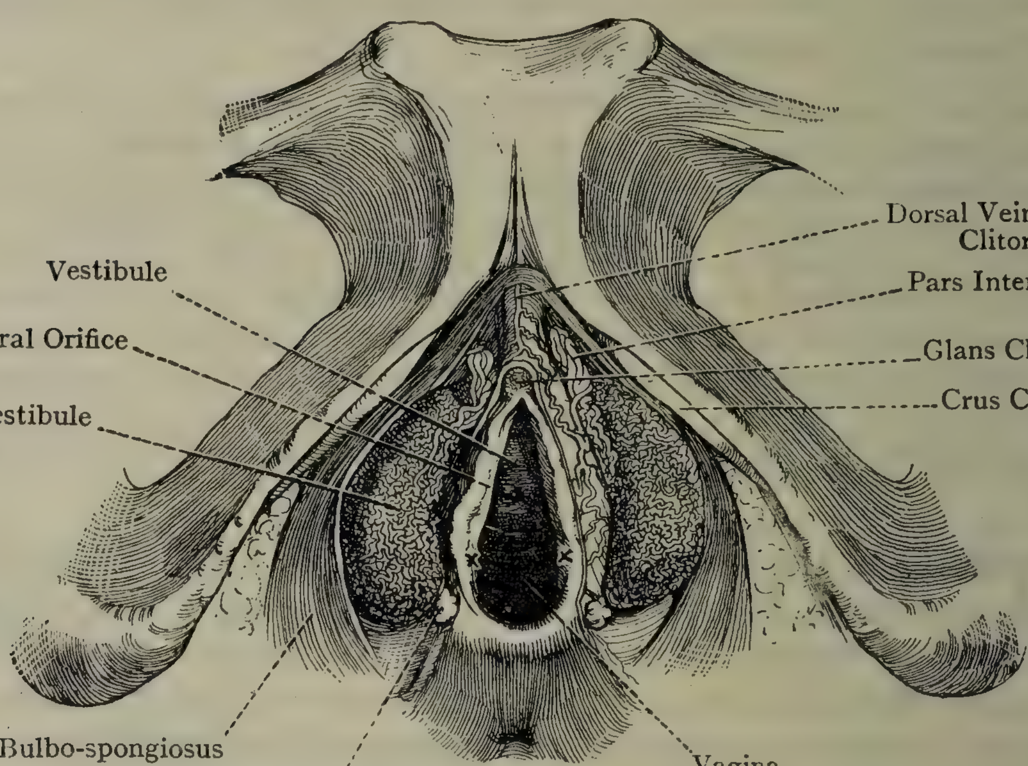


FIG. 412.—DISSECTION SHOWING THE BULBS OF VESTIBULE AND GREATER VESTIBULAR GLANDS (MODIFIED FROM KOBELT).

The cross on either side of the vaginal orifice shows the position of the opening of the duct of the greater vestibular gland.

The **vestibular fossa (navicularis)** is a small depression which li between the hymen and the frenulum labiorum.

The **bulbs of vestibule** (Fig. 412) are two ovoid masses of erecti tissue 1 inch in length, which are situated on either side of the vestibu beneath the mucous membrane. Each bulb is covered by a delica fibrous capsule derived from the inferior layer of the perineal membran superficial to which the bulb of either side lies. The outer surface convex, and is covered by one half of the bulbo-spongiosus muscl The inner surface is slightly concave, and is covered by the vagin mucous membrane. Posteriorly the bulbs diverge, and anterior having become narrow, they pass upwards and forwards, and ultimate meet in the middle line, where they are attached to the inferior layer the perineal membrane. In front of the bulbs there is a plexus of vein which is continuous behind with their erectile tissue, and in front wit

that of the glans clitoridis. This plexus of veins is known as the **pars intermedia.** It receives veins from the labia minora, and its blood is conveyed into the vaginal plexus.

The bulbs of the vestibule together represent the bulb of the male urethra, which latter presents on its under surface a faint groove in the middle line, indicating a bilateral origin. The pars intermedia is regarded as representing that part of the male corpus spongiosum which extends from the bulb to the glans penis.

The **greater vestibular glands** (**Bartholin's glands**) belong to the class of racemose or acino-tubular glands. They are two in number, right and left, and each resembles a small bean. They lie on either side of the external orifice of the vagina, immediately behind the posterior extremities of the bulbs of the vestibule, into which certain of their lobules may project. The duct of each gland is about $\frac{3}{4}$ inch long, and opens in the angle between the attached border of the labium minus

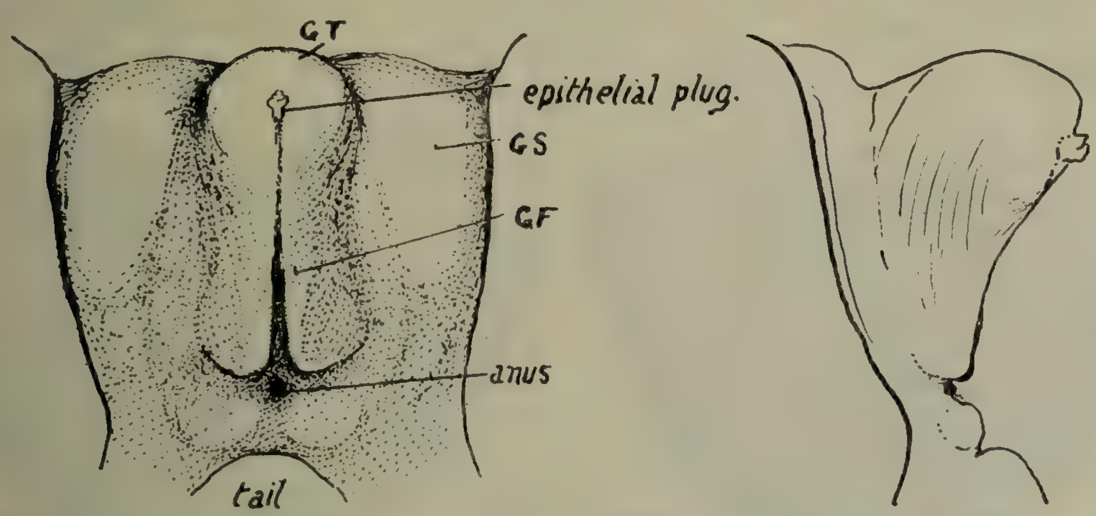


FIG. 413.—THE EXTERNAL GENITAL ORGANS AT THE END OF THE INDIFFERENT STAGE SEEN FROM THE FRONT AND FROM THE SIDE.

GF, labio-scrotal fold; GS, genital swelling; GT, genital tubercle.

and the hymen or its remains a little in front of the vestibular fossa. The orifices of these ducts are usually plainly visible to the naked eye.

These glands are homologous with the bulbo-urethral glands, and their structure is similar.

The greater vestibular glands are developed from the lining epithelium of the uro-genital sinus.

The external uro-genital organs of the female have received the name of **vulva.** As this word, however, literally signifies a 'covering,' it is strictly applicable only to the labia majora, which by their approximation form a covering for the uro-genital cleft and its contents.

Development of the External Genital Organs.

In the early stages no sexual differences are apparent in the development of the external genital organs. The chief parts concerned are (1) the genital eminence, (2) the genital groove, (3) the labio-scrotal folds, and (4) the genital swellings.

Female External Organs.—The surface-depression corresponding the cloacal membrane, which bounds the cloaca postero-inferiorl is known as the **cloacal depression.** As the cloaca becomes divid into two compartments—dorsal or intestinal, and ventral or ur genital—by the cloacal or uro-rectal septum, the cloacal membra is also divided into two parts—dorsal or anal, and ventral or ur genital. Moreover, the superficial cloacal depression is likewi divided into two parts—dorsal, which is called the *anal depressi* or *proctodæum*; and ventral, which is known as the *uro-genital d pression*, and is somewhat cleft-like. When the uro-genital portic of the cloacal membrane ruptures, the uro-genital sinus or canal cor municates with the exterior by means of the *uro-genital opening cleft.*

The formation of the subdivisions of the cloaca is described ar figured on p. 98, and the slit-like opening of the uro-genital sinu

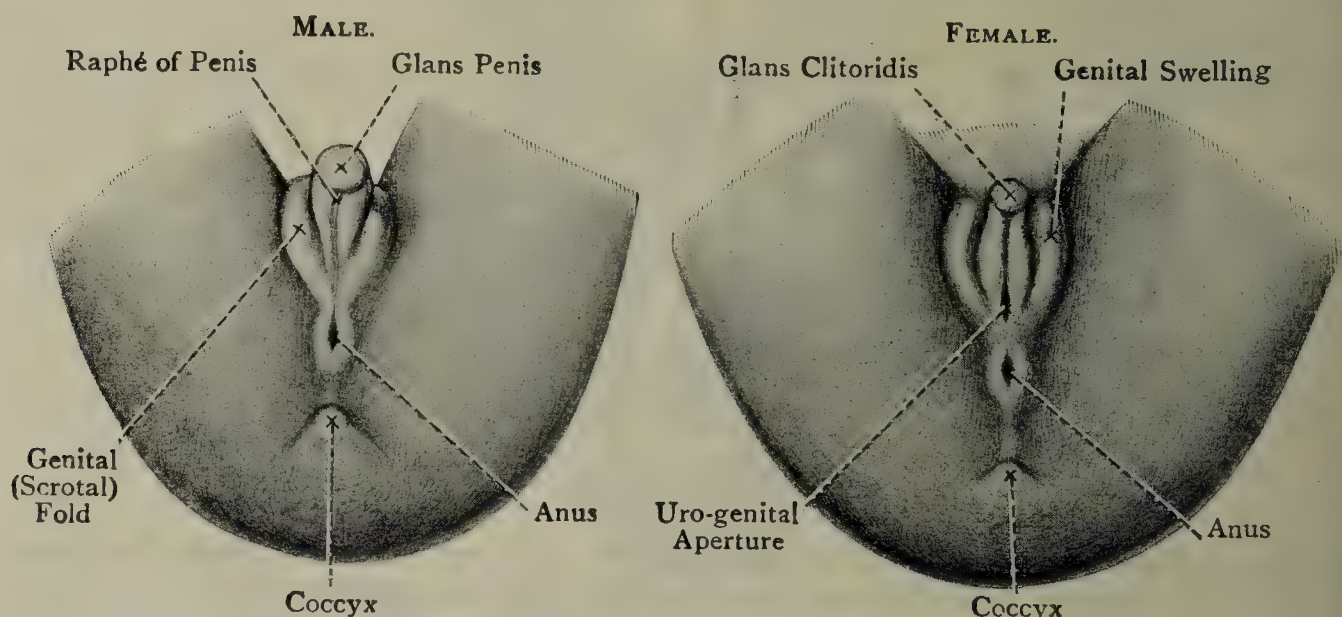


FIG. 414.—DEVELOPMENT OF THE EXTERNAL GENITAL ORGANS.

is seen to extend forward on the lower aspect of the growing genita tubercle.

The **female external genital organs** are developed around the uro genital opening. At the cephalic part of the primitive vestibule small tubercle, called the **genital eminence** or **tubercle,** makes it appearance in the median line. On the lower, or vestibular, surfac of this eminence a furrow, called the **genital groove,** marks the forwar prolongation of the uro-genital opening. The lips of this groove which are laterally disposed, are called the **labio-scrotal folds.** Or either side of the genital eminence, external to the corresponding genita fold, a low ridge makes its appearance. These ridges are known as the **genital swellings.** They are continuous with each other on the ventral aspect of the genital eminence, and they extend dorsalwards lying on either side of the vestibule, and finally meeting behind in the perineum.

The **genital eminence** undergoes lengthening, and gives rise to the *clitoris.* The terminal extremity of the eminence becomes enlarged,

and forms the *glans clitoridis*, whilst the remainder gives rise to the *corpora cavernosa clitoridis*.

The **labio-scrotal folds,** which in the male fuse, enclosing the spongy part of the urethra, and forming the corpus spongiosum penis, remain separate in the female, and form the *labia minora*. The **genital swellings,** which in the male come together and form the scrotum, remain separate in the female, and give rise to the *labia majora*. The ventral portions of the external swellings, which are continuous with each other on the ventral aspect of the genital eminence, form the *mons pubis*.

The *hymen* appears as a semilunar fold of mucous membrane, extending as a rule over the dorsal part of the external orifice of the vagina.

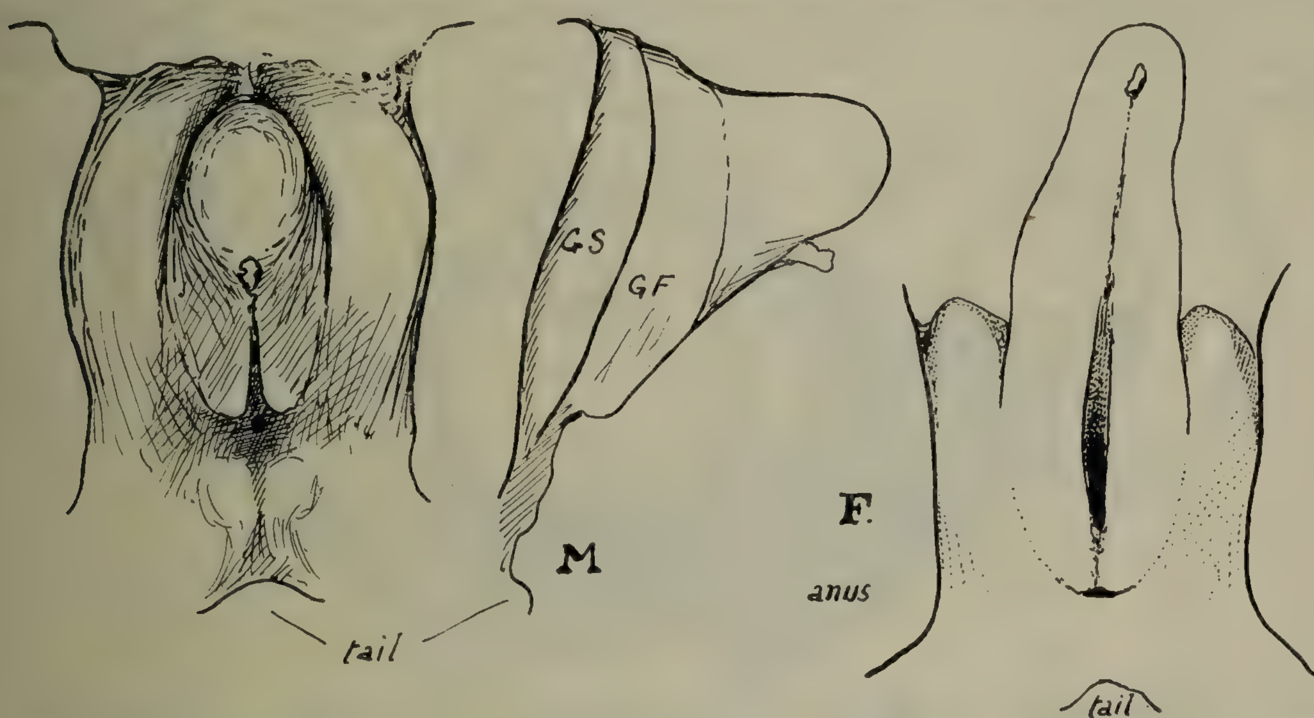


FIG. 415.—FIGURES OF MALE AND FEMALE ORGANS AT THE END OF THE SECOND MONTH.

The labio-scrotal fold (GF) is being carried forward on the base of the penile prominence in the male. The clitoris is very long in the female, but the folds and the genital swellings (GS) are less prominent.

The *greater vestibular glands* are developed laterally as evaginations of the epithelial lining of the caudal part of the uro-genital sinus, which part, when expanded, forms the vestibule.

The *bulbs of the vestibule* and the *pars intermedia* are developed as masses of erectile tissue close to the labia minora and clitoris.

Male External Organs.—The genital tubercle undergoes lengthening, although this is not so marked a feature in the male at first as it is in the female. The lengthening, occurring later, appears to be of a different nature than in the female, for the parts of the labio-scrotal folds which are related to the tubercle seem to be drawn out with it in its growth, and help to form the shaft of the penis. The eminence forms the *glans*, and the *corpora cavernosa* are developed partly from the tubercle, but mainly from the genital folds. With the elongation

and general growth the groove on the lower surface is drawn out an deepened. The **labio-scrotal folds** forming the lips of the groove, whic remain open in the female, close over it in the male, so that the groov is converted into the *spongy urethra.*

It is difficult to decide whether the lips fuse from behind forward, or the hinder junction is simply carried forward with the folds on the lengthening peni The presence of a *raphé* on the scrotal aspect of the penis seems to suggest tha fusion occurs.

The opening of the uro-genital sinus on the surface is thus carrie forward more and more, reaching the lower surface of the penil prominence (Fig. 416). Continuation of the closing process shuts o the spongy urethra from the surface, but about the time this take place the urethra in the glans is formed by hollowing out of the ecto dermal plate which occupied the (potential) groove on the eminence

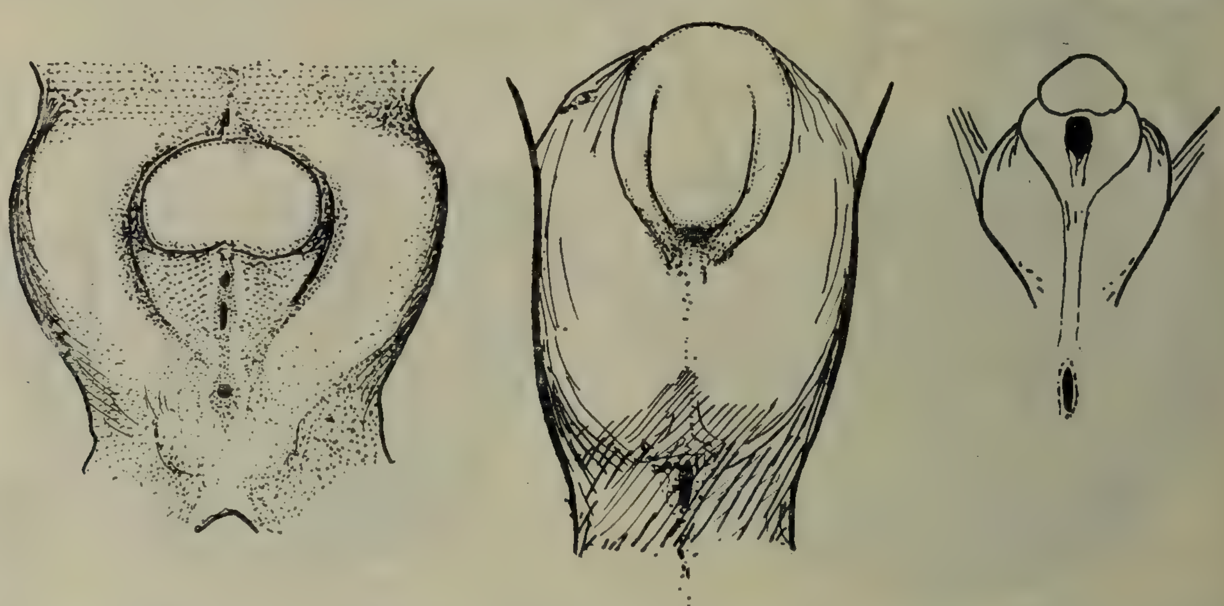


FIG. 416.—MALE EXTERNAL ORGANS DURING THE THIRD AND EARLY PART OF FOURTH MONTH.

the canal formed in this way becomes continuous with the spongy urethra.

The spongy part of the urethra extends as far as the **uro-genital sinus,** from the lower part of which the *prostatic* and *membranous parts* of the canal are developed.

In rare cases the genital folds fail to unite over some portion of the genital groove. In such cases the spongy urethra opens externally on the under, or scrotal, aspect of the penis, and the condition is known as *hypospadias.*

The labio-scrotal folds, which enclose the spongy part of the urethra, acquire erectile tissue and constitute the *corpus spongiosum penis.* The genital eminence, having lengthened considerably, and having acquired erectile tissue, gives rise to parts of the *corpora cavernosa penis,* whilst its terminal enlargement forms the *glans penis.*

The genital swellings, which in the female remain separate and form the labia majora, unite in the male and give rise to the *scrotum.* The line of fusion is indicated in adult life by the *scrotal raphé.*

It is to be noted that, whilst the **prostatic** and **membranous portions** the male urethra are developed from the lower part of the uro-ıital sinus, and are therefore *non-penile*, the **spongy portion** of the ıal is developed from (1) the genital groove on the lower surface of the ıital eminence, and (2) the internal genital folds. The spongy part the urethra is therefore *penile*.

The *bulb* of the corpus spongiosum penis represents the *bulbs of vestibule* of the female, and the portion of the corpus spongiosum nis between the bulb and the glans penis represents the *pars inter-dia of the body of the clitoris* in the female.

Perineum Proper.

The perineum proper is the region which lies between the anus and e vestibule. It is in this division that the perineal body is situated.

Perineal Body.—It is situated between the anus and the vaginal ifice. It is triangular in outline, and is about $1\frac{1}{2}$ inches in breadth.

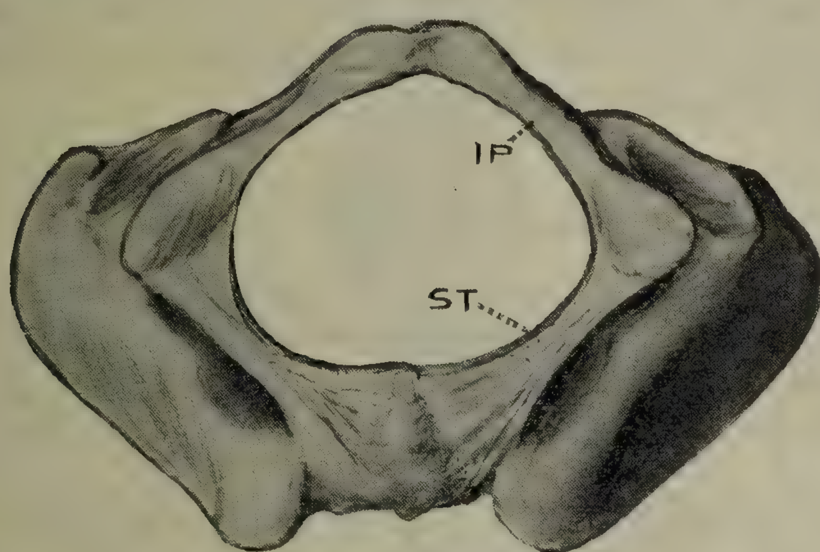


FIG. 417.—FEMALE BONY PELVIS FROM BELOW.
ST = sacro-tuberous ligament; IP = ischio-pubic ramus.

is bounded *in front* by the posterior wall of the vagina, *behind* by the ıterior wall of the anal canal, and *inferiorly* by the skin. The perineal ıdy is produced by a thickening of connective tissue, with a free lmixture of elastic tissue and a few muscular fibres derived from the :ternal sphincter, levatores ani, and bulbo-spongiosus muscles. It rves as a support to the posterior wall of the vagina. During parturi-on it becomes greatly stretched, but its elastic tissue usually guards against rupture.

Perineal Membrane.—The perineal membrane resembles that of ıe male in being composed of two layers, inferior and superior.

The **inferior layer,** on account of the greater width of the pubic :ch in the female, is broader than in the male, though it is more ıdefinite on account of its being pierced by the vagina. It is attached t either side to the posterior margin of the inner border of the ischio-ubic ramus, and anteriorly blends with the transverse perineal liga-ıent. In the middle line, where it is pierced by the vagina, it blends ith the wall of that canal. Its base is joined by a somewhat indefinite

layer of fascia representing the deep layer of superficial perineal fasc in the male, and by the superior layer. The openings in the inferi layer are similar to those in the male, with this exception, that t ducts of the greater vestibular glands do not pierce it as the ducts the bulbo-urethral glands do in the male, the greater vestibular glan being situated superficial to this layer. The urethral opening is situat 1 inch below the symphysis pubis. The opening for the vagina, whi is of large size, lies below the urethral orifice, from which it is separat by a few fibres. The openings for the arteries of the bulbs of t vestibule are situated one on either side of the vaginal opening. T openings for the deep artery of clitoris, for the dorsal artery and ner of the clitoris, and for the superficial perineal vessels and nerves, a situated as in the male.

It is to be noted that the dorsal vein of the clitoris, like the corr sponding vessel in the male, passes between the inferior and transver perineal ligaments.

The **superior layer** is similar to the corresponding layer in the mal and presents openings for the urethra, vagina, and internal pudend vessels and pudendal nerves of each side.

Anal Division.

The chief characters of the anal division in the female are as follow the aperture of the anus is somewhat nearer the coccyx than in t male, the distance between the ischial tuberosities is greater than the male, and the ischio-rectal fossæ are wider and shallower than the male.

Muscles.—The muscles of the female perineum, as compared wi those of the male, present certain differences.

Levatores Ani.—The anterior fibres of these muscles embrace t vagina instead of the prostate gland, as in the male.

Ischio-cavernosus (**Erector Clitoridis**).—This muscle replaces t ischio-cavernosus of the penis, and is of small size.

Bulbo-spongiosus (**Sphincter Vaginæ**).—This muscle arises from t perineal body, where it meets the external sphincter and superfici transverse perineal muscles. It then passes forwards and divid into two symmetrical parts which surround the vaginal orifice an vestibule, each part closely embracing the outer surface of the corr sponding bulb of vestibule. Anteriorly the two parts become ve narrow, and each is inserted into the fibrous sheath of the corpu spongiosum. A few fibres are here detached to be inserted into tendinous expansion on the dorsum of the clitoris covering the dors vein, which vessel would be thereby compressed when the muscle in action. Some of the inner fibres of the bulbo-spongiosus are inserte into the mucous membrane of the vestibule.

Sphincter Urethræ.—This muscle, as in the male, lies between th two layers of the perineal membrane. It is attached on either sid to the inner margin of the ischio-pubic ramus, and in the middle lin

: is almost completely divided into two parts by the vagina. The nterior part passes transversely across the pubic arch in front of the rethra, whilst the posterior and larger part passes inwards, partly ransversely and partly obliquely, to blend with the vaginal wall.

The external sphincter and superficial transverse perineal muscles re similar to those in the male.

Internal Pudendal Artery.—This vessel is of smaller size than in the ıale, but it takes a similar course. The difference, therefore, in the wo sexes affects chiefly the branches of the artery.

The **superficial perineal artery** is larger than in the male, and is istributed to the labium majus.

The **artery of the bulb** is of comparatively small size, and is disributed to the bulb of the vestibule.

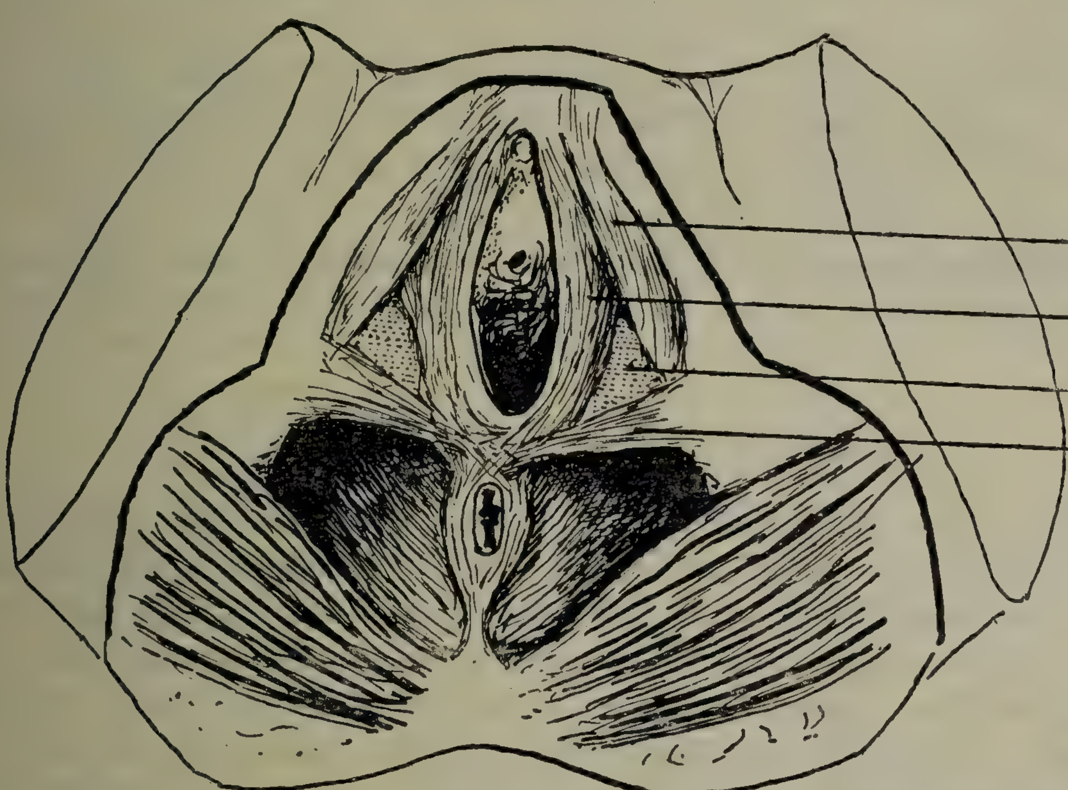


FIG. 418.—ISCHIO-RECTAL FOSSA AND MUSCLES OF FEMALE PERINEUM.

The **deep artery of the clitoris,** having pierced the inferior layer of he perineal membrane, enters the crus clitoridis, and is then continued nwards in the centre of the corpus cavernosum.

The **dorsal artery of the clitoris,** like the preceding, is comparatively mall in size. Having pierced the inferior layer of the perineal memrane, it passes between the crura clitoridis, and also between the wo layers of the suspensory ligament of the clitoris. It is then coninued along the dorsum of that organ as far as the glans, having the orsal vein of the clitoris on its inner side and the dorsal nerve of the litoris on its outer side. On reaching the glans it divides into branches or the supply of the glans and its prepuce. As it passes along the orsum of the clitoris it gives off several branches, which enter the orpus cavernosum by piercing its fibrous sheath.

The **veins** of the female perineum are so similar to those in the male s not to require any special description. An exception, however, has

to be made in the case of the **dorsal vein of the clitoris.** This vein is formed by branches which return the blood from the glans and prepuce, and also to a certain extent from the corpora cavernosa. It passes backwards in the groove between the corpora cavernosa, where it has on either side of it the dorsal artery, and lateral to this the dorsal nerve, of the clitoris. In this part of its course it receives tributaries from the corpora cavernosa. On reaching the root of the organ it passes between the two layers of the suspensory ligament of the clitoris, and then between the inferior and transverse perineal ligaments, and so enters the pelvic cavity, where it terminates in the plexus of veins at the neck of the bladder.

Lymphatics.—The lymphatics of the vulva, including those of the prepuce of clitoris, terminate in the superficial *inguinal glands*, which lie immediately below the inguinal ligament. The lymphatics of the glans clitoridis, like those of the glans penis, pass to the deep inguinal and external iliac glands. The lymphatics of the vagina and urethra run with the vaginal vessels, those of the bulb and corpora cavernosa clitoridis with the internal pudendal vessels, both sets of lymphatics terminating in the *internal iliac glands*.

The **pudendal nerve** and its branches are similar to those in the male, the superficial perineal nerves being distributed to the labia majora.

ABDOMINAL WALL.

Landmarks.—The position of the **linea alba** is indicated by the mid-abdominal groove, which extends from the xiphoid process of the sternum to the umbilicus, and by the mid-abdominal line, which extends from the umbilicus to the upper part of the symphysis pubis. After removal of the skin the linea alba presents a dense white appearance, and is slightly depressed below the level of the adjacent surfaces. It is produced by the decussation of the aponeuroses of the abdominal muscles of opposite sides, except the recti, and is divided into two parts, supra-umbilical and infra-umbilical. The supra-umbilical part is about $\frac{1}{4}$ inch broad, the recti being here separated to that extent. The infra-umbilical part is only about $\frac{1}{8}$ inch wide on account of the approximation of the recti in this situation. Over the whole extent of its posterior or abdominal surface it is invested by the parietal peritoneum, unless in cases of abnormal distension of the bladder, when the peritoneum is stripped from the lower part to an extent corresponding with the height to which the distended bladder ascends. The anterior abdominal wall is thinner and less vascular along the linea alba than at any other part. This line is therefore selected for such operations as suprapubic lithotomy, tapping a distended bladder above the symphysis pubis, and ovariotomy.

The structures which are divided in opening the abdominal cavity along the linea alba are as follows: the skin, the decussating fibres of the aponeuroses of opposite sides, fascia transversalis, subperitoneal areolar tissue, and parietal peritoneum. There are no bloodvessels of any importance in this situation.

The posterior aspect of the linea alba has important visceral relations. The left lobe of the liver lies behind it for about 2 inches below the xiphoid process of the sternum. The relation of the stomach to it is variable. When the viscus is moderately distended it lies behind the linea alba below the margin of the liver. In the empty condition, however, it recedes from the linea alba, and this gives rise superficially to the *epigastric depression*, or *scrobiculus cordis* (' small trench of the heart '). The transverse colon, covered by the greater omentum, as it crosses from right to left, usually lies behind the linea alba just above the umbilicus. The coils of the jejunum and ileum, also covered by the greater omentum, lie behind it below the umbilicus.

In young persons the upper part of the bladder, being extra-pelvic, lies behind the lowest part of the linea alba. In adults the upper part of that viscus, when abnormally distended, also lies behind the lowest part of this line.

The **umbilicus** takes the form of a cicatricial depression which is situated in the linea alba at the junction of the upper three-fifths and lower two-fifths. As seen from the front it is irregularly circular, the skin being more or less puckered according to the state of distension of the abdomen. When viewed from the back it is smaller in size, and its long measurement lies transversely. Besides cicatricial tissue and fat, the lower part of it contains the upper ends of the urachus and obliterated hypogastric arteries, whilst the upper part is occupied by part of the obliterated umbilical vein. The upper part is weaker than the lower. The umbilicus is on the same horizontal plane as the disc between the bodies of the third and fourth lumbar vertebræ.

In embryonic life there is an opening in the middle line of the ventral abdominal wall, through which the intra-embryonic and extra-embryonic portions of the gut are continuous with one another. The body-stalk or umbilical cord is attached to the *caudal* margin of this opening, extending for a little distance along its sides also, especially on the left side. When the intestines enter the abdomen, in the tenth week, the edges of the opening come together, joining medially in a few days, but the umbilical cord, of course, retains its attachment. After birth, when the fœtal end of the cord sloughs off, the area of its previous attachment forms a scar, which is the **umbilicus.** If the original opening were to persist, it would be in front (above) this scar, though close to it, and on the right-hand side of the umbilical end of the ligamentum teres of the liver, the remnant of the left umbilical vein.

The **lineæ semilunares** (Fig. 419) coincide with the outer borders of the recti abdominis. The position of each is indicated by a line drawn from the lowest part of the eighth costal cartilage to the pubic tubercle. This line is curved, with the convexity outwards, and at the level of the umbilicus it is about 3 inches from it. Over the upper three-fourths of the rectus abdominis it indicates the splitting of the aponeurosis of the internal oblique into two laminæ, which encase that extent of the muscle in a sheath. Over the lower fourth it indicates where the aponeurosis of the external oblique and part of the aponeurosis

of the internal oblique separate from the remainder of the aponeuros of the internal oblique and the aponeurosis of the transversus, t former aponeuroses passing forward in front of the rectus, while t latter pass with a curved course downward along the outer edge the rectus.

The substance of the rectus abdominis is traversed by three ho zontal **tendinous intersections** (*linea transversæ*) which cross the rect in the following situations: one at the level of the umbilicus, one

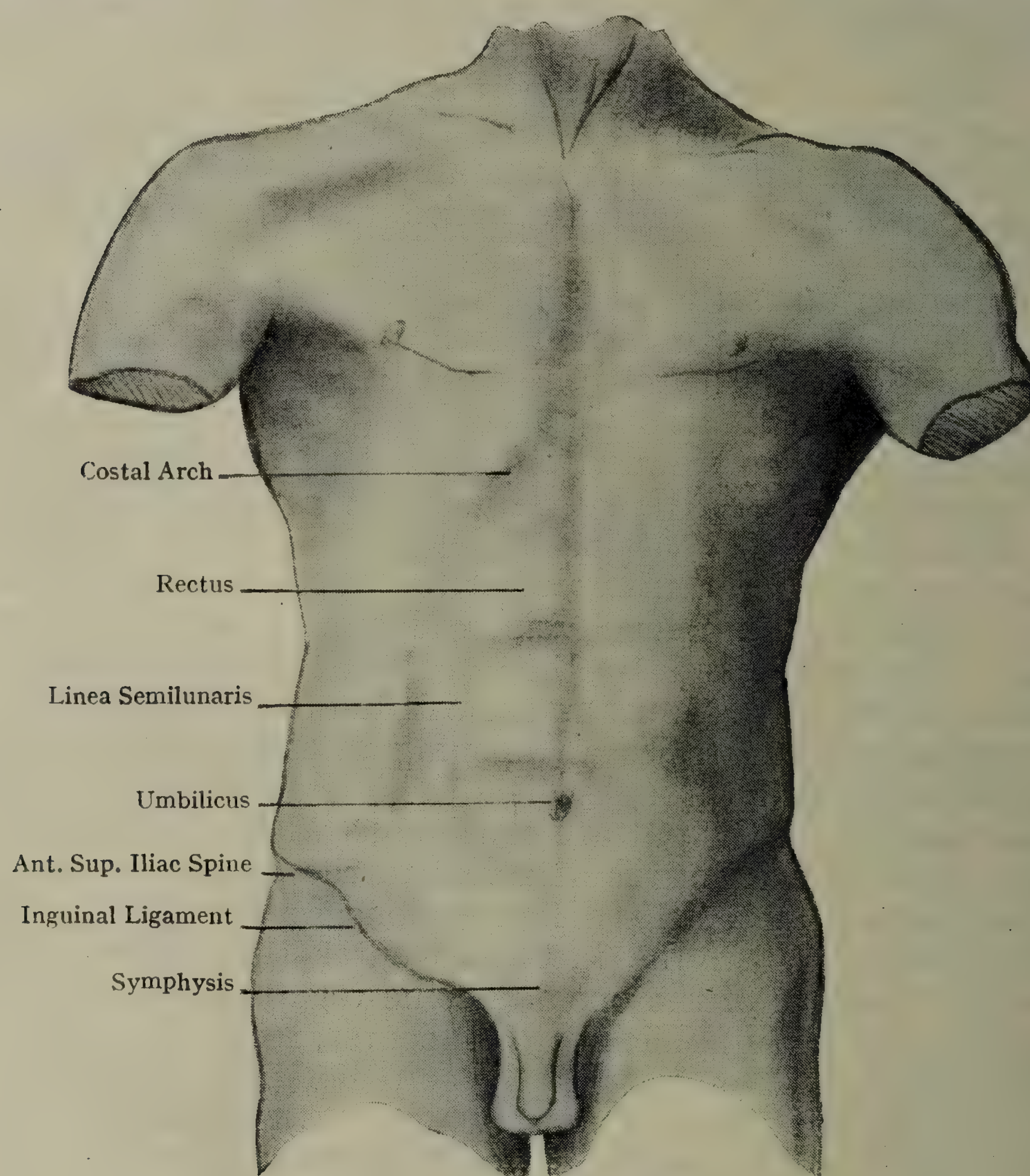


FIG. 419.—ANTERIOR ABDOMINAL WALL.

the level of the lower margin of the thorax, and one about midwa between these two. The positions of the intersections are indicate by three faint grooves. The anterior wall of the sheath of the rectu is closely bound down to the tendinous intersections, and so each muscl above the umbilicus is mapped out into quadrangular areas, and th interior of the sheath, anterior to the muscle, is also divided int distinct compartments. An abscess may form in one or other of thes compartments, or there may be a spasmodic contraction of one o other of these quadrangular areas of the muscle, a condition in eac

case which would necessarily have a circumscribed limit, and might lead to error in diagnosis.

The **spino-umbilical lines** are two in number, right and left, and each extends from the anterior superior iliac spine to the umbilicus.

The **anterior superior spine of the ilium** is situated at the anterior extremity of the iliac crest, and, being very superficial, can be readily felt. It is on the same level with that of the opposite side, and therefore a line connecting the two should be quite horizontal. The plane of this interspinous line is rather lower than the promontory of the sacrum. The anterior superior iliac spine is one of the points from which the measurement of the lower limb is taken, the other point being the medial malleolus. This spine is also a good ready guide to the position of the greater trochanter, which is situated about 4 inches below it, and about $4\frac{1}{2}$ inches behind a line passing vertically through it.

The **pubic tubercle** is situated at the lower and inner part of the anterior abdominal wall, about $1\frac{1}{2}$ inches outside the upper part of the symphysis pubis. It is sometimes a sharp-pointed process, and then can readily be felt beneath the skin. In most persons, however, it takes the form of a more or less indistinct tubercle, and cannot readily be made out. In such cases the scrotal integument may be invaginated with the finger, and so the adipose tissue raised from over the spine. If it cannot be felt in this way, the thigh should be well abducted to render prominent the adductor longus muscle, the tendon of origin of which will serve as a guide to the spine, which lies above and to the outer side of it. The pubic tubercle is the guide to the superficial inguinal ring, the femoral ring, and the saphenous opening. The **superficial inguinal ring** is situated immediately above the pubic tubercle. In exploring the ring, the best way to proceed is to invaginate the scrotal integument, and carry the examining finger up the inner side of the spermatic cord, when the ring will be reached. In normal circumstances it should admit the point of the little finger. In making this examination the spermatic cord is readily felt, and the vas deferens can be distinguished as a firm cord-like structure lying posteriorly, and easily separable from the other constituents of the cord. In the female the ligamentum teres of the uterus takes the place of the spermatic cord, but, being a very ill-defined structure, it usually escapes detection. The **femoral ring** is situated fully 1 inch lateral to the pubic tubercle in a line drawn transversely outwards from that spine across the front of the thigh. The **saphenous opening** is situated below, and lateral to, the pubic tubercle.

The **pubic crest** extends transversely inwards for about $1\frac{1}{4}$ inches from the pubic tubercle, and terminates in the pubic angle, which surmounts the medial surface of the pubic body, and is usually a rudimentary tubercle. The crest may be felt with the finger as the superficial inguinal ring, of which it forms the base, is being explored.

The **inguinal ligament** can be felt as a tense band, especially when the thigh is extended, abducted, and rotated outwards, passing between the anterior superior iliac spine and the pubic tubercle.

The **deep inguinal ring** is situated ½ inch above the mid-point o the inguinal ligament.

The **inguinal canal** extends for 1½ inches obliquely downwards forwards, and inwards from the deep to the superficial inguinal ring and is situated immediately above the inner half of the inguina ligament.

Topography of Arteries, Triangles, and Iliac Fossæ.—The **bifur cation of the aorta** into right and left common iliac arteries usuall takes place opposite the centre of the body of the fourth lumba vertebra, a finger's breadth to the left of the middle line. The positio of the bifurcation is indicated in one of two ways: (1) a point ¾ incl below and to the left of the umbilicus; (2) a more definite guide is a point in the line which connects the highest parts of the iliac crest a finger's breadth to the left of where it intersects the linea alba.

The **common and external iliac arteries** are indicated by a line drawn from a point midway between the anterior superior iliac spine and the symphysis pubis to the point corresponding to the bifurcatio of the aorta. This line should be slightly curved, with the convexity directed outwards. Its upper 2 inches indicate the course of the common iliac artery, and the remainder represents the externa iliac.

The **inferior epigastric artery,** in its first or oblique part, is indicated by a line drawn from the inner border of the deep inguinal ring to the outer border of the rectus abdominis at a point midway between the upper border of the symphysis pubis and the umbilicus. The subsequent course of the vessel is represented by a line corresponding to the centre of the rectus abdominis, and reaching to a point about 2 inches above the umbilicus. This latter line is about 1½ inches distant from the linea alba.

The **inguinal triangle** (**Hesselbach's**) is situated on the inner side of the first or oblique part of the inferior epigastric artery, and above the inner half of the inguinal ligament.

The **lumbar triangle** (**of Petit**) is situated immediately above the centre of the iliac crest. In this region a lumbar hernia may protrude, and a lumbar abscess may here come to the surface.

The **right iliac fossa** contains the terminal part of the ileum, the cæcum, the vermiform appendix, and beginning of the ascending colon.

The **left iliac fossa** contains the iliac part of the descending colon.

McBurney's point is situated in the right spino-umbilical line between 1½ and 2 inches from the anterior superior iliac spine. According to McBurney, it corresponds very accurately in the living subject to the base of the vermiform appendix. Practically it coincides with the centre of the right iliac fossa. The point is now regarded as indicating approximately the situation of the ileo-colic valve, and not the base of the vermiform appendix. The guide to the base or opening of the appendix is a point on an average rather more than 1 inch below the ileo-colic valve.

Anterior Abdominal Fasciæ.—The **superficial fascia** of the anterior vall of the abdomen, from the inguinal ligament to a line drawn trans- ersely from the anterior superior iliac spine to the linea alba, resembles he superficial fascia of the uro-genital division of the perineum in eing divisible into two layers. The layer immediately beneath the kin is called the fatty superficial layer, and the other layer is called he deeper membranous layer.

The *fatty superficial layer* (*fascia of Camper*) is composed of areolar issue containing adipose tissue in its meshes. When traced upwards, t blends with the deep layer above the level of the line connecting the nterior superior iliac spine with the linea alba. When followed in- vards, it is continuous with the corresponding layer of the opposite ide. In a downward direction it is freely continuous over the inguinal igament with the superficial layer of the superficial fascia of the ront of the thigh. When traced downwards and inwards, it passes long the spermatic cord into the scrotal wall and over the penis, in vhich situations, more especially the former, it contains involuntary nuscular fibres, which replace its adipose tissue, and so, with the deep ayer which it here joins, it forms the *dartos muscle*. In the female, he fatty superficial fascia passes along the ligamentum teres of the iterus into the labium majus.

The *deeper membranous layer* (*fascia of Scarpa*) is a strong mem- rane which contains yellow elastic tissue. It is separated from the uperficial layer by the superficial epigastric vessels, and in the region f the inguinal ligament by the inguinal glands. Its deep aspect is oosely connected by areolar tissue to the subjacent aponeurosis of he external oblique muscle. Superiorly, above the line connecting he anterior superior iliac spine with the linea alba, it blends with uperficial layer. At the middle line it is firmly bound down by fibrous ands to the linea alba. Inferiorly it blends medially with the inguinal gament, but laterally it passes over that ligament for a distance of n inch or so, and then becomes incorporated with the fascia lata of he thigh. When traced downwards and inwards, it passes along the permatic cord into the scrotal wall and over the penis. In the former ituation it forms, along with the superficial layer, the *dartos muscle*. n the female, the deeper layer passes along the ligamentum teres of he uterus into the labium majus.

The superficial layer is continuous through the dartos muscle with he superficial layer of the superficial fascia of the uro-genital division f the perineum, and the deeper layer is similarly continuous with the eep layer of the superficial fascia. In the middle line the deeper layer s continued down in the form of a collection of fibres which, separating nto two bundles, pass on either side of the penis to blend with the heath. To these fibres the term superficial suspensory ligament of he penis has been applied.

The disposition of the deeper membranous layer at the line of the roin explains why, in cases of extravasation of urine beneath the deep ayer of superficial perineal fascia, the urine, when it reaches the

anterior abdominal wall, does not pass downwards to the front of th thigh, but takes an upward course.

The deeper layer of superficial fascia represents the *tunica abdominalis* c quadrupeds, which is composed almost entirely of elastic tissue, and serves as a important adjunct to the abdominal parietes.

The separation, entirely artificial, of the superficial fascia int a superficial fatty layer and a deep membranous layer, the so-calle deep fascia, obtains throughout the body, but in the lower part c the anterior abdominal wall is more apparent than elsewhere. Th reasons are (1) the frequent accumulation of fat in this region makin the superficial layer very distinct; (2) the presence in considerabl abundance of strong fibres, some of which are said to be elastic, i the deep layer, accentuating its membranous character; (3) the exist ence beneath the deep layer of an aponeurosis, and the consequen tendency for the formation of a membranous covering. While else where the two layers are named superficial and deep fascia respectively it is customary in the region of the anterior abdominal wall for historica reasons to speak of both layers as forming the superficial fascia, and t make no reference to any deep fascia.

Cutaneous Nerves.—The **anterior cutaneous nerves** are the termina branches of the lower five intercostal nerves and of the anterior primar division of the twelfth thoracic nerve (subcostal nerve). Havin emerged through the anterior wall of the sheath of the rectus abdomini in a straggling manner, they give a few twigs inwards, and then tur outwards to supply the anterior abdominal integument, in which the communicate with the anterior branches of the lateral cutaneous nerves The nerves pursue a tortuous course, and are therefore not so subjec to strain during the movements of the anterior abdominal wall as the would be if their course were straight.

The **anterior cutaneous branch of ilio-hypogastric nerve** pierces th external oblique aponeurosis about 1 inch above the superficial inguina ring, and is distributed to the skin of the suprapubic region. It i serially continuous with the anterior cutaneous nerves.

The skin below the xiphoid process is supplied by the seventh thoracic nerve that on a level with the umbilicus by the tenth thoracic; and that over the lowe half of the infra-umbilical region by the subcostal and the ilio-hypogastric.

The **lateral cutaneous nerves** are branches of the lower five inter costal nerves. Having emerged between the digitations of the externa oblique muscle in the mid-axillary line, each divides into an anterio and a posterior branch. The *posterior branch* turns backwards t supply the skin over the lower part of the back. The *anterior branc* passes forwards to supply the skin of the anterior abdominal wall communicating with an anterior cutaneous nerve.

Cutaneous Arteries.—The **superficial external pudendal artery** arises from th femoral about ¾ inch below the inguinal ligament, after which it pierces th femoral sheath and cribriform fascia. Having emerged through the saphenou opening, it passes inwards and upwards over the spermatic cord or ligamentum

eres of the uterus, according to the sex, to be distributed to the skin of the uprapubic region, the adjacent portion of the scrotum in the male and the abium majus in the female, and the dorsum of the penis by a branch which xtends as far as the prepuce, lying lateral to the dorsal artery of penis. The essel in its course gives branches to the inguinal glands, and the covering of he spermatic cord, or of the ligamentum teres of the uterus. It anastomoses vith the following arteries: (*a*) the cremasteric branch of the inferior epigastric,

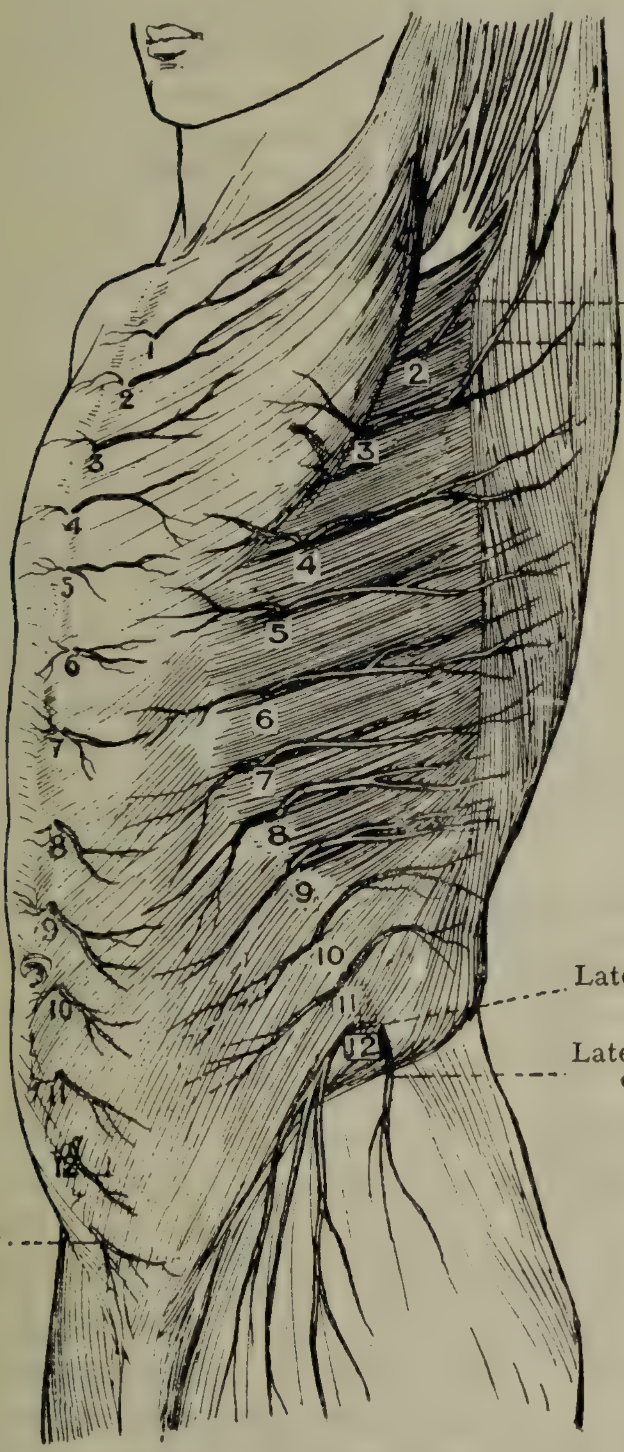


FIG. 420.—CUTANEOUS NERVES OF THE TRUNK (ANTERO-LATERAL VIEW) (AFTER HENLE).

1-12, anterior cutaneous; 2-12, lateral cutaneous.

or in the female the artery to the ligamentum teres of the uterus; (*b*) its fellow of the opposite side; (*c*) the deep external pudendal; (*d*) the superficial perineal; and (*e*) the dorsal artery of penis.

The venæ comites of this artery terminate in one vessel, which joins the long saphenous vein.

The **superficial epigastric artery** arises from the femoral about $\frac{1}{2}$ inch below the inguinal ligament. Having pierced the femoral sheath and cribriform fascia, or the outer border of the saphenous opening, it turns upwards over the inguinal

ligament a little to the inner side of the centre, and then ascends as high as t level of the umbilicus. As it turns upwards it supplies branches to the supe ficial inguinal glands, and on the abdominal wall anastomoses with branches the inferior epigastric artery.

There are at first two venæ comites with this artery, but these eventual join to form one vessel which terminates in the long saphenous vein. T radicles of these venæ comites communicate with the following vessels: the par umbilical veins in the region of the umbilicus, which lie on the surface of t ligamentum teres of the liver, and communicate with the branches of the ve portæ; the lateral thoracic and subscapular veins, upon the side of the thora which are tributaries of the axillary vein; and the superior epigastric vein which are tributaries of the internal mammary veins. In the superficial epigast vein and its tributaries the blood can flow in either direction. In cases of port obstruction the venous anastomoses in the neighbourhood of the umbilicus n infrequently become engorged, resulting in a system of subcutaneous vei radiating from the umbilicus and known as the *Caput Medusæ*.

The **superficial circumflex iliac artery** often arises in common with the supe ficial epigastric from the femoral about ½ inch below the inguinal ligamen Having pierced the fascia lata on the outer side of the saphenous opening, passes outwards below the outer part of the inguinal ligament to the anteri part of the iliac crest, where it is distributed to the adjacent abdominal integ ment. In its course it gives branches to the iliacus and sartorius muscles ar the outer inguinal glands, and it anastomoses with (*a*) the deep circumflex ili of the external iliac, and (*b*) the superior gluteal of the internal iliac.

The vein corresponding to this artery terminates in the long saphenous vei

The **anterior cutaneous arteries** are derived from the inferior and superi epigastric arteries. They emerge through the anterior wall of the sheath of t rectus abdominis in an irregular manner, and accompany more or less close the anterior cutaneous nerves.

The veins corresponding to these arteries terminate in the inferior and superi epigastric veins.

The **lateral cutaneous arteries** are branches of the lower five posterior inte costal and subcostal arteries, and they emerge with the lateral cutaneous nerv between the digitations of the external oblique muscle in the mid-axillary line

The veins corresponding to these arteries are tributaries of the lower fi posterior intercostal and subcostal veins.

Superficial Lymphatics.—The superficial lymphatics *below* the lev of the umbilicus accompany the superficial epigastric vessels, an terminate in the superficial inguinal glands. Those *above* the lev of the umbilicus pass to the axillary glands. The superficial lymphati of the *lateral* abdominal wall terminate in two ways. Some accompan the superficial circumflex iliac vessels, and terminate in the superfici inguinal glands; others accompany the abdominal branches of th lumbar arteries, and terminate in the deeply-placed aortic group c lumbar glands. For the deep lymphatics of the antero-lateral ab dominal wall, see p. 733.

Penis—Coverings.—The **skin** at the free extremity of the glans being doubled upon itself, passes backwards until it reaches the con striction behind the **corona glandis** called the **neck.** Here it is reflecte forwards, closely investing the neck, corona glandis, and body of th glans. On reaching the lips of the **external orifice of urethra** it become continuous with the mucous membrane of the urethra. The ski covering the glans is provided with papillæ, but these do not appea on the surface. The duplicature, which the skin forms in the regio

the glans, is called the prepuce. The under part of the prepuce connected to the under surface of the glans by a median, laterally npressed, triangular fold, called the **frenulum,** which extends as far the lower part of the external orifice of urethra. Sebaceous glands ve been described by Kölliker as present on the inner surface of the epuce, particularly in the region of the frenulum, and less constantly the glans and at the corona. Glands in these regions were first ted by Tyson in the orang, and are sometimes in consequence named er him. Whether they exist in man or not is a matter of some doubt; rtain histologists do not hesitate to deny their presence, and attribute e so-called secretion under the prepuce—the **smegma preputii**—to the eaking down of desquamated epithelial cells. The **dartos muscle** is uated immediately beneath the skin, and is destitute of adipose sue. It is continuous with fatty superficial and deeper membranous

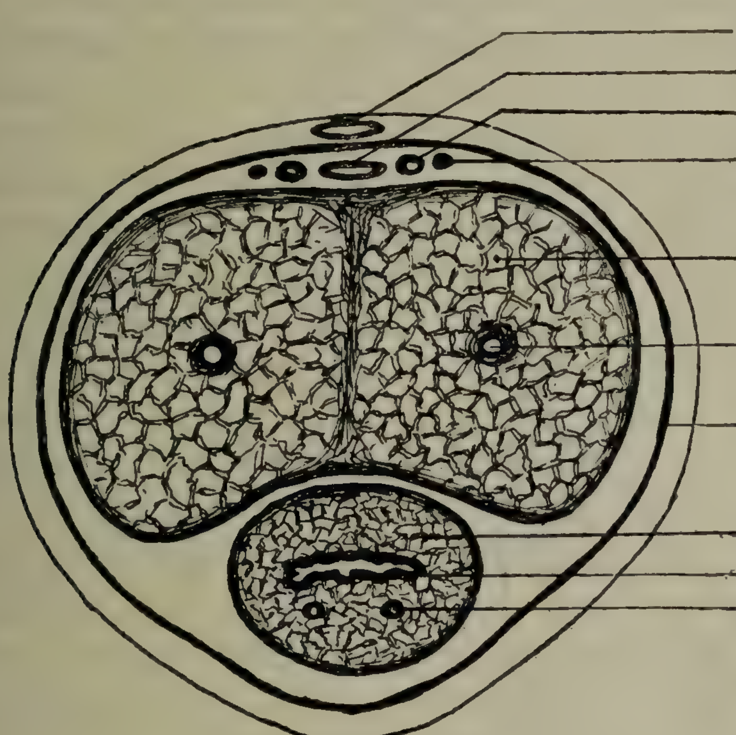


FIG. 421.—DIAGRAM OF SECTION ACROSS THE PENIS (ENLARGED).

yers of the fascia of the anterior abdominal wall, and with the dartos uscle of the scrotum, like which latter it contains involuntary muscular ssue. The **fascial investment** or **sheath** is rich in elastic fibres, and vers the penis, with the exception of the glans. It is situated beneath e dartos muscle, from which it is separated by loose areolar tissue, d at the neck blends with the skin of the glans. Towards the root the organ it receives expansions from the ischio-cavernosus and lbo-spongiosum muscles, and covers the dorsal vessels and nerves. this way the dorsal vein is compressed during the action of these. t the root of the organ the fascial investment blends with the two yers of the suspensory ligament.

Suspensory Ligament.—This ligament, sometimes called the deep spensory ligament, is strong and triangular in outline, and is composed of fibrous and elastic tissues. It is attached superiorly to the ont of the symphysis pubis, where it is single, and inferiorly it divides

into two laterally-disposed, diverging laminæ, which blend with t fascial sheath of the penis. The interval between the two laminæ occupied by the dorsal vessels and nerves. The ligament is part formed from fibres continued into it from the aponeurosis of t external oblique muscle.

The Dorsal Arteries.—For the description of these arteries, s p. 688.

In addition to the dorsal artery, the skin of the organ is suppli by the superficial external pudendal arteries, the branch from each these vessels lying lateral to the dorsal artery or penis.

Deep Dorsal Vein.—The tributaries which give rise to this ve come from the glans and corpora cavernosa. They form at first tv dorsal veins, but these soon unite into one vessel, which passes bac wards in the middle line, occupying the groove between the corpo cavernosa, where it is under cover of the fascial sheath of the peni At the root of the organ it passes between the two laminæ of the su pensory ligament, and then between the inferior and transverse perine ligaments. In this part of its course it communicates with the veno plexus in the sphincter urethræ muscle in which the internal pudend venæ comites arise. On entering the pelvis it divides into two branche which terminate in the right ar left portions of the prostat plexus of veins.

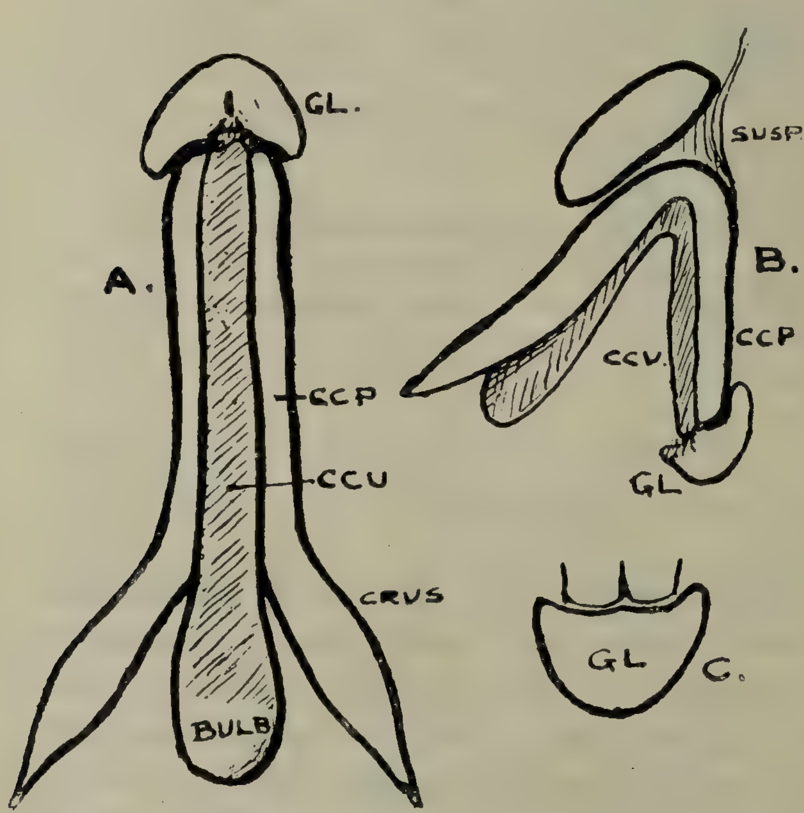


FIG. 422.—PLANS TO SHOW STRUCTURE OF PENIS.

A, ventral aspect; B, lateral; C, terminal, showing glans covering the ends of corp. cav. penis; CCP, corp. cav. penis; CCU, corp. spongiosum; GL, glans; susp., suspensory ligament.

In addition to the deep dors vein, there are two **superficial dors veins** which take up blood from tl glans and skin. Each accompani a branch of the superficial extern pudendal artery, and opens into tl superficial external pudendal vein

For a description of th dorsal nerves of the penis, se p. 689.

The relation of the struc tures on the dorsum of the peni from the middle line outward is as follows: deep dorsal vei dorsal artery, and dorsal nerv

Composition of the Penis.– The penis has two surfaces– upper or dorsal, and under c scrotal. Viewed as a whol the organ is composed of thre cylindrical bodies—namely, tw corpora cavernosa and a corpu spongiosum—closely applied t each other. It is divisible int a root, body, neck, and glans. The **root** is formed by the crura c the corpora cavernosa, which are attached to the inner margins c

: ischio-pubic rami. The upper surface of the root is also connected the symphysis pubis by the suspensory ligament. The upper or rsal surface of the **body** is formed by the corpora cavernosa, the der or scrotal surface being formed by the corpus spongiosum in the ddle line and the corpora cavernosa at either side. The corpora vernosa and corpus spongiosum at their meeting become flattened, d so the shape of the body is subcylindrical. The corpora cavernosa minate in round extremities, in front of which the corpus spongiosum rns upwards, and, becoming much enlarged, forms the glans penis. ie **neck** is the constriction between the body and the glans. The **ins penis** is formed by the corpus spongiosum. It is somewhat nical, and has been likened to an acorn, from which circumstance it s been called the *balanus*. At the base there is a wheel-like rim, lled the **corona glandis.** The part anterior to the corona is called : body of the glans, and presents anteriorly a vertical fissure lled the **external orifice of urethra.** For the structure of the penis, : p. 682.

Lymphatics.—These are divided into a superficial and deep set.

The **lymphatics** of the *prepuce* form a finely meshed plexus which the region of the corona communicates with the lymphatics of the ins. The collecting trunks from the plexus pass backwards, forming single median vessel, double bilateral, or more frequently multiple ssels, which run on the dorsum of the penis and receive as they go butary lymphatic vessels from the suprathecal portion of the penis. ı reaching the symphysis the vessels turn some to the right, others the left—a single vessel dividing—and running immediately under e skin terminate in the superficial inguinal glands. Owing to the e anastomosis which exists between the vessels, the glands of either le may become infected from a septic focus on one side.

The lymphatics of the *glans* form a very finely meshed plexus, e collecting trunks from which pass downwards, at the side of the nulum, and then, after communicating with the lymphatics of the epuce and the anterior part of the urethra, pass dorsally surrounding e corona glandis, after which they run backwards along the dorsum rallel with those from the prepuce, but lying deep to, instead of perficial to, the sheath of the penis, receiving in their course tributary mphatics from the infrathecal portion of the penis. On reaching the mphysis they form a plexus in which occasionally small presymphysial mph nodules are to be found, and then pass outwards either to the ep inguinal glands or through the femoral and inguinal canals to the ands forming the medial and lateral chains respectively of the external ac glands.

The lymphatics of the **clitoris** correspond with those of the penis.

Scrotum.—The wall of the scrotum is complex, and its constituent rts will be made more evident if they are enumerated in the order which the testes receive them in their original descent from the dominal cavity. It may be premised that the descent of each stis is preceded by a process of peritoneum, called the processus

vaginalis, the lower part of which remains permanent as the tun vaginalis testis, the upper part becoming obliterated, and be normally represented in the adult, if at all, by a fibrous cord. T constituent parts of the scrotal wall, enumerated from within outwar are as follows: tunica vaginalis testis, subperitoneal areolar tiss internal spermatic fascia, cremasteric muscle and fascia, exter spermatic fascia, dartos muscle, and skin.

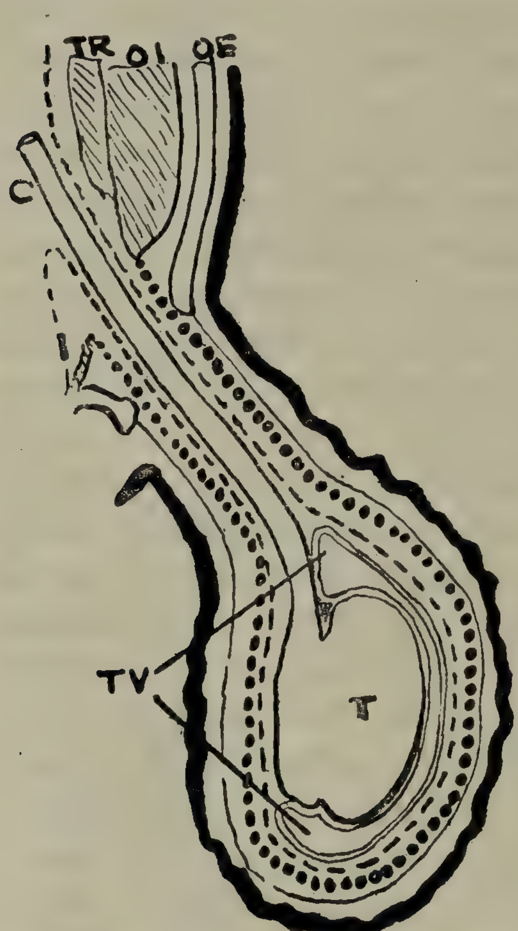


FIG. 423.—PLAN OF STRUCTURE OF SCROTAL WALLS.

TV, tunica vaginalis; C, cord; T, testis. The coverings, deep to the corrugated skin, are (1) external spermatic fascia (from external oblique) shown by a fine line; (2) dotted line, cremasteric fascia from internal oblique; (3) interrupted line, internal spermatic fascia from transversalis fascia.

The **tunica vaginalis testis** is the pari layer of the tunica vaginalis.

The **subperitoneal areolar tissue** is compo of areolar and adipose tissues, and a cert amount of plain muscular tissue.

The **internal spermatic fascia** is deri from the fascia transversalis at the margins the deep inguinal ring, in which vicinity it called the **infundibuliform fascia.** In assoc tion with the subperitoneal areolar tissue forms the *fascia propria* of Cooper.

The **cremasteric fascia** is composed striated muscular tissue, forming the cremas muscle, and of areolar and elastic tissues. is traceable superiorly to the lower border the internal oblique, the deep surface of inguinal ligament, and the pubic tubercle.

The **external spermatic fascia** is compos of connective tissue, and is derived from t intercrural fibres which extend between t columns of the superficial inguinal ring. T above three layers of fasciæ are so closely corporated as to be indistinguishable fro one another.

The **dartos muscle** lies immediately with the skin. It is derived from the fatty supe ficial and deeper membranous layers of t fascia of the anterior abdominal wall. It chiefly composed of plain muscular tissue, b it also contains fibro-areolar and elastic tissue and it has a brick-red colour.

The **skin** is thin, very extensible, dark colour, and provided with hairs, sweat-gland and sebaceous glands. It is more depende on the left side on account of the low position of the left testis. In the middle li it presents a raphé, which is continuous behin with that of the anterior part of the perineum and in front with that on the under surface the penis. This raphé is an external indication of the bilateral symmetry the scrotum. On either side of the raphé the skin is thrown into a number transverse rugæ, the corrugated condition being due to the plain muscular tissu of the dartos muscle.

The interior of the scrotum is divided into two compartment each of which lodges the corresponding testis. This division is effecte by the **scrotal septum,** formed by the fusion of the contiguous walls o the two scrotal chambers, except the skin, which forms one continuou investment to both. Inferiorly the septum is attached to the botton

he scrotal chamber and superiorly to the under surface of the root he penis.

Blood-supply.—The scrotum receives its chief arterial supply from superficial and deep external pudendal branches of the femoral of h side, and the superficial perineal branches of the internal pudendal eries.

The **veins** corresponding to these arteries terminate in the long henous and internal pudendal veins.

The cremasteric branch of the inferior epigastric of each side also es part in the supply of the scrotal wall, the venous blood being ırned into the inferior epigastric vein, which at its termination is gle.

Lymphatics.—The lymphatics of the scrotum are divided into a erior and an inferior set. They pass upwards and outwards to ninate in the superior and inferior groups respectively of the superal inguinal glands.

Nerve-supply.—The nerves of the scrotum are as follows: (1) the eral and medial posterior scrotal branches of the pudendal; (2) the g perineal nerve from the posterior cutaneous nerve of thigh; the ilio-inguinal from the lumbar plexus; and (4) twigs of the ital branch of the genito-femoral nerve from the lumbar plexus.

Development.—The genital swellings.

Muscles of Abdominal Wall—Obliquus Externus Abdominis—*Origin.* he outer surfaces of the lower eight ribs by means of eight fleshy s, the upper five of which interdigitate with slips of the serratus erior, and the lower three with slips of the latissimus dorsi.

Insertion.—(1) The anterior half of the outer lip of the iliac crest fleshy fibres. (2) By means of an aponeurosis into (*a*) the linea a, and so into the xiphoid cartilage and symphysis pubis; (*b*) the ic tubercle and crest of the opposite side by means of the reflected t of inguinal ligament; (*c*) the pubic tubercle and anterior superior c spine of the same side by means of the inguinal ligament; and the first inch of the pectineal line by means of the pectineal part he inguinal ligament.

Nerve-supply.—The lower five intercostal nerves and the subcostal ve.

Action.—(1) The two muscles, acting conjointly, diminish the size of the ominal cavity, and so compress the viscera, as in defæcation. (2) The two scles, acting conjointly from their origins, raise the front part of the pelvis flex it upon the thorax. (3) Acting conjointly from their insertions, they the thorax upon the pelvis, the vertebral column being also flexed in the er thoracic and lumbar regions; but, if the column is fixed, the two muscles ress the lower eight ribs. (4) One muscle, acting from its origin, is a lateral or of the pelvis. When it acts from its insertion it flexes the thorax towards wn side and rotates it to the opposite side.

Most of the fibres of the external oblique pass downwards and wards, coinciding in direction with those of the external intercostal scles. The only parts of the muscle which are free are the part

between the last rib and the iliac crest, and the part opposite the pu crest. The aponeurosis attains its greatest width and strength and below, the level of the anterior superior iliac spine, and it narrowest opposite the umbilicus. Superiorly it gives origin to fib of the pectoralis major. Crossing the fibres of the aponeurosis in upward and inward direction there are several superadded fibres. the lower part of the abdominal wall these are specially well mark

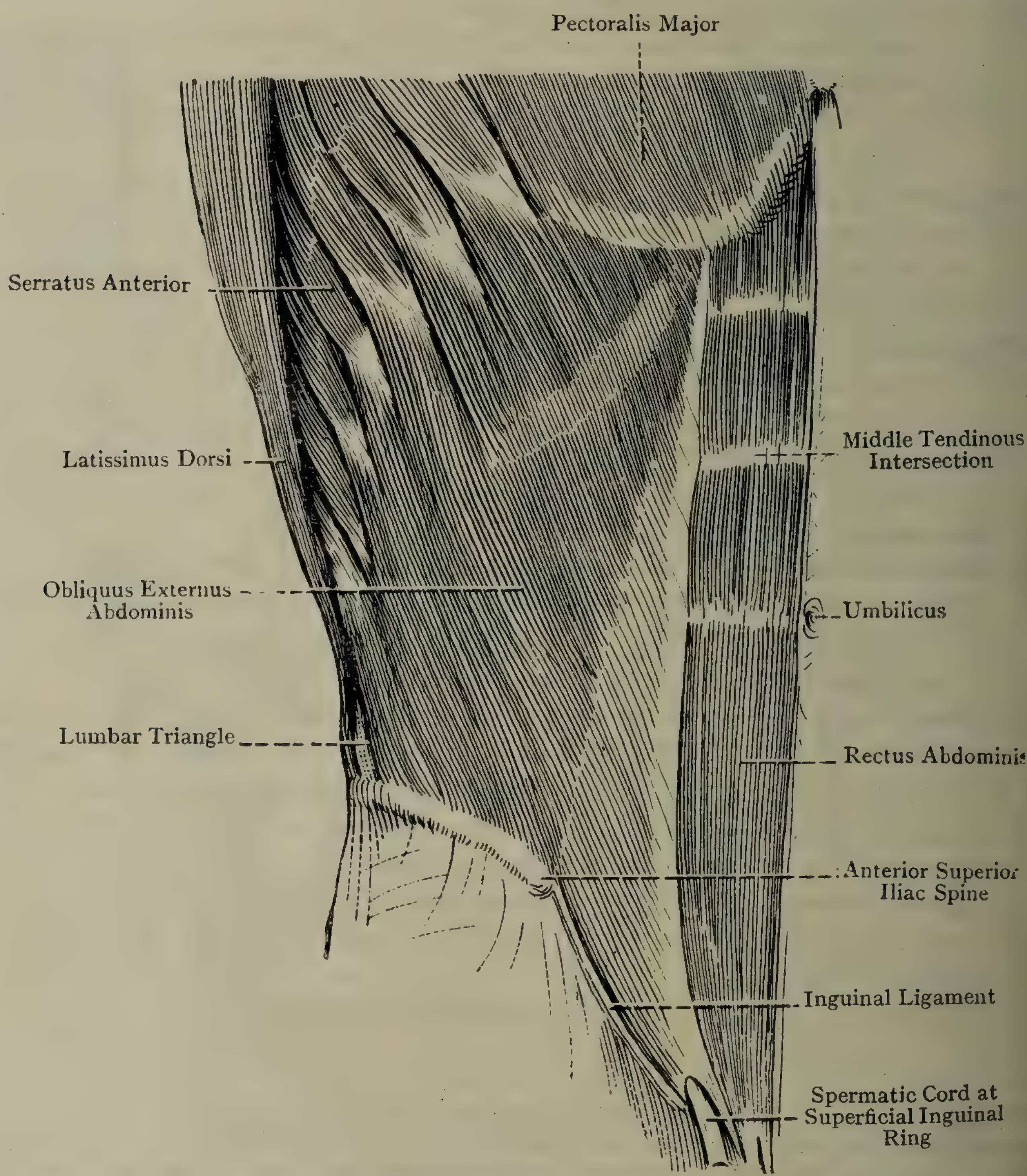


FIG. 424.—THE EXTERNAL OBLIQUE MUSCLE.

and are here spoken of as the **intercrural fibres.** Under this na they spring from the outer third of the inguinal ligament, whence th pass upwards and inwards in a curved manner, the convexity bei downwards. On arriving at the upper and outer part of the superfic inguinal ring they extend from one column to the other. They rou off and close the ring, and are prolonged upon the spermatic cord form the *external spermatic fascia.*

The following parts of the external oblique aponeurosis require cial description: inguinal ligament, pectineal part of inguinal ligant, the reflected part of inguinal ligament, the superficial inguinal g, and the linea alba.

Inguinal ligament (**Poupart's**) is the thickened lower border of the ernal oblique aponeurosis, which is folded backwards. Laterally s attached to the anterior superior iliac spine, and medially to the oic tubercle, from which it is reflected outwards and backwards on the pectineal line for fully 1 inch to form its *pectineal part.* The ment is curved, the convexity being directed downwards and outrds, due to the attachment of the iliac lamina of the fascia lata to its er border. The convexity is greatest when the thigh is extended, lucted, and rotated outwards, in which position the fascia lata on front of the thigh is tightened.

Relations—*Superficial.*—Skin; the superficial and deeper layers of the fascia he anterior abdominal wall; superficial epigastric vessels, a little to the inner of the centre; superficial circumflex iliac vessels just below its outer part; and superficial inguinal glands along its lower border. *Deep.*—Internal oblique, nsversus abdominis, and cremaster muscles, which take part of their origin n its deep surface; the ilio-psoas and pectineus; the fascia transversalis and ia iliaca, which are attached to its lateral portion, forming a canal containing deep circumflex iliac vessels; the fascia transversalis, forming the anterior l of the femoral sheath; the deep femoral arch, femoral vessels, deep inguinal nds, and lymphatic vessels; the femoral and genito-femoral nerves, and the ral cutaneous nerve of thigh.

The **deep femoral arch** is a thickening of the fascia transversalis as it passes nwards beneath the inguinal ligament to form the anterior wall of the femoral ath. The thickening is due to superadded fibres which extend inwards from centre of the inguinal ligament on its deep aspect to the pectineal line, where y are attached behind its pectineal part near its base.

The pectineal part of inguinal ligament (**Gimbernat's**) is the reflection he inguinal ligament from the pubic tubercle along the pectineal line. length is fully 1 inch, and it is triangular, the apex being at the oic tubercle. It presents three borders and two surfaces. Two of borders are fixed, one, called the *inguinal border,* being continuous h the inner end of the inguinal ligament, and the other, called the *tineal border,* being implanted on the pectineal line. The third der is free, and is called the **base.** It is sharp, wiry, and concave, l is situated immediately to the inner side of the femoral ring. The faces of the ligament are femoral and abdominal. They occupy oblique plane, the *femoral surface* looking downwards, forwards, and ghtly outwards, whilst the *abdominal surface* looks upwards, backrds, and slightly inwards. This latter surface, along its line of juncn with the inguinal ligament, forms the floor of the inguinal canal in lower third, where it supports the spermatic cord in the male, and ligamentum teres of the uterus in the female. The fascia transrsalis is attached to the base of the ligament on its abdominal ect, and the conjoint tendon and fascia transversalis lie behind it the pectineal line. A few of the fibres of the superior cornu of the phenous opening terminate on the femoral surface of the ligament,

and the pectineus muscle and pubic lamina of the fascia lata are front of its pectineal attachment.

The **reflected part of inguinal ligament (triangular fascia),** also know as the *ligament of Collès,* is situated behind the spermatic cord ar superior crus of the superficial inguinal ring. Its fibres are derive from the external oblique aponeurosis of the opposite side; havir crossed the linea alba, they gain insertion into the pubic tubercle ar

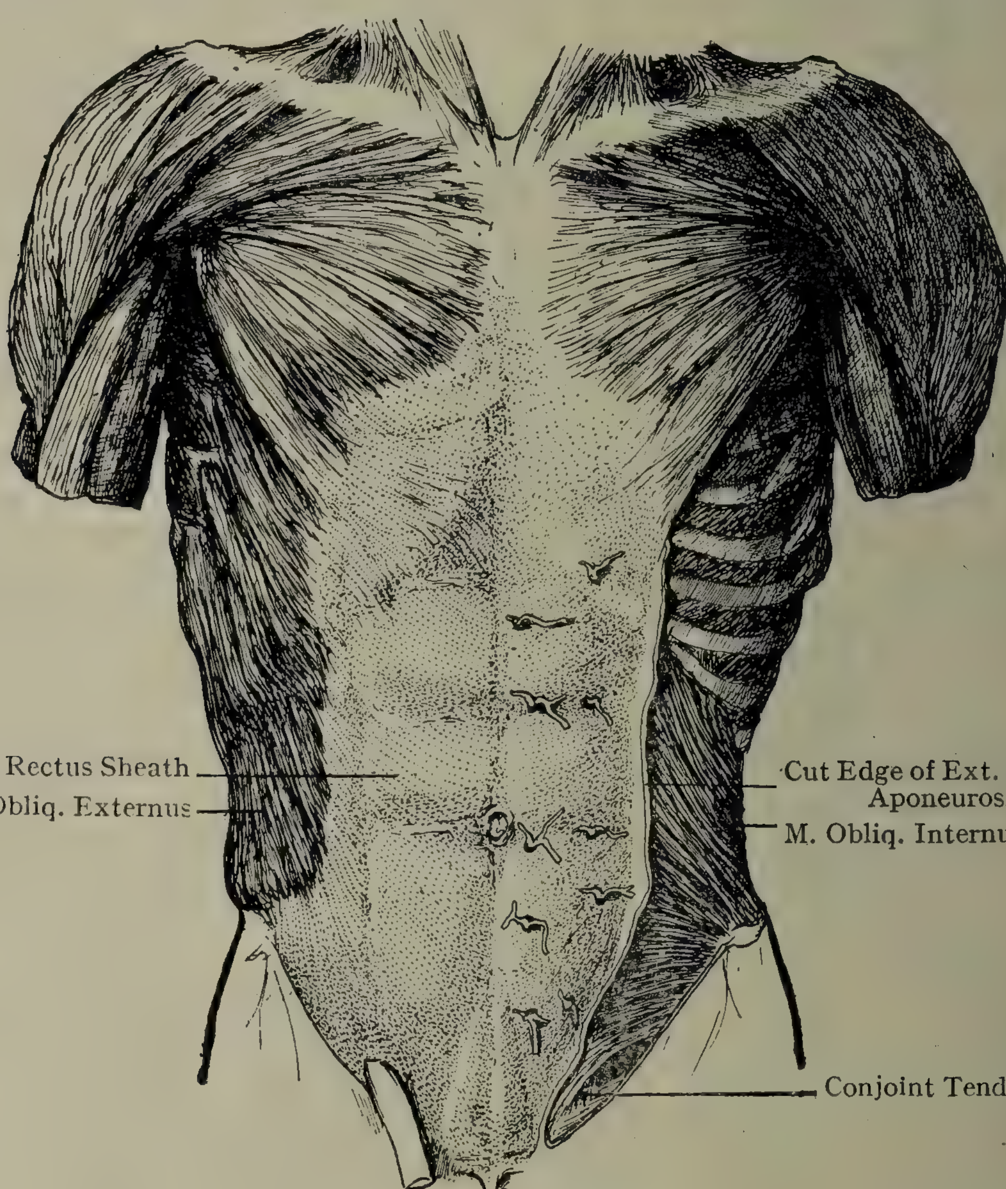


FIG. 425.—ANTERIOR VIEW OF MUSCLES AND APONEUROSES.

External oblique removed on one side to expose the internal oblique. Termin cutaneous branches of nerves shown on one side, coming through sheat of rectus.

crest. A portion of the fascia is seen lying in the lower and inner par of the superficial inguinal ring.

The **superficial inguinal (external abdominal) ring** is an opening i the aponeurosis of the external oblique, and is situated immediatel above the pubic tubercle. It serves for the passage of the spermati cord in the male, and the ligamentum teres of the uterus in the female In the natural condition no opening is perceptible, the intercrura fibres rounding it off, and being prolonged downwards upon the trans mitted structure. When the intercrural fibres and fascia have bee removed, the ring is seen to be formed in the following manner: th

ɔres of the external oblique aponeurosis, as they approach the os ıbis, are disposed in two diverging bundles. One bundle, which ·presents the inner end of the inguinal ligament, is fixed to the pubic ıbercle. The other bundle passes to be attached to the front of the ʼmphysis pubis, where its fibres decussate with those of its fellow f the opposite side, the fibres from the right side being superficially laced. An interval is thus left between these diverging bundles, hich is widest at the lower and inner part, where it corresponds with

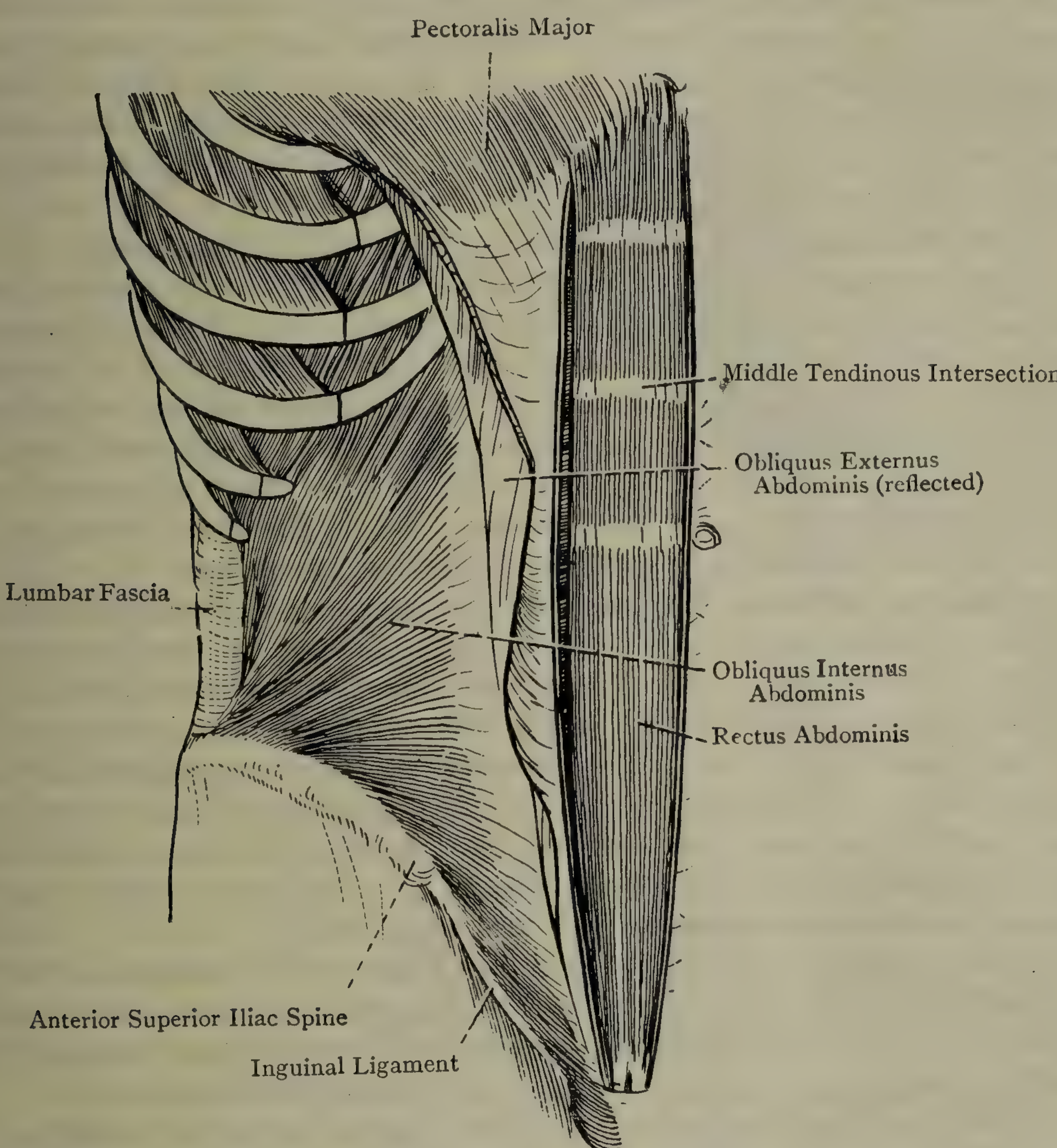


FIG. 426.—THE INTERNAL OBLIQUE MUSCLE.

ı portion of the pubic crest. This interval is the superficial inguinal ·ing. Its direction is upwards and outwards, and it is parallel with ·he inner part of the inguinal ligament. Its length is from 1 inch to $1\frac{1}{2}$ inches, and its breadth at the base about $\frac{1}{2}$ inch. It is triangular, the base being formed by part of the pubic crest, and the apex being directed upwards and outwards. The margins of the ring are called the crura. From the oblique position of the ring one crus is lateral and inferior, the other being medial and superior. The *superior crus*, which is thin and straight, passes to be attached to the front of the

symphysis pubis. The *inferior crus* is at first thin, but it soon becomes thick and prismatic, and is fixed to the pubic tubercle. It presents superiorly a concavity which lodges the spermatic cord in the male and the ligamentum teres of the uterus in the female. The external spermatic fascia is attached to both crura, lying upon the spermatic cord. Certain of the lower intercrural fibres are directed with their concavity downwards, and, passing beneath the cord, serve to round off the lateral margins of the ring. The presence of the fascia explains why urine, extravasated into the perineum, does not find its way into the inguinal canal. Within the lower and inner part of the ring is the reflected part of inguinal ligament, and directly behind the ring is the conjoint tendon, which strengthens what would otherwise be a weak part of the abdominal wall. The ring is smaller in the female than in the male.

The **linea alba** has been already described (see p. 704).

The **lumbar triangle (triangle of Petit)** is only present when the latissimus dorsi and external oblique do not meet. It is situated immediately above the centre of the iliac crest, and is bounded *in front* by the posterior border of the external oblique, *behind* by the anterior border of the latissimus dorsi, and *below* by the central portion of the iliac crest. It is covered only by skin and fascia, and its *floor* is formed by a part of the internal oblique. In this situation a lumbar hernia may occur, or a lumbar abscess may find its way to the surface.

Obliquus Internus Abdominis—*Origin.*—(1) The deep or abdominal surface of the inguinal ligament over its outer half or two-thirds; (2) the middle lip of the iliac crest over its anterior two-thirds; and (3) the *posterior layer* of the lumbar fascia of the transversus abdominis.

Insertion.—(1) The lower borders of the cartilages of the lower three ribs; (2) the lower borders of the cartilages of the seventh, eighth, and ninth ribs, and the side of the xiphoid process of the sternum; (3) the linea alba in its whole length; (4) the pubic crest; and (5) the medial portion of the pectineal line for ½ inch.

Nerve-supply.—This is similar to that of the external oblique, with the addition of twigs from the ilio-inguinal nerve and the anterior branch of the ilio-hypogastric, both of which are derived from the lumbar plexus, more particularly the first lumbar nerve.

Action.—This is similar to that of the external oblique. When the right internal oblique acts simultaneously with the left external oblique, the trunk is rotated to the right side, and *vice versa.* To understand this action, it is to be noted that the fibres of the internal oblique of one side coincide in direction with those of the external oblique of the opposite side.

Most of the fibres pass upwards and forwards across those of the external oblique, coinciding in direction with those of the internal intercostal muscles. The fibres from the inguinal ligament, however, pass downwards and inwards, and join the corresponding fibres of the transversus abdominis to form the conjoint tendon. The aponeurosis is broader above than below. In its upper three-fourths it divides at

e outer border of the rectus abdominis into two laminæ, one of which .sses in front of the muscle and the other behind it. The anterior mina joins the aponeurosis of the external oblique, and the posterior mina joins the *anterior* aponeurosis of the transversus. It is this tter lamina which has an insertion into the seventh, eighth, and ninth stal cartilages and xiphoid process. In its lower fourth the aponeurosis ;ain divides at the outer border of the rectus, but the division is not apparent; the fibres forming the anterior lamina pass as before in ont of the rectus to join the aponeurosis of the external oblique; e fibres forming the posterior mina, on the other hand, curve ›wnwards, and, passing along e outer border of the rectus, in the aponeurosis of the transersus, the fibres of which are milarly directed, to form the onjoint tendon, which in certain ises may be said to form a slot which the outer border of the ectus fits. The fibres of the uscle which arise from the inuinal ligament are at their rigin in front of the spermatic ord as it lies in the upper third f the inguinal canal. They then rch over it, and finally descend ehind it as it lies in the lower wo-thirds of the inguinal canal. n this latter situation the fibres ave terminated in the conjoint endon.

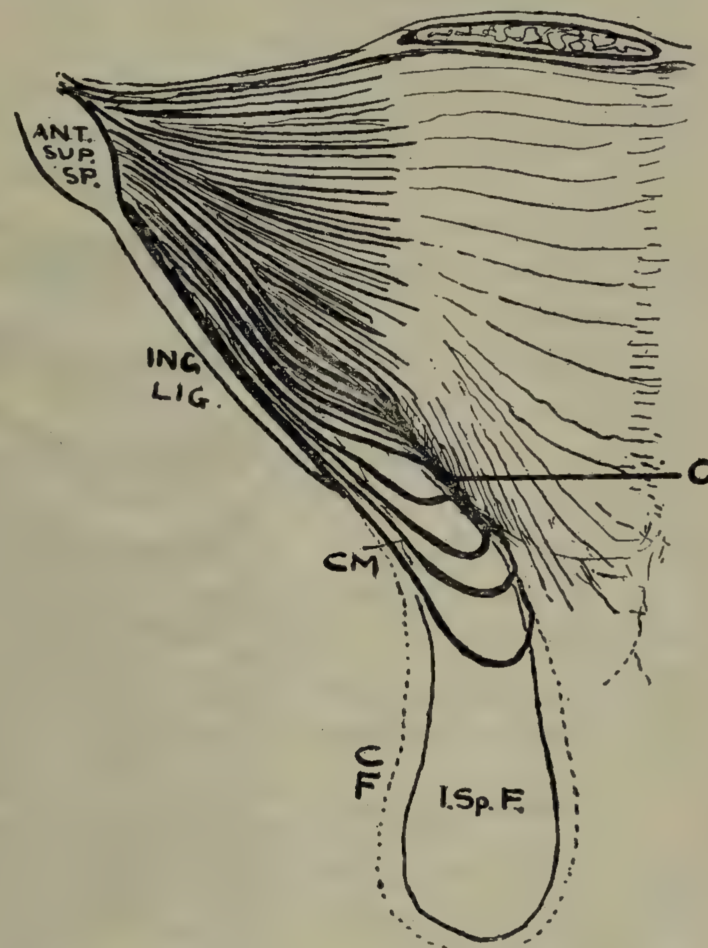


FIG. 426A.—DIAGRAM TO SHOW HOW THE LOWER FIBRES OF INTERNAL OBLIQUE FORM A CREMASTER MUSCLE (CM) CONTINUOUS WITH CREMASTERIC FASCIA (CF).

I.Sp.F., internal spermatic fascia; C, conjoint tendon.

Cremaster—*Origin.*—The deep spect of the inguinal ligament n its inner part. A few fibres re also derived from the lower order of the internal oblique. The fibres descend in a series of loops upon the outer and nterior aspects of the spermatic cord. The lowest loops reach the unica vaginalis of the testis, upon the upper part of which they spread out in an arched manner, some of the fibres terminating on t. The other loops are successively shorter from below upwards, and ascend on the inner and posterior aspects of the cord, where they become tendinous and indefinite, to gain *insertion* into the pubic tubercle and anterior lip of the pubic crest. The loops of the muscle are separated by intervals occupied by areolar tissue. This combination of muscular loops and areolar tissue forms the *cremasteric fascia.* The cremaster muscle lies in series with the lower border of the internal

oblique, and is peculiar to the male. It is occasionally represented i the female by a few fibres which descend on the ligamentum teres c the uterus in the inguinal canal.

Nerve-supply.—The genital branch of the genito-femoral nerv from the lumbar plexus, more particularly from the first and th ventral division of the second lumbar nerves.

Action.—To support and raise the testis towards the superfici inguinal ring. The fibres composing the muscle are of the *striate* variety, but the action is involuntary, and of a reflex character.

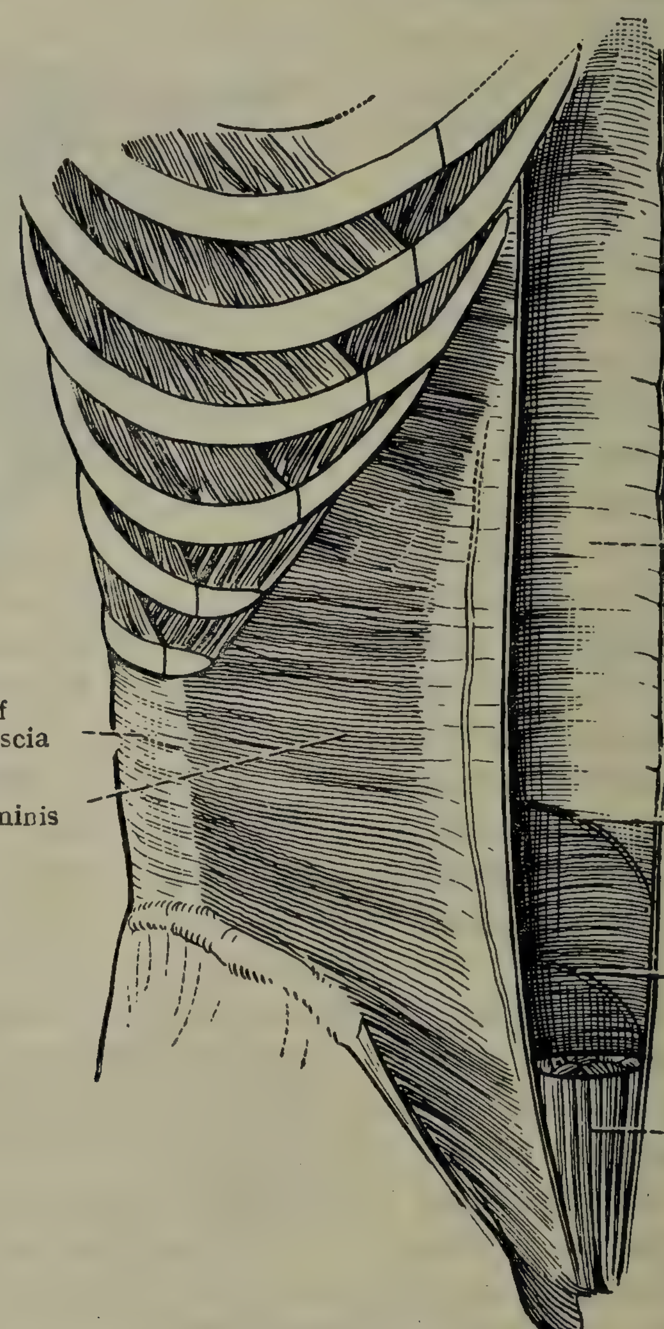


FIG. 427.—THE TRANSVERSUS ABDOMINIS MUSCLE.

Cremasteric Reflex.—The *afferent* nerve involved in the cremasteric reflex either the **ilio-inguinal,** which is distributed to the side of the scrotum and inne side of the thigh, or the **femoral branch** of the **genito-femoral,** which is distribute to the integument over the femoral triangle. The *efferent* nerve is the **genit branch** of the **genito-femoral.**

Transversus Abdominis—*Origin.*—(1) The deep aspect of the in guinal ligament over its outer third; (2) the inner lip of the iliac cres over its anterior two-thirds; (3) the lumbar fascia, which by its *posteri*

er is connected with the spinous processes of the lumbar and sacral rtebræ and the posterior fourth of the outer lip of the iliac crest, by *middle layer* with the tips of the lumbar transverse processes, and its *anterior layer* with the anterior surfaces of the lumbar transrse processes; and (4) the inner surfaces of the cartilages of the ver six ribs by six slips which interdigitate with slips of the aphragm.

Insertion.—(1) The linea alba; (2) the pubic crest; and (3) the edial portion of the pectineal line for 1 inch.

Nerve-supply.—This is similar to that of the internal oblique.

Action.—To diminish the capacity of the abdominal cavity, and compress the viscera. To a limited extent the two muscles aid e external and internal oblique muscles in elevating the pelvis, flexing e thorax, and depressing the ribs.

Most of the fibres pass transversely forwards, and terminate in the nterior aponeurosis. The fibres, however, from the inguinal ligament ass downwards and inwards, and join the corresponding fibres of the ternal oblique to form the conjoint tendon. The *anterior aponeurosis* narrow above, but broad below. The narrowness above is due to e fact that for some distance below the xiphoid process the muscular bres of the transversus are continued behind the rectus, and only ecome aponeurotic on nearing the linea alba. In its upper threeurths the aponeurosis passes behind the rectus muscle, but in its wer fourth it passes down along its lateral margin. The transversus odominis is continuous superiorly with the transversus thoracis muscle, nd its lower border is free where it arches over the spermatic cord or e ligamentum teres of the uterus.

For the *posterior aponeurosis* of the muscle, see p. 840.

Conjoint Tendon.—This is the tendon which gives a common inseron to the fibres of the internal oblique and transversus abdominis uscles which arise from the inguinal ligament. It is *inserted* into 1) the pubic crest, and (2) the medial portion of the pectineal line or 1 inch. The tendon is formed principally by the transversus bdominis, which extends for 1 inch along the pectineal line, whilst the nternal oblique only extends along that line for ½ inch.

Relations—*Superficial.*—The structures in front of the conjoint tendon, from he middle line outwards, are as follows: the lower part of the superior crus of the uperficial inguinal ring; the triangular fascia; the insertion of the cremaster; ectineal part of inguinal ligament; the inner part of the inguinal ligament; and he spermatic cord. *Deep.*—The fascia transversalis.

The conjoint tendon varies greatly in development, and in many cases is ardly distinguishable. As a rule, it covers the inner two-thirds of the floor f the inguinal triangle, where it lies behind the inner two-thirds of the inguinal anal, and has the spermatic cord, or the ligamentum teres of the uterus, as a uperficial relation. It also lies directly behind the superficial inguinal ring, and o strengthens what would otherwise be a weak part of the abdominal wall.

Interfoveolar Ligament.—In normal circumstances the conjoint tendon is imited to the first inch of the medial portion of the pectineal line. Sometimes, however, the anterior aponeurosis of the transversus abdominis is prolonged outwards beyond the normal limit of the conjoint tendon in the form of a thin

semilunar expansion which extends as far as the inner and lower parts of the deep inguinal ring, and is attached inferiorly to the deep crural arch. The semilunar expansion of the conjoint tendon is known as the **interfoveolar ligament**. Its concavity is directed outwards, and, when present, it covers the outer third of the floor of the inguinal triangle, where it lies behind the spermatic cord, and is closely connected with the subjacent fascia transversalis, to which it imparts strength.

An inspection of the external oblique, internal oblique, and transversus abdominis muscles shows that they cross each other at different angles, the external oblique passing downwards and forwards, the internal oblique upwards and forwards (these two muscles thus crossing like the limbs of the letter X), and the transversus horizontally forwards. They thus form an intricate lattice-work which renders the abdominal wall very strong, and is a powerful safeguard against hernial protrusions.

Rectus Abdominis—*Origin.*—This muscle arises by two heads, both of which are tendinous. The **lateral head,** broad and flat, arises from the pubic crest, and the **medial head,** narrow and somewhat rounded, from the fibrous structures in front of the symphysis pubis, where it is closely connected with its fellow of the opposite side. The two heads join about 1 inch above the symphysis pubis.

Insertion.—By means of three flat slips, which are at first fleshy and subsequently tendinous, into the anterior surfaces of the fifth, sixth, and seventh costal cartilages. The most medial slip is sometimes partially inserted into the side of the xiphoid process of the sternum.

Nerve-supply.—The lower five intercostal nerves and the subcostal nerve.

Action.—The action is similar to that of the two oblique and transversus muscles, with the exception that it does not produce lateral rotation of the thorax.

The muscle is long, flat, and strap-like, its fibres being directed vertically upwards by the side of the linea alba. It is narrow below and broad above, its greatest breadth being about 3 inches. Below the umbilicus the two muscles are very near each other, the interval between them being not more than about $\frac{1}{8}$ inch. Above the umbilicus, however, the muscles are separated by an interval of about $\frac{1}{4}$ inch. Each muscle is marked by *tendinous intersections* which cross it in a somewhat irregular manner at certain intervals. They are usually three in number, and are situated as follows: one at the level of the umbilicus, a second opposite the margin of the thorax, and a third about midway between these two. Sometimes there is a fourth intersection, which crosses the muscle a little below the umbilicus, but this one is faint, and does not usually extend the whole width. These intersections, which do not usually penetrate to the posterior surface, map out the upper part of the muscle into quadrangular areas, and are firmly bound to the anterior wall of its sheath. Above the level of the umbilicus, therefore, the interior of the sheath, anterior to the muscle, is divided into distinct compartments.

The tendinous intersections are the intersegmental parts of the lateral sheets of mesoderm. The muscles of the abdominal wall, including the rectus, are formed from ventral downgrowths derived from the somites, and therefore segmental in nature. The downgrowths pass ventrally in the lateral mesodermal sheet, and the parts of the lateral sheet remaining between the separate downgrowths are hence intersegmental; they are best marked between the ventral extremities of the downgrowths, which are not so broad here. The lateral sheet only forms the simple connective tissues in the trunk, never muscular tissue, and in most cases the intersegmental lines show as the tendinous lines in the rectus; in some animals, however, such as the crocodile, the connective tissue becomes fibro-cartilaginous in nature, making what are sometimes termed 'abdominal ribs' in these animals. In man they serve the purpose of strengthening the muscle.

Pyramidalis—*Origin.*—The front of the pubic crest.

Insertion.—The linea alba for 2 inches or more above the symphysis pubis.

Nerve-supply.—The subcostal nerve.

Action.—To render tense the linea alba.

The muscle is sometimes present only on one side; sometimes it is absent on both sides; and sometimes it is double on one or both sides. In man it is a small muscle, and vestigial like the plantaris; but it attains a large size in marsupials and monotremes, and is attached to the epipubic bone of these mammals. It is frequently separated in man from the rectus by a fascial expansion from the conjoint tendon.

Sheath of Rectus Abdominis.—Above the level of the thoracic margin the sheath of the rectus is deficient posteriorly, and is formed anteriorly by the aponeurosis of the external oblique; from the thoracic margin to a level about midway between the umbilicus and the symphysis pubis the **anterior wall** is formed by the anterior lamina of the internal oblique aponeurosis and the external oblique aponeurosis, the two being closely connected, and the **posterior wall** is formed by the posterior lamina of the internal oblique aponeurosis and the anterior aponeurosis of the transversus abdominis, these two being likewise closely connected. Below a line midway between the umbilicus and symphysis the anterior wall is formed by the aponeurosis of the external oblique reinforced by fibres derived from the aponeurosis of the internal oblique, and the posterior wall is only represented by the fascia transversalis, since part of the aponeurosis of the internal oblique here blends with the aponeurosis of the transversus to form the conjoint tendon, which, instead of passing inwards, curves downwards, skirting the lateral border of the rectus.

The line along which this transition occurs is curved with the concavity downwards, and is known as the **arcuate line (fold of Douglas)**. This so-called fold is extremely variable, sometimes scarcely apparent, at other times multiple. When well developed it is traceable to the linea alba at its upper and inner extremity, and to the pubic crest, where it blends with the inner edge of the conjoint tendon at its lower and outer extremity. It thus bounds supero-laterally a large oval area, within which the inferior epigastric vessels pierce the fascia trans-

versalis, and so enter the sheath of the rectus. These vessels, as th course upwards, pass anterior to the fold.

The **contents** of the sheath are as follows: the rectus abdomin pyramidalis, inferior epigastric vessels, superior epigastric vessels, a terminal parts of the lower five intercostal and subcostal nerves.

Relation of Structures at the Pubic Crest.—The relation of structures fr before backwards is as follows:

1. The reflected part of inguinal ligament.
2. The conjoint tendon splitting medianly to enclose the lateral margins the pyramidalis and rectus.
3. The pyramidalis.
4. The outer head of the rectus abdominis.
5. The fascia transversalis.

A few fibres of the cremaster are inserted into the pubic crest close to the pu tubercle.

Relation of Structures at the Medial Portion of the Pectineal Line.—The relati of structures from before backwards is as follows:

1. The pubic lamina of the fascia lata, incorporated with which is the pectine (ligament of Cooper) ligament.
2. The pectineus.
3. Pectineal part of inguinal ligament.
4. The conjoint tendon.
5. The fascia transversalis and the deep femoral arch.

Deep Nerves of the Abdominal Wall.—The **lower five intercost nerves,** after leaving the intercostal spaces, lie between the intern oblique and transversus abdominis, and pass downwards and forwar to the outer border of the rectus. Here they pierce in succession t posterior wall of the sheath, the rectus, and the anterior wall of t sheath, after which they terminate as the anterior cutaneous nerve In their course they supply the two oblique, the transversus, and t rectus muscles. Each nerve gives off a lateral cutaneous branch the mid-axillary line. These lateral cutaneous branches, having pierc the internal oblique, appear between the slips of the external oblique a divide into anterior and posterior branches.

The **subcostal nerve** is the anterior primary division of the twelf thoracic nerve. It is in series with the eleventh intercostal, but not ranked as an intercostal nerve, inasmuch as it lies along the low border of the twelfth rib. It is commonly spoken of as the *last thorac nerve.* Its abdominal relations, course, and distribution are simil to the preceding nerves, with an additional distribution to the pyram dalis abdominis. Its *lateral cutaneous branch,* which is undivide having pierced the internal and external oblique muscles, descen over the anterior part of the iliac crest 1 inch behind the anteri superior iliac spine, and is distributed to the skin of the anterior pa of the gluteal region as low as the greater trochanter of the femur; th nerve is very variable in size, and is not infrequently absent.

The **ilio-hypogastric nerve,** having pierced the posterior part of th transversus abdominis a little above the iliac crest, furnishes its *later cutaneous branch,* which perforates the internal and external obliqu and, having crossed the iliac crest at the junction of its middle an

nterior thirds, is distributed to the skin of the adjacent part of the luteal region. The nerve then continues its course forwards between ne internal oblique and transversus, supplying branches to these nuscles and communicating with the ilio-inguinal nerve. About inch in front of the anterior superior iliac spine it pierces the internal blique, and runs forwards between that muscle and the external blique aponeurosis. Finally, it pierces that aponeurosis about 1 inch bove the superficial inguinal ring, and is distributed to the skin of the ıprapubic region, where is in series with the nterior cutaneous nerves.

The **ilio-inguinal nerve,** s it passes forwards, lies ıst above, or it may be nedial to the inner lip of, ne iliac crest, beneath he transversus muscle. Iear the anterior part of he iliac crest it pierces he transversus, and here ommunicates with the nterior cutaneous branch f the ilio-hypogastric. t subsequently perforates he internal oblique, after vhich it descends through he lower two-thirds of he inguinal canal, and merges through the uperficial inguinal ring, vhere it lies lateral to the permatic cord. Finally, t is distributed to the kin of the inner side of he thigh in its upper hird, and to the skin of he scrotum or labium najus, according to the ex. The nerve in its course supplies branches to the internal oblique nd transversus muscles. The fibres of the ilio-hypogastric and ilio-nguinal nerve often run for a variable distance within the same sheath.

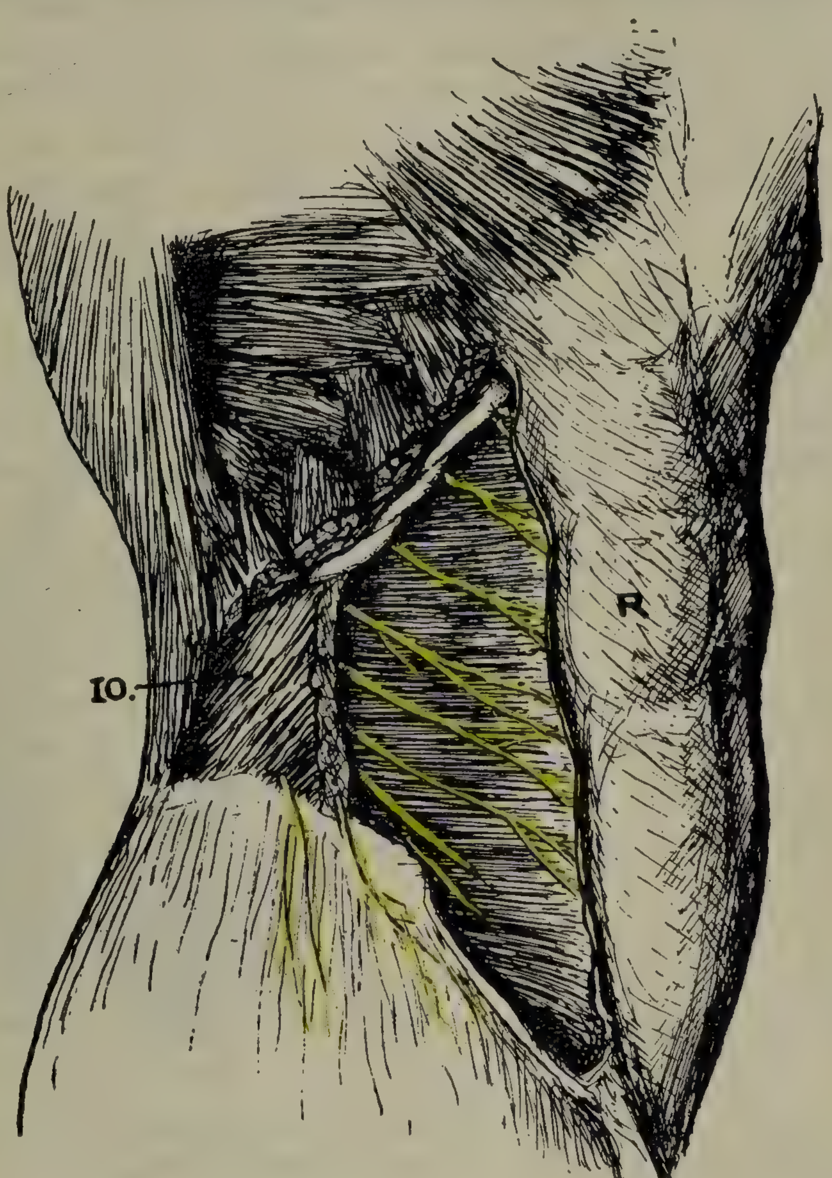


Fig. 428.—Deep Nerves of Abdominal Wall lying between Transversus and Internal Oblique (IO).

Deep Arteries of the Abdominal Wall.—The **inferior epigastric ırtery** arises from the inner side of the external iliac, about $\frac{1}{4}$ inch ıbove the inguinal ligament. At first for a very short distance it oasses inwards between the inguinal ligament and the lower border of the deep inguinal ring, lying in the extraperitoneal fatty tissue. It hen changes its course, and passes upwards and inwards, lying close to he inner side of the deep inguinal ring, only the external vena comes

intervening. On arriving at the outer border of the rectus abdomin at a point about midway between the upper border of the symphy pubis and the umbilicus, it pierces the fascia transversalis, and ascen within the sheath over the arcuate line of the sheath of the rect It then changes its course, and ascends vertically between the mus and the posterior wall of the sheath as high as the umbilicus. Here enters the muscle, and about 2 inches above the umbilicus ends in terminal branches, which anastomose with branches of the super epigastric artery. The inferior epigastric lies at first in the subpe toneal areolar tissue, having the parietal peritoneum on its deep surfa

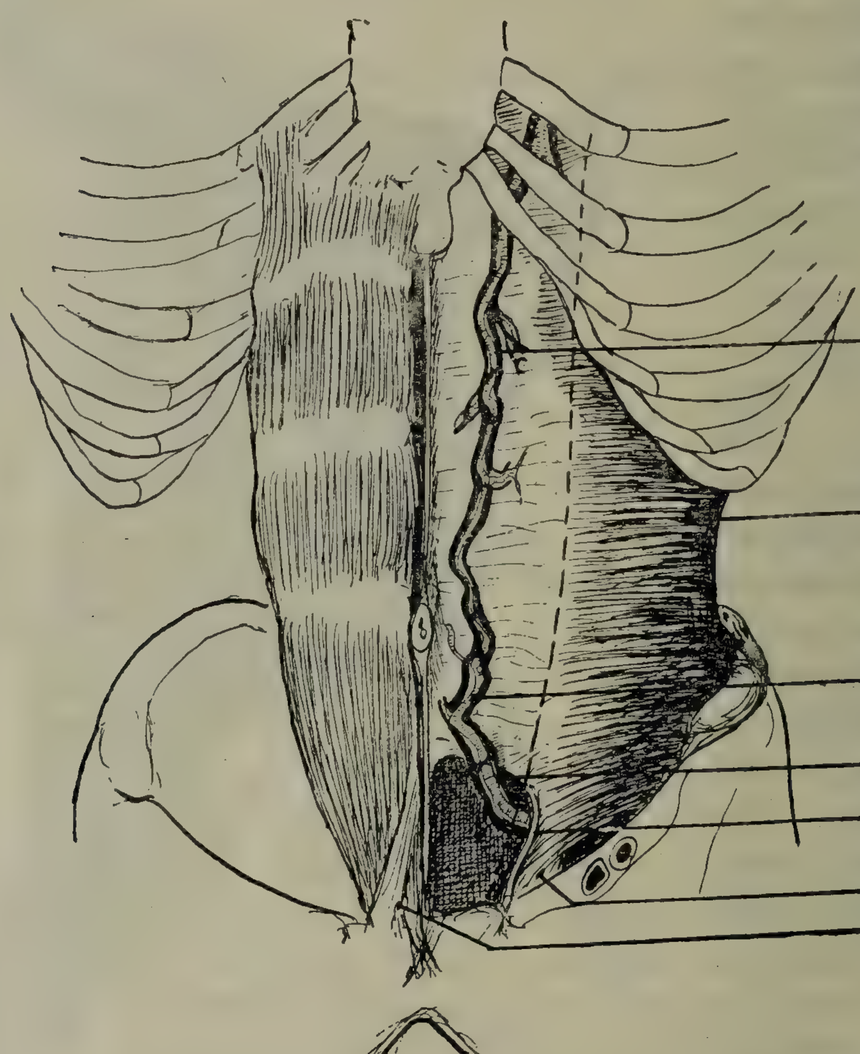


Fig. 429.—Scheme of Vascular Anastomosis on the Posterior Wall Sheath of Rectus.

and the fascia transversalis superficial to it. Shortly after passing t deep inguinal ring the vessel pierces the fascia transversalis, and in course to the outer border of the rectus forms the outer boundary the inguinal triangle. As the vessel turns from the lower border the inner sides of the deep inguinal ring it has the spermatic cord front of it, and the vas deferens here hooks round its outer side. T course of the vessel in its first or oblique part is indicated by a li drawn from the inner border of the deep inguinal ring to the out border of the rectus abdominis at a point about midway between t umbilicus and the upper border of the symphysis pubis. The cour of the second or vertical part of the vessel is represented by a vertic

ne corresponding with the centre of the rectus, and distant from the nea alba about $1\frac{1}{2}$ inches.

Branches.—These are as follows: cremasteric, pubic, muscular, utaneous, peritoneal, and terminal or anastomotic.

The *cremasteric artery* enters the spermatic cord and supplies the remaster muscle and the other coverings of the cord. It anastomoses rith the testicular artery, the superficial and deep external inferior rteries, and the superficial perineal artery. The cremasteric artery ; replaced in the female by the *artery of the ligamentum teres of the terus.*

The *pubic artery* passes inwards behind the inner half of the in-uinal ligament to the back of the body of the os pubis, where it anasto-ioses with the pubic branch of the obturator artery and its fellow of he opposite side.

The *muscular branches* arise chiefly from the outer side of the ıferior epigastric, and supply the two oblique, transversus, and rectus ıuscles. They anastomose with the lower two posterior intercostal rteries, the subcostal artery, the abdominal branches of the lumbar rteries, and a large ascending branch of the deep circumflex iliac rtery.

The *cutaneous branches* perforate the rectus and the anterior wall f its sheath, to be distributed to the skin, in which they anastomose vith branches of the superficial epigastric.

The *peritoneal branches* pierce the posterior wall of the sheath of he rectus, to be distributed to the adjacent parietal peritoneum.

The *terminal* or *anastomotic branches* enter the rectus above the evel of the umbilicus, and anastomose with the superior epigastric of the nternal mammary.

For the abnormal obturator artery, see p. 566.

There are two venæ comites with the inferior epigastric artery, one n either side. These ultimately join to form one vessel, which erminates in the external iliac vein.

The **superior epigastric artery** is one of the terminal branches of the nternal mammary from the first part of the subclavian. It descends ehind the seventh costal cartilage, passes between the sternal and ostal portions of the diaphragm, and enters the sheath of the rectus, vhere it lies at first between the muscle and the posterior wall of its heath. It then enters the muscle and anastomoses with the inferior pigastric. Its branches are as follows: *sternal,* which crosses in front f the xiphoid process and anastomoses with its fellow of the opposite ide; *phrenic,* to the diaphragm; *muscular,* to the muscles of the ab-lominal wall; *anterior cutaneous,* to the skin; *hepatic* (present only on he right side), which passes to the liver in the falciform ligament and nastomoses with the hepatic artery; and *peritoneal,* which pierce the osterior wall of the sheath of the rectus, to be distributed to the djacent parietal peritoneum. The vessel is accompanied by two enæ comites, which terminate in those of the internal mammary rtery.

The **deep circumflex iliac artery** arises from the outer side of t external iliac, nearly opposite the origin of the inferior epigastric. passes outwards and upwards behind the outer half of the ingui ligament, where it is contained in a canal formed at the junction the fascia transversalis and fascia iliaca. Having arrived at t anterior superior iliac spine, it pierces the fascia transversalis, a courses outwards and backwards along the iliac crest on its inn aspect. At its termination it anastomoses with the lumbar bran of the ilio-lumbar from the internal iliac. Over about the anter half of the iliac crest the artery lies beneath the transversus musc but about the centre of the crest it pierces that muscle, and sub quently lies between it and the internal oblique.

Branches.—In the first part of its course the vessel gives branches the ilio-psoas, sartorius, and tensor fasciæ latæ, in which latter mus it anastomoses with the ascending branch of the external circumfl from the arteria profunda femoris. As it courses along the iliac cr it furnishes branches to the muscles of the abdominal wall, some which reach the gluteal region, where they anastomose with the super gluteal of the internal iliac and the superficial circumflex iliac of t femoral. It also gives branches to the iliacus muscle, which anast mose with the iliac branch of the ilio-lumbar from the internal ili One of the muscular branches of the artery is very constant and large size. It springs from the vessel near the anterior superior ili spine, and, having pierced the fascia transversalis and transvers muscle, it ascends vertically between that muscle and the intern oblique, where it anastomoses with the abdominal branches of t lumbar arteries. This branch is usually spoken of as *the ascendi branch.*

The deep circumflex iliac artery is accompanied by two ven comites. These ultimately join to form one vessel, which crosses t external iliac artery from without inwards about $\frac{1}{2}$ inch above t inguinal ligament, and terminates in the external iliac vein.

The **lower two posterior intercostal arteries** ultimately leave t tenth and eleventh intercostal spaces, and pass towards the rect muscle, lying in their course between the internal oblique and tran versus. They anastomose with the superior epigastric, inferi epigastric, and subcostal arteries.

The **subcostal artery** lies below the last rib, and is in series wi the posterior intercostal arteries above and the lumbar arteries belo In the abdominal wall it anastomoses with the last intercostal, t abdominal branch of the first lumbar, and the superior epigastr arteries.

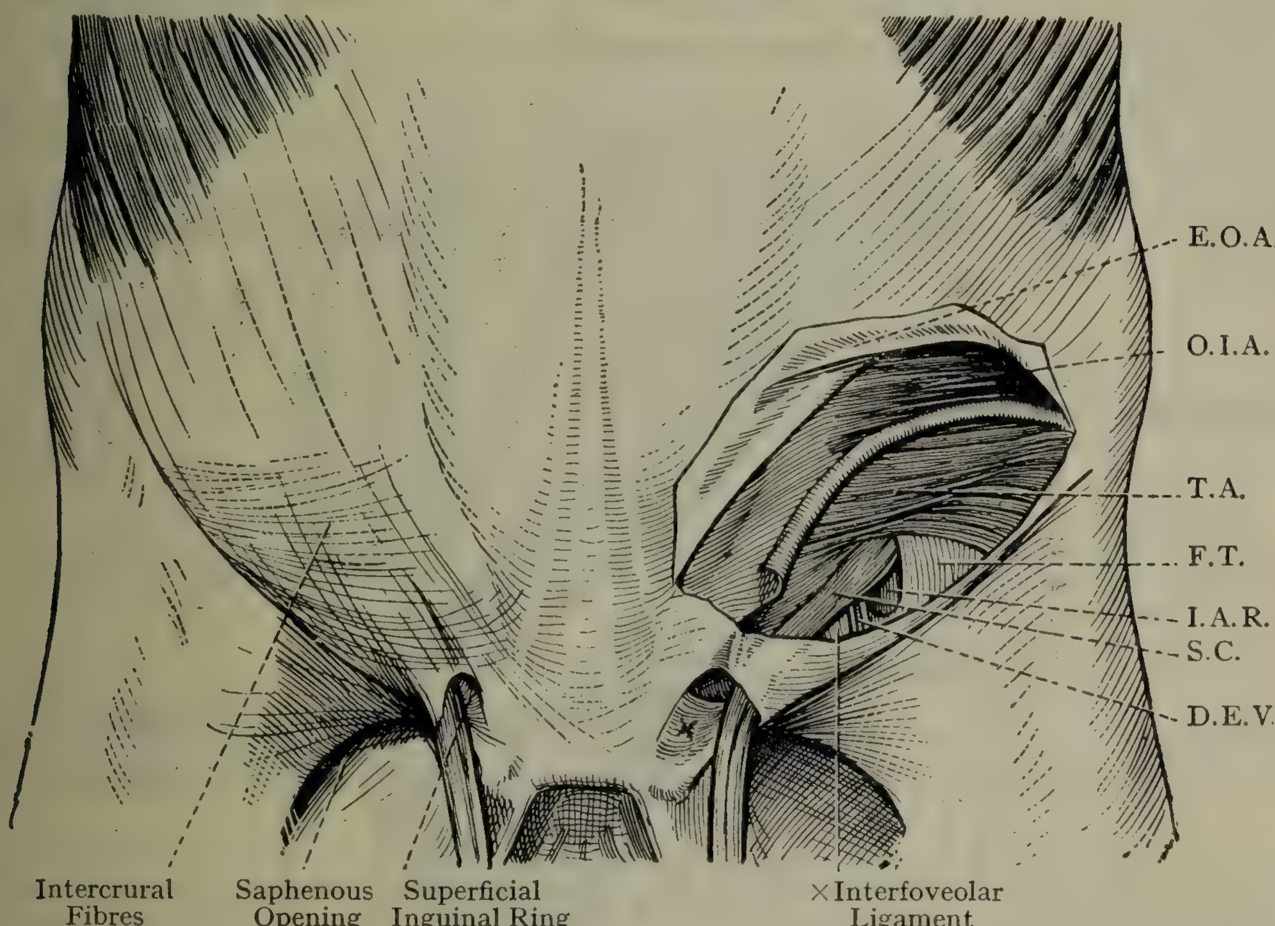
The **abdominal branches of the lumbar arteries** pass forward towards the rectus abdominis. They anastomose with the inferi epigastric, subcostal, and ascending branch of the deep circumfle iliac.

The veins corresponding to the lower two posterior intercost arteries terminate in the corresponding intercostal veins. The subcost

ein of the right side terminates in the azygos vein, and that of the eft side in the inferior vena hemiazygos. The veins accompanying he abdominal branches of the lumbar arteries terminate in the lumbar eins, which are tributaries of the inferior vena cava.

Deep Lymphatics.—The deep lymphatics of the lower part of the *nterior* abdominal wall accompany the inferior epigastric and deep ircumflex iliac vessels, and terminate in the external iliac glands; hose of the upper part accompany the superior epigastric artery, and erminate in the sternal glands.

The deep lymphatics of the lower part of the *lateral* abdominal vall accompany the abdominal branches of the lumbar arteries, and



IG. 430.—SUPERFICIAL AND DEEP DISSECTION OF THE LOWER PART OF THE ANTERIOR ABDOMINAL WALL (AFTER COOPER).

E.O.A. External Oblique Aponeurosis
O.I.A. Obliquus Internus Abdominis
T.A. Transversus Abdominis
F.T. Fascia Transversalis
I.A.R. Deep Inguinal Ring
S.C. Spermatic Cord
D.E.V. Inferior Epigastric Vessels
X. Reflected Part of Inguinal Ligament

erminate in the lateral group of lumbar glands; those of the upper art accompany the adjacent anterior intercostal and musculo-phrenic rteries, and terminate in the sternal glands.

For the superficial lymphatics of the antero-lateral abdominal vall, see p. 712.

Fascia Transversalis.—The fascia transversalis is situated undereath the transversus abdominis muscle. It is of greatest strength ver the lower part of the abdominal wall, particularly between the ower free border of the transversus and the inguinal ligament. When raced upwards to the costal margin it becomes very thin, and is there ontinuous with the fascia which covers the abdominal surface of the

diaphragm. Along the linea alba it is continuous with the fascia the opposite side. In the lumbar region it is continuous with t anterior wall of the sheath of the quadratus lumborum. In the regi of the iliac crest it is attached to the anterior two-thirds of the cre immediately medial to its inner lip, where it meets and becomes co tinuous with the fascia iliaca, both of these fasciæ being here interpos between the transversus and iliacus muscles. The most importa disposition of the fascia is along the line of the groin, where its attac ments are as follows: along the outer half of the inguinal ligament it firmly attached to that ligament on its deep aspect, and over th extent it meets and is continuous with the fascia iliaca, the two fasc

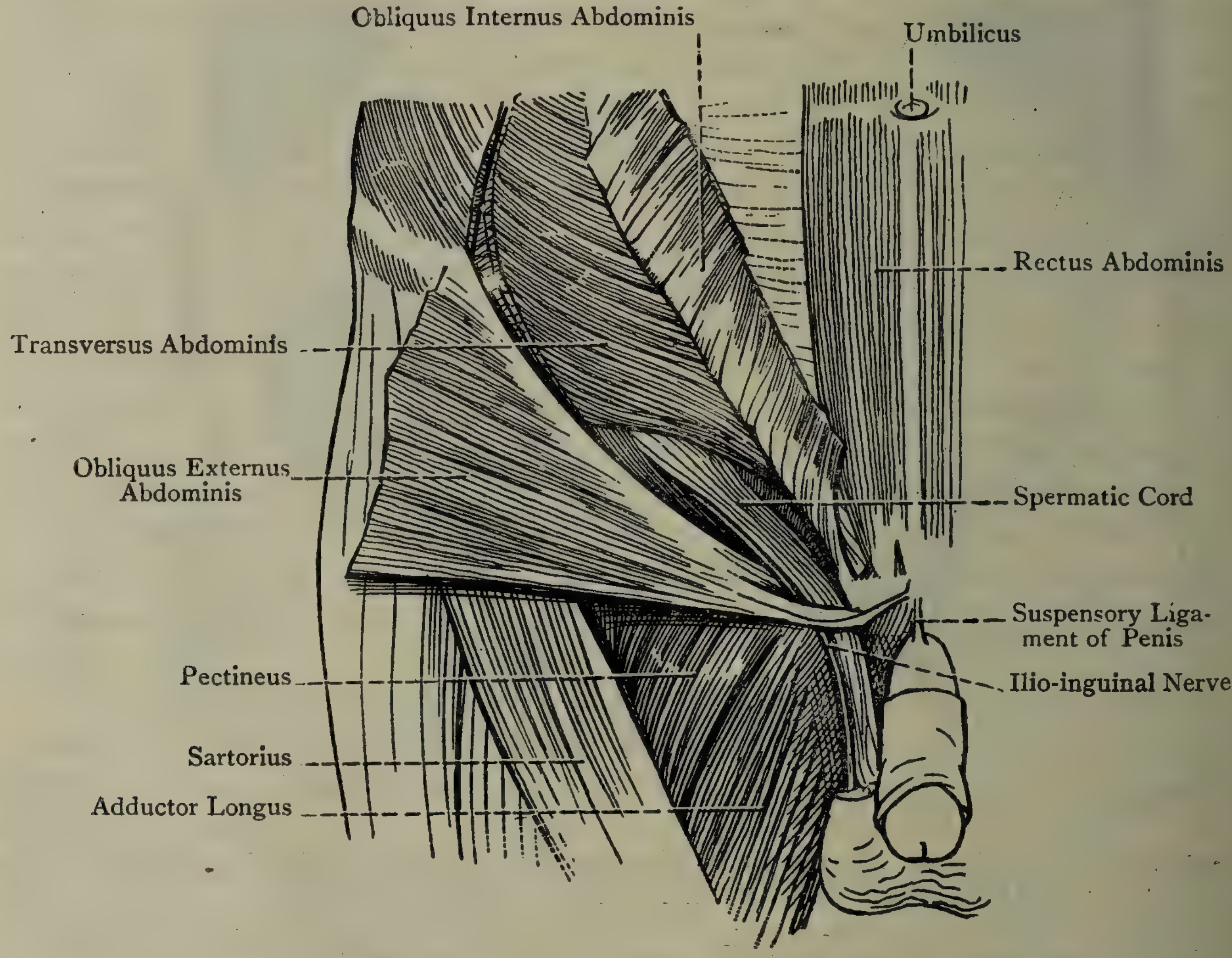
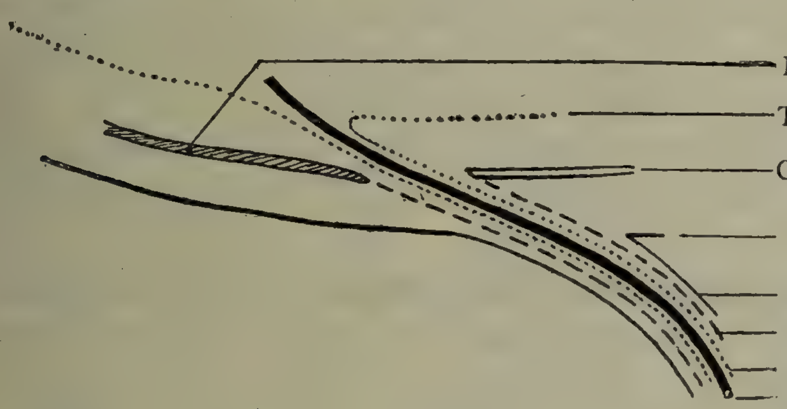


Fig. 431.—Dissection of the Inguinal Region.

here forming a canal, which contains the deep circumflex iliac vessel In the situation of the external iliac vessels, and as far inwards as th base of the pectineal part of inguinal ligament, it is only loosely attache to the inguinal ligament, and is here prolonged downwards beneat the ligament to the thigh, where it lies in front of the femoral vessel and forms the anterior wall of the femoral sheath. As the fascia i prolonged beneath the inguinal ligament it is strengthened by super added fibres, which are known as the *deep femoral arch*. In the regio of the pectineal part of inguinal ligament the fascia is attached in suc cession to the medial portion of the pectineal line behind the conjoin tendon, and to the pubic crest. Behind the symphysis pubis the fasci

lescends into the pelvis, and becomes continuous with the pubo-prosatic, or anterior true, ligaments of the bladder. The strongest part f the fascia transversalis, as before stated, is between the lower free order of the transversus muscle and the inguinal ligament, this part f the abdominal wall being uncovered by muscular structures. It is ı this situation that the fascia is pierced by the spermatic cord in he male and the ligamentum teres of the uterus in the female.

Deep Inguinal Ring.—This ring is situated in the fascia transversalis t a point midway between the symphysis pubis and the anterior superior iac spine, and $\frac{1}{2}$ inch above the inguinal ligament. It serves for the assage of the spermatic cord in the male and the ligamentum teres of he uterus in the female. As viewed from the front, no opening is isible in the undissected state, because the fascia transversalis is pronged like the finger of a glove round the spermatic cord as the internal spermatic fascia. When fully dissected the ring is oval, with the long xis lying vertically, in which direction it measures $\frac{3}{4}$ inch, the transerse measurement being $\frac{1}{2}$ inch. The inferior epigastric artery lies at



IG. 432.—SCHEME TO SHOW THE COMPOSITION OF THE FRONT AND BACK WALLS OF INGUINAL CANAL, AND DERIVATIONS OF COVERINGS OF THE CORD.

rst *below*, and then on the *inner* side of, the ring, the vessel being ere beneath the fascia transversalis. The interfoveolar ligament may e upon the inner side of, and below, the ring. In front of the ring re the lower fibres of the internal oblique, and above is the lower free order of the transversus. The fascia at the outer and lower parts the ring is stronger than elsewhere.

Inguinal Canal.—The inguinal canal is the oblique passage in the wer part of the anterior abdominal wall, which transmits the spermatic ord or ligamentum teres of the uterus, according to the sex, and also e inguinal nerve in its lower two-thirds. It is situated immediately bove the inner half of the inguinal ligament, its direction being downards, forwards, and inwards, and it is $1\frac{1}{2}$ inches in length. The inlet the canal is the deep inguinal ring, the outlet being the superficial guinal ring. Its component parts are a floor, a roof, an anterior wall, nd a posterior wall. The **floor** in its upper two-thirds is formed by e meeting between the fascia transversalis and the inguinal ligament. his portion of it presents a groove, which lodges the spermatic cord. ı the lower third the floor is formed by the abdominal surface of the

pectineal part of inguinal ligament along its line of junction with t latter. The **roof** is formed by the approximation of the anterior a posterior walls, separated only by the lower border of the transvers The **anterior wall** is formed by the following structures from bef backwards: (1) the skin; (2) the superficial fatty and deeper me branous layers of the fascia of the anterior abdominal wall; (3) exter oblique aponeurosis (all these four structures extending over the wh length of the anterior wall); and (4) the lower fibres of the inter oblique over the outer third. The **posterior wall** is formed by t following structures, in order from behind forwards: (1) the parie peritoneum; (2) subperitoneal fat; (3) fascia transversalis; (4) conjo tendon over the inner two-thirds, and it may be the interfoveolar lig ment over the outer third; and (5) the outer portion of the reflect part of inguinal ligament (provided that ligament is well develope which forms anteriorly the extreme inner part of this wall.

In early life the inguinal canal is very short. Indeed, at one peri of life it is non-existent, inasmuch as the deep inguinal ring in ve early life lies directly behind the superficial ring. As the pelvis, ho ever, increases in breadth, the deep ring is gradually shifted outwar and so the inguinal canal becomes formed.

The inguinal canal in the female differs from that in the male being of smaller size, and in containing the ligamentum teres of t uterus.

Inguinal Triangle (Hesselbach's Triangle).—This triangle is situat at the lower part of the anterior abdominal wall above the inner h of the inguinal ligament.

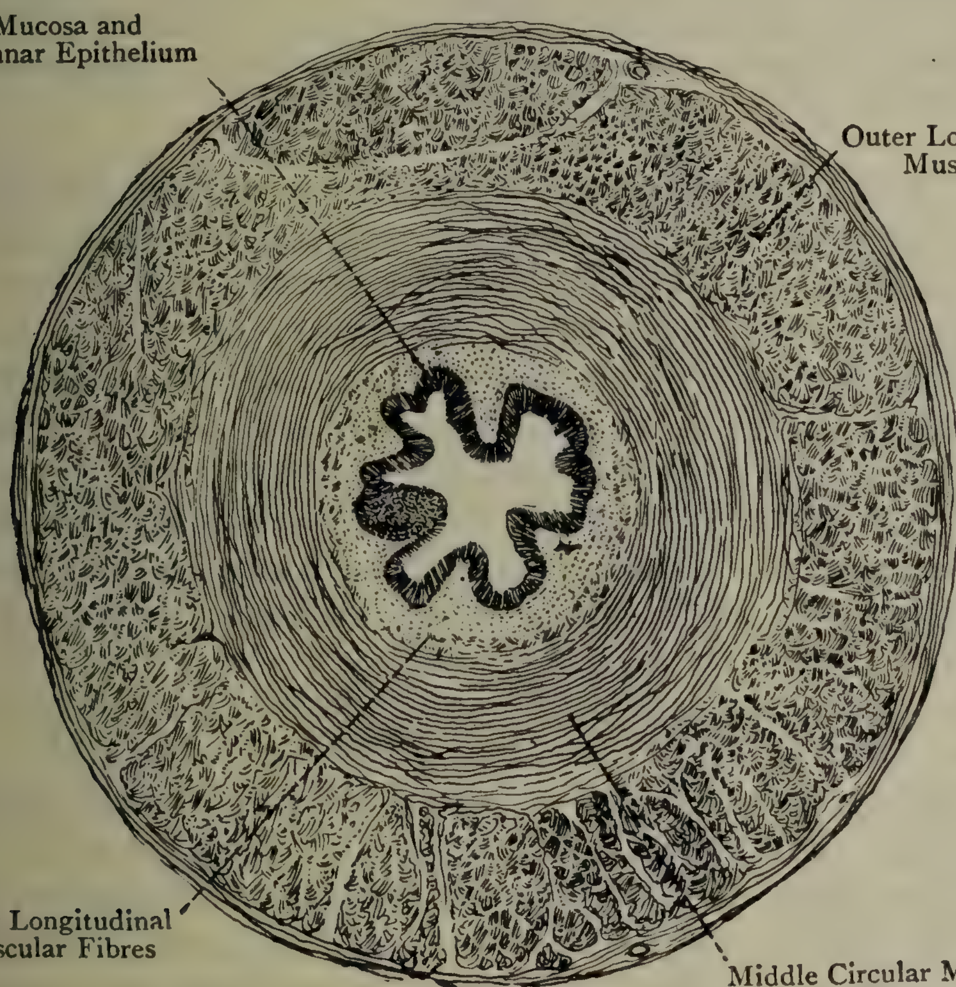
Boundaries—*Medial.*—The outer border of the rectus abdomi over about its lower 2 inches. *Lateral.*—The inferior epigastric vesse *Inferior* (base).—The inner half of the inguinal ligament. The *ap* corresponds with the point where the inferior epigastric vessels pa beneath the outer border of the rectus. The *floor* is covered over whole extent by the fascia transversalis, superficial to which, ov the inner two-thirds, is the conjoint tendon, and over the outer thi sometimes the interfoveolar ligament. The floor is, therefore, co veniently divided into an inner two-thirds, where the conjoint tend lies, and an outer third, where the interfoveolar ligament may situated. The triangle is covered superficially by the skin, both laye of the fascia of the anterior abdominal wall, and the external obliq aponeurosis. The triangle is further crossed obliquely by a fibro cord, the obliterated hypogastric artery, which divides the triangle in median and lateral portions.

Spermatic Cord.—The spermatic cord extends from the deep i guinal ring to the upper part of the posterior border of the testis. F the first $1\frac{1}{2}$ inches of its course it lies in the inguinal canal, and is direct downwards, forwards, and inwards. After passing through the supe ficial inguinal ring it enters the scrotum, in which it descends almo vertically. The relations of the cord in the inguinal canal will understood on referring to the description of that canal. In the low

thirds of the canal it is accompanied by the ilio-inguinal nerve, :h lies to its outer side.

'he spermatic cord is composed of the following structures: the vas rens; three arteries—namely, the testicular artery, the artery of vas deferens, and the cremasteric artery; the pampiniform plexus eins; the lymphatics of the testis and epididymis; the testicular us of sympathetic nerves; and the genital branch of the genito- ral nerve. These structures are connected by areolar tissue, and cord receives certain coverings to be presently described.

'he **vas deferens** is the excretory duct of the testis. It commences ie tail or globus minor of the epididymis, and terminates at the



'IG. 433.—TRANSVERSE SECTION OF THE VAS DEFERENS, SHOWING ITS MINUTE STRUCTURE.

of the prostate gland by joining the duct of seminal vesicle to form ejaculatory duct. This latter duct, having passed between the dle and lateral lobes of the prostate gland for about 1 inch, opens n the lateral margin of the orifice of the prostatic utricle on the of the prostatic portion of the urethra. The vas deferens at its mencement is slightly tortuous, but it soon becomes straight. It at first on the inner side of the epididymis, and along the posterior ler of the testis. After entering the cord it is placed *behind* all the r elements, where it can be readily felt and recognized from a resem- ce to whipcord. It maintains this position until it arrives at the inguinal ring, where it lies on the *inner* side of the other elements he cord. After passing through the deep inguinal ring it hooks

round the outer side of the inferior epigastric artery, and, having cros the external iliac vessels from without inwards, it dips down on inner side of the external iliac vein, and so enters the pelvis under co of the peritoneum, where it will be afterwards described. The deferens in its natural state measures about 1 foot in length, but wl straightened attains a length of about 1½ feet.

Structure of the Vas Deferens.—The vas deferens has a very thick wall, feels like a piece of whip-cord. Its outer coat consists of fibrous tissue. Wit this there is a thick muscular coat composed of plain muscular tissue, wl is arranged in three layers—an outer longitudinal, a middle circular (both which are thick), and an inner thin longitudinal layer. Within the muscu coat is the mucosa, which is covered by non-ciliated columnar epithelium.

Development.—The Wolffian or mesonephric duct is converted into the deferens in the male, becoming connected with the testis through some of tubules of the mesonephros. It degenerates in women.

The **artery of the vas deferens** is usually a branch of the super vesical of the internal iliac, though it may arise from the infer vesical; it divides into a descending and an ascending branch. *descending branch* passes downwards to supply the lower part of vas deferens and the seminal vesicle. The *ascending branch* acco panies the vas deferens through the inguinal canal to the testis, supp ing the vas deferens, and giving a few twigs to the tail of the epididym in which latter situation it anastomoses with the epididymal bran of the testicular artery. The artery to the vas is sometimes of la size, and may take the place of the testicular artery when that ves is absent.

The **vein** from the vas opens into the vesical plexus of veins, a thence into the internal iliac vein.

The **testicular artery** arises from the abdominal aorta about 1 in below the renal artery. On approaching the upper part of the tes it divides into *glandular* and *epididymal branches*, the former supplyi the testis and the latter the epididymis. As the artery descends in t spermatic cord it supplies branches to its coverings which anastomo with the cremasteric artery; its epididymal branches anastomose wi the artery of the vas.

For the **cremasteric artery,** see p. 731.

The **testicular veins** issue from the testis along its posterior bord In the cord they form a copious plexus, called the **pampiniform plex** At the deep inguinal ring two veins emerge from this plexus, whi range themselves on either side of the testicular artery. These, as th ascend, soon join to form one vessel, that of the *right* side opening in the inferior vena cava, and that of the *left* side into the left renal vei The veins of the pampiniform plexus have valves, but they are n competent. There is, however, a competent valve as a rule at t termination of each testicular vein.

The lymphatics of the testis and spermatic cord, the testicul plexus of sympathetic nerves, and the genital branch of the genit femoral nerve will be afterwards described.

Coverings of the Spermatic Cord.—The coverings, enumerated from [w]ithin outwards, are as follows:

1. The subperitoneal areolar tissue, which is continuous with that [of] the abdominal wall through the deep inguinal ring.

2. The fascia transversalis, prolonged from the margins of the [de]ep inguinal ring, and known as the *internal spermatic fascia.* This [co]vering near the ring is funnel-shaped, and is hence called the *in[fun]dibuliform fascia,* but lower down it becomes incorporated with [th]e subperitoneal areolar tissue and forms the *fascia propria* of Cooper.

3. The cremasteric fascia.

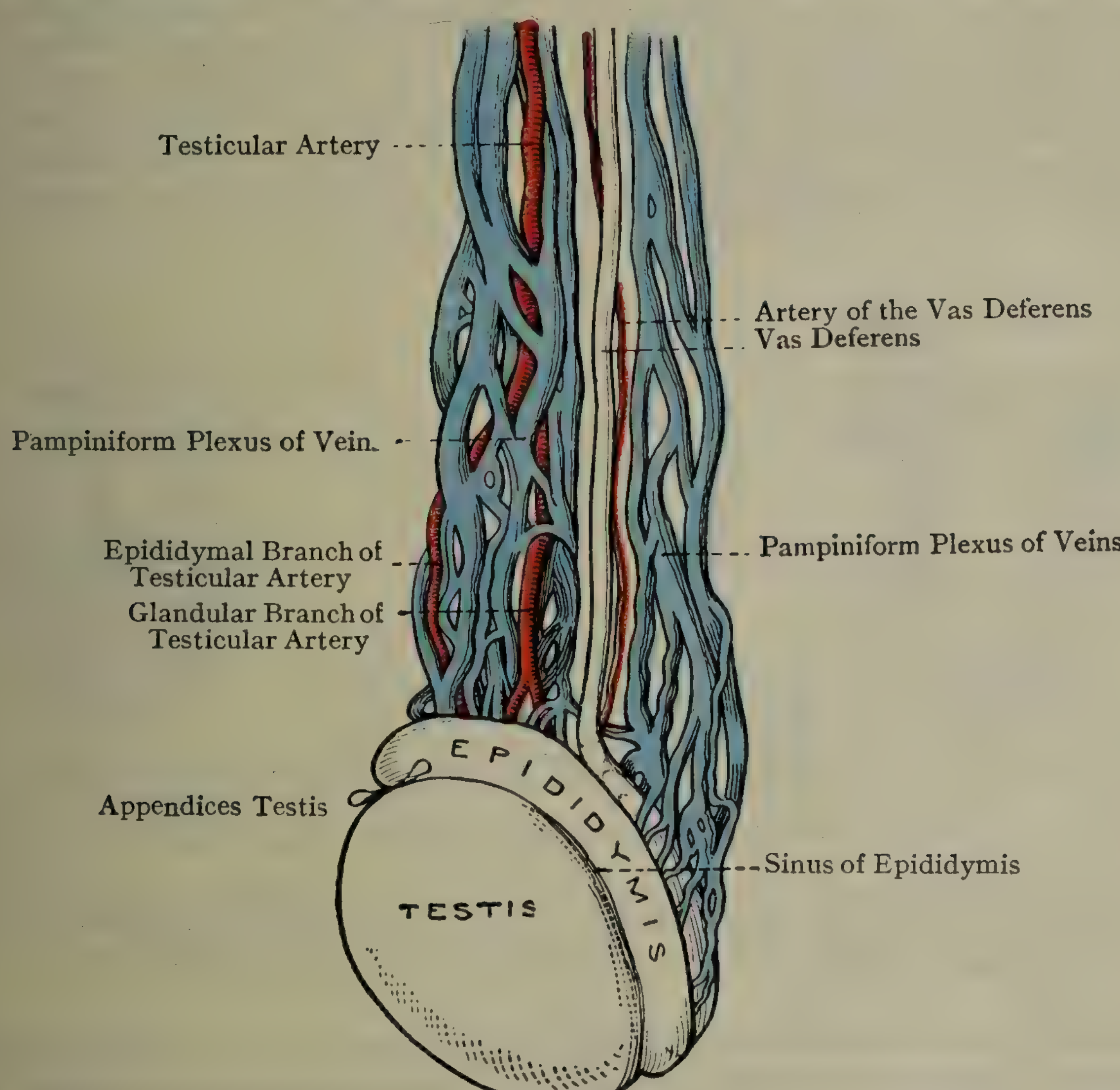


FIG. 434.—DISSECTION OF THE SPERMATIC CORD, SHOWING THE BLOODVESSELS AND DUCT OF THE TESTIS (AFTER SAPPEY).

4. The external spermatic fascia.
5. The dartos muscle.
6. The skin.

Within the innermost of these coverings there are a few scattered [m]uscular fibres, which constitute the *internal cremaster of Henle,* and [wh]ich are regarded as representing the gubernaculum testis of the [fo]etus.

The fibres of the cremaster proper are of the striated variety, but [th]ose of the internal cremaster are of the plain variety.

Descent of Testis and Formation of Inguinal Canal.—The testis originally [lie]s in the lumbar region of the abdomen, on the mesial side of the Wolffian body [or] mesonephros. The conditions in the sixth week are shown in Fig. 63.

The elongated gonad is attached to the inner side of the mesonephros by **mesorchium** (or **mesovarium** in the female). The mesonephros is attache the dorsal wall by the **mesonephric mesentery** (or **mesonephric ligament**). W the mesonephros atrophies, the gonad has the appearance of having more di dorsal attachment, made by the combination of the original mesorchial mesonephric attachments, and this is known as the **uro-genital mesentery.**

Gubernaculum Testis.—Near the lower end of the mesonephros a perito fold is found at a fairly early stage, connecting the uro-genital mesentery the inguinal region at a point corresponding with the site of the future deep i The fold is the **plica gubernatrix** or **plica inguinalis.** It is seen in Fig. 63, an a later stage and much thickened in Fig. 69.

In the female this fold, as it descends, becomes connected with the co sponding para-mesonephric (Müllerian) duct at the level where this duct f with its fellow to form the rudiment of the uterus and vagina.

Within the plica gubernatrix fold a fibro-muscular cord is developed, sisting of connective tissue and plain muscular tissue. This cord is called **gubernaculum testis.** Inferiorly it is attached at first to the posterior sur of the anterior abdominal wall in the inguinal region at a point correspondin

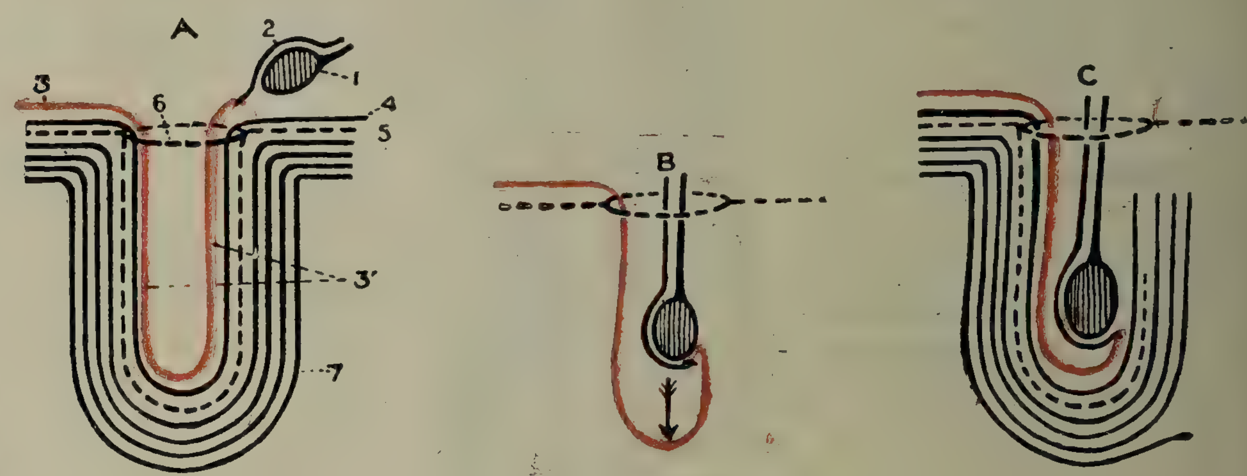


FIG. 435.—DIAGRAM SHOWING THE DESCENT OF THE TESTIS.

A, first stage; B, second stage; C, final stage.

1. Testis (in Abdomen)
2. Primitive Peritoneum (Tunica Adnata)
3. Parietal Peritoneum
3'. Processus Vaginalis
4. Subperitoneal Areolar Tissue
5. Fascia Transversalis
6. Deep Inguinal Ring
7. Integument

the situation of the future deep inguinal ring, whence it, or the greater par it, ultimately extends to the bottom of the corresponding scrotal cham Superiorly its attachment is twofold: (1) it is principally attached to the lo part of the epididymis at the junction of the tail and vas deferens. (2) A por of it ascends within the inferior testicular fold to be attached to the ca end of the testis. According to some authors, the lower part of the gubernacu testis is reinforced by striated muscular fibres derived from the internal obli and transversus abdominis muscles. These fibres, which form the so-ca *inguinal cone,* are superadded to the fibro-muscular cord just referred to, wl constitutes the core of the gubernaculum. Superiorly these superadded fil from the inguinal cone are described as being attached to the testis and epididy Inferiorly, three attachments are ascribed to them as follows: (1) the *outer bu* is attached to the deep aspect of the inguinal ligament near its centre; (2) *middle* or *principal bundle* accompanies the gubernaculum testis to the bott of the scrotal chamber; and (3) the *inner bundle* is attached to the pubic crest

Two views are thus entertained regarding the structure of the gubernacul testis. According to one view it consists solely of plain muscular tissue connective tissue arranged as a cord within the peritoneal fold, called the p gubernatrix or plica inguinalis. According to the other view, in addition

ese fibro-muscular elements, there are superadded striated muscular fibres rived from the internal oblique and transversus abdominis muscles in the form the inguinal cone. However constituted, the gubernaculum testis soon comes a stout thick cord, the final destination of which will be presently erred to.

The **descent,** or more properly the *migration,* of the organ commences before the ird month of intra-uterine life, and its usual destination is the corresponding otal chamber. The migration is accomplished in *four stages*—pelvic, inguinal, raparietal, and scrotal—and throughout all these stages it follows the lead the gubernaculum, which necessarily undergoes shortening.

The *pelvic stage* soon brings the testis into the iliac fossa, where it lies near e brim of the true pelvis, having the epididymis laterally and the vas deferens edially, the latter dipping into the pelvic cavity.

The *inguinal stage* takes the testis to the posterior aspect of the inguinal rtion of the anterior abdominal wall at a point corresponding to the future ep inguinal ring, where it arrives about the sixth to seventh month.

Some time previous to this a path has been made for its further progress by e formation of the inguinal canal and scrotal cavity. In the immediate inity of the lower or inguinal end of the gubernaculum testis a *peritoneal*

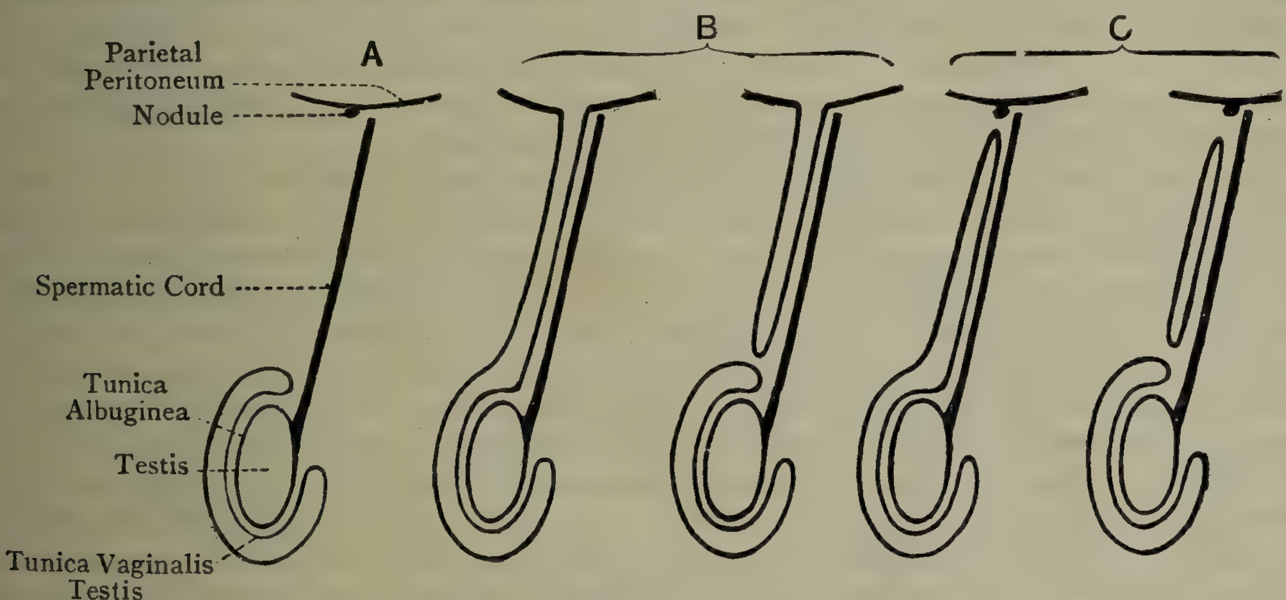


FIG. 436.—VARIETIES OF THE TUNICA VAGINALIS.

A, normal type; B, congenital type; C, infantile type.

pression is formed, and the principal part of the inguinal end of the guber-culum now slowly penetrates the compact anterior abdominal wall in the guinal region, thus giving rise to the **inguinal canal** and **inguinal rings.** In eparing this path for the testis, its gubernaculum takes with it the parietal ritoneum forming the peritoneal depression just alluded to, which accord-gly constitutes a peritoneal process, called the **vaginal process.** This process ay be likened to the finger of a glove, being open towards the peritoneal or dominal cavity, but closed at its distal end. The principal part of the guber-culum lies *behind* the vaginal process, which latter aids the stout gubernaculum the formation of the inguinal canal.

As the vaginal process penetrates the inguinal portion of the abdominal wall, elongates before it the several elements which compose the wall in the following der from *within outwards*:

1. Extraperitoneal areolar tissue.
2. Fascia transversalis.
3. Lowermost inguinal fibres of internal oblique muscle (cremaster).
4. External oblique aponeurosis.
5. Both layers of anterior abdominal wall fascia (dartos muscle).
6. Skin of scrotum.

In the foregoing manner the deep inguinal ring, inguinal canal, and su ficial inguinal ring are formed by the gubernaculum testis and vaginal proc Beyond the superficial inguinal ring these two structures enter the correspon scrotal chamber, the lower part of the vaginal process forming a serous lining it. The lower part of the gubernaculum extends lower down than the lc end of the vaginal process, and this portion is attached to the fundus of scrotal chamber.

The *intraparietal stage* in the migration of the testis consists in the pas of the organ through the inguinal canal. This stage commences about seventh month of intra-uterine life, and the testis follows the lead of the mi or principal bundle of the gubernaculum testis, gliding along the posterior of the vaginal process, and being post-vaginal in position.

The *scrotal stage* consists in the entrance of the testis into the correspon scrotal chamber, which usually takes place about the end of the eighth mont intra-uterine life. The organ still lies *behind* the lower part of the vaginal proc which it invaginates from behind to form the tunica vaginalis. The middl principal bundle of the gubernaculum testis has now become very short, an ultimately represented by an indefinite fibrous bundle, spoken of as the *rem of the gubernaculum*, which connects the lower parts of the epididymis and te to the fundus of the scrotal chamber. The testis lies just outside the superfi ring during the ninth month, and descends to the fundus of the scrotum after bi

As the testis descends into the scrotum, the outer and inner bundles of gubernaculum testis, according to the view that there is a *conus inguinalis,* drawn downwards on the sides of the spermatic cord.

There are two theories regarding the migration of the testis, which may called developmental and muscular. According to the *developmental th* the migration is not an active process due to muscular contraction, but is brou about by developmental changes of the nature of disproportionate or unec growth, which take place in the lumbar, iliac, and inguinal regions of the tru According to the *muscular theory,* maintained by those who favour the existe of a conus inguinalis, the migration is brought about by muscular contractio follows: All three bundles of the muscular inguinal cone would draw the te down to the inguino-pubic region and thereafter the middle bundle would d it down into the scrotal chamber, the outer and inner bundles being elonga downwards. The non-striated muscular fibres in the core of the gubernacul may also take part in the descent, and the descent may be aided by the ' retr tion ' of the connective tissue of the gubernacular core.

Female.—The portion of the **plica gubernatrix** or **plica inguinalis** (of wh plica the embryonic inferior ovarian fold forms a part) between the caudal of the ovary and the fusion of the para-mesonephric duct with its fellow to fo the rudiment of the uterus represents the ligament of the ovary; and the p which extends from the para-mesonephric fusion through the inguinal cana the labium majus contains the ligamentum teres of the uterus, which is homologue of part of the gubernaculum testis. In other words, the entire p gubernatrix in the male contains the gubernaculum testis; whereas in the fem it pertains to (1) the ligament of the ovary, and (2) the ligamentum teres of uterus. The **urogenital mesentery** of either side, which is formed by the me varium, mesonephric mesentery, and uro-genital fold (within which latter para-mesonephric duct lies along with the mesonephric duct) becomes the co sponding broad ligament of the uterus (see p. 101).

Metamorphosis of the Vaginal Process.—As stated, the vaginal process originally a tubular process or diverticulum of the parietal peritoneum of inguinal region, resembling the finger of a glove, which precedes the descent the testis, and *behind* which the testis descends, following the lead of the mid bundle of the gubernaculum testis. After the testis has reached the scro chamber it invaginates the vaginal process from *behind* to form the tun vaginalis, and that process now undergoes certain changes. To understa these changes, familiarity with the following facts is necessary: (1) The vagi process is closed below and open above; (2) the lumen of the process is sim

liverticulum of the cavity of the peritoneum; (3) the part of the process related the testis is called the *testicular portion*; and (4) the part in front of the spermatic rd is referred to as the *funicular portion.*

The changes are as follows: (1) About the period of birth the vaginal process ıally becomes constricted and closed superiorly at the deep inguinal ring, d then the process is an elongated tube, closed at each end, its lumen being w shut off from the cavity of the peritoneum. (2) A few days after birth the ocess usually becomes constricted and closed a little above the testis. (3) The *ıicular portion* of the process usually becomes impervious and converted into ibrous thread, which as a rule disappears in the course of the first month after th. (4) The *testicular portion* of the process persists as a shut serous sac, led the *tunica vaginalis.* Normally the persistent remains of the embryonic ginal process in the adult are (1) the testicular portion, which forms the tunica ginalis; and (2) a small nodule on the parietal peritoneum immediately behind e deep inguinal ring. Instead of a mere nodule, however, a slender fibrous read, called the *ligamentum vaginale,* may extend downwards from this part the parietal peritoneum in front of the spermatic cord as low as the superficial guinal ring, and sometimes as low as the tunica vaginalis.

In the female the vaginal process is represented by a tubular process of the ritoneum, which lies in front of the ligamentum teres of the uterus for a short stance in the inguinal canal. When this process remains open superiorly, it known as the *canal of Nuck.*

Abnormal Conditions of the Vaginal Process—Congenital Type.—(1) The ginal process may remain permanently open throughout, under which circum-ınces the cavity of the tunica vaginalis is in direct communication with the neral peritoneal cavity. (2) The vaginal process may be closed just above the nica vaginalis, but may remain as a permanently open tube above this point.

Infantile or Funicular Type.—(1) The vaginal process may be closed only at its per end near the deep inguinal ring. In these cases the tunica vaginalis, stead of being limited to the region of the testis, is prolonged upwards as an ongated tube in front of the spermatic cord into the inguinal canal. (2) The ginal process may be closed above near the deep inguinal ring, and also below st above the tunica vaginalis, the portion of it intervening between these two ints remaining as an elongated tube, closed at either end, and lying in front the spermatic cord. (3) The vaginal process is sometimes closed at intervals ong the course of the spermatic cord, and when serous fluid accumulates in the tervening patent portions, the condition is known as encysted hydrocele of e cord.

Abnormal Positions of Testis.—(1) The testis may remain permanently in e abdominal cavity. (2) Its descent may be arrested in the inguinal canal, or the superficial inguinal ring. Such conditions constitute what is known as *yptorchism.*

Ectopia Testis.—The testis may occupy unusual situations. (1) It may be ınd in the anterior part of the perineum. (2) It may be found on the front of e thigh in the region of the saphenous opening, in which cases it might simulate femoral hernia. (3) It may be found dorsal to the penis, in front of the sym-ıysis pubis.

For the structure and development of the testis, see pp. 750 and 752.

Extraperitoneal Tissue.—This is situated between the fascia trans-rsalis and the parietal peritoneum. Its condition is subject to uch variety, being fairly well marked in some bodies, and in others ırdly perceptible. Medial to the external iliac vein at the inguinal gament it forms the *femoral septum,* which closes the upper end of the moral canal, and at the internal abdominal ring it is carried down-ards round the spermatic cord underneath the internal spermatic ıfundibuliform part) fascia.

Parietal Peritoneum.—This is the innermost covering of the ab-dominal wall, and it is connected with the fascia transversalis by subperitoneal areolar tissue. Behind the deep inguinal ring it forms a slight projection, which in some cases enters the ring, the corresponding depression on its abdominal aspect at this point being known as the **digital fossa.** The projecting part of the parietal peritoneum corresponds with the upper end of the original processus vaginalis, and may be continued into a slender thread-like process, the obliterated upper part of the processus vaginalis. It is here in the female that a diverticular process may extend for a short distance into the inguinal canal in front of the ligamentum teres of the uterus, forming the canal of Nuck.

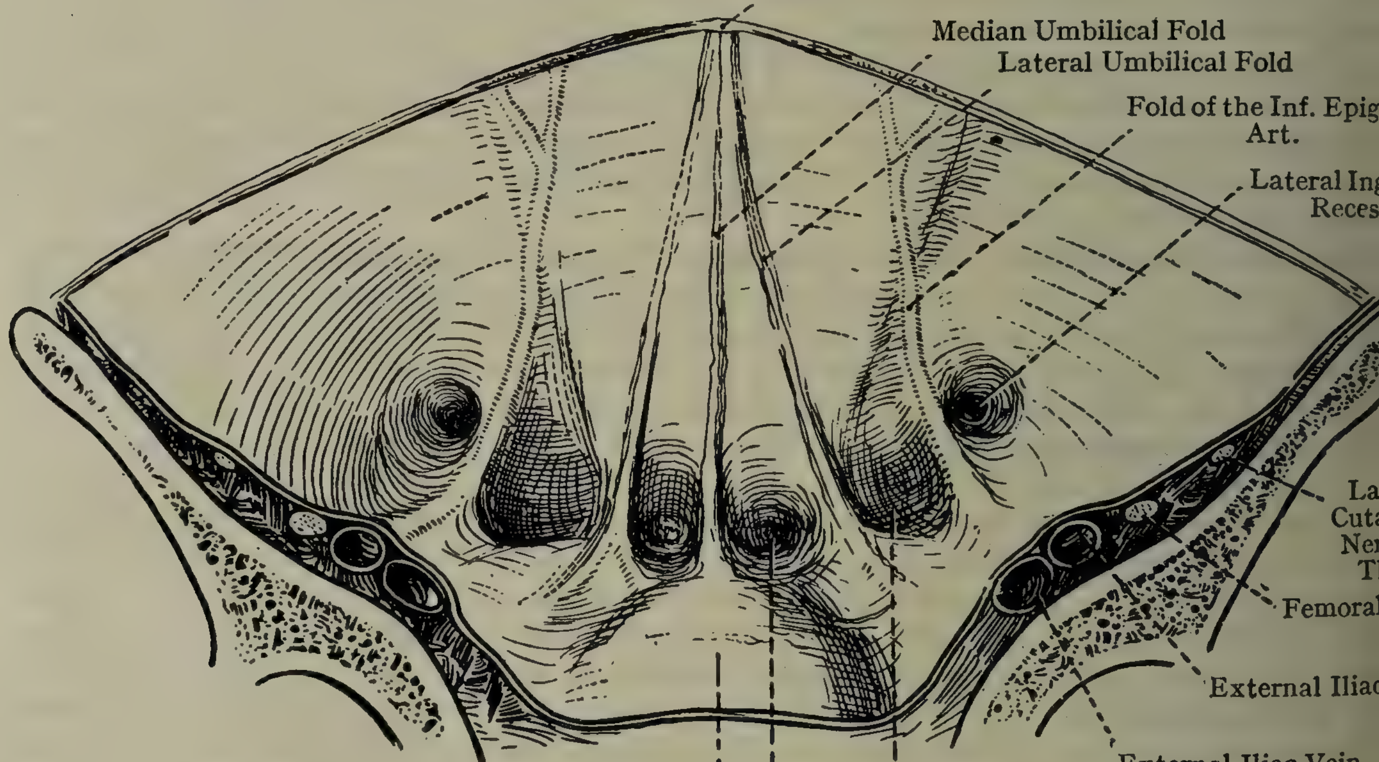


Fig. 437.—The Folds and Recesses on the Posterior Surface of the Anterior Abdominal Wall.

Peritoneal Folds and Inguinal Recesses.—The peritoneum lining the posterior surface of the anterior abdominal wall below the umbilicus presents folds and recesses.

The **folds** are five in number, one being situated in the middle line and two on either side. The median fold extends from the apex of the bladder to the umbilicus, and contains the urachus. It is called the **median umbilical fold.** Of the two lateral folds, the more medial one contains the obliterated hypogastric artery, and is called the **lateral umbilical fold.** It is oblique in direction, and meets the median umbilical fold and its fellow of the opposite side at the umbilicus. It corresponds to the junction of the inner two-thirds and outer third of the inguinal triangle. The lateral of the two lateral folds is pr

duced by the inferior epigastric artery, and is called the **fold of the inferior epigastric artery.**

The **inguinal recesses** are six in number, three right and three left, and are called medial, intermediate, and lateral. The **medial inguinal recess** is situated between the median and lateral umbilical folds, and lies behind the inner two-thirds of the inguinal triangle, the conjoint tendon, and the superficial inguinal ring. The **intermediate inguinal recess** is situated between the lateral umbilical fold and the fold of the inferior epigastric artery, and lies behind the outer third of the inguinal triangle. The **lateral inguinal recess** is situated on the outer side of the fold of the inferior epigastric artery, and its lower and inner part is behind the deep inguinal ring.

Inguinal Hernia.

By an inguinal hernia is meant a protrusion of a viscus (usually bowel, or, it may be, greater omentum) from the abdominal cavity in the inguinal region. This region is predisposed to such an occurrence from the presence of the two inguinal rings and inguinal canal, and the inguinal recesses. All forms of inguinal hernia, if complete, ultimately protrude through the superficial inguinal ring, and enter the scrotum. Relatively to the inferior epigastric artery there are two varieties of inguinal hernia—namely, lateral and medial, the former leaving the abdominal cavity lateral to that vessel, and the latter escaping medial to it. Inasmuch, however, as the region inside the inferior epigastric artery—namely, the inguinal triangle—is divisible into an inner two-thirds and an outer third, there may be two forms of medial hernia. Viewing, therefore, inguinal hernia in its relation to the abdominal wall, there are three varieties—namely, lateral oblique, medial direct, and medial oblique.

Lateral Oblique Inguinal Hernia.—This variety is called *lateral* because the hernia, as it leaves the abdominal cavity, is lateral to the inferior epigastric artery; and *oblique*, from its oblique course. The course of the hernia is as follows: it enters the lateral inguinal fossa, and stretches over it the peritoneum forming that fossa. It then passes through the deep inguinal ring, and traverses the entire length of the inguinal canal, from which it emerges through the superficial inguinal ring into the scrotum, thus forming a complete lateral oblique inguinal hernia. Throughout its entire course the hernia lies in front of the spermatic cord, and its descent is arrested at the upper part of the testis, which can be felt at its lower and back part. The bowel may be arrested at any part of the inguinal canal, the hernia being then called incomplete, and forming what is known as a *bubonocele.* In its descent the bowel elongates and carries before it certain investments from the structures to which it is related, these investments being called the **coverings** of the hernia. The first covering of this form of hernia, as of the other varieties, is derived from the parietal peritoneum, the particular part being that which forms the lateral inguinal fossa, and this constitutes the **sac.** The other coverings are simply those of the spermatic cord, which are all superadded to the sac.

The **coverings,** enumerated in order from within outwards, are as follows:

1. Parietal peritoneum, which forms the sac.
2. Extraperitoneal tissue.
3. Fascia transversalis, from the margins of the deep inguinal ring, forming the internal spermatic fascia.
4. Cremasteric fascia, at the lower border of the internal oblique muscle.
5. External spermatic fascia, from the crura of the superficial inguinal ring.
6. Dartos muscle.
7. Skin.

A short distance below the internal abdominal ring the subperitoneal fat an internal spermatic fascia become united, and are known as the **fascia propria.**

The **sac** is composed of the following parts: (1) the *mouth,* which is the openin by which its interior communicates with the general peritoneal cavity; (2) th *neck,* which is the constricted part immediately beyond the mouth; and (3) th *body.* The neck of the sac is on a level with the margins of the deep inguina ring, and the inferior epigastric vessels lie immediately on its *inner* side.

The seat of stricture may be (1) at the superficial inguinal ring; (2) at th lower border of the internal oblique muscle; or (3) at the neck of the sac, the las being the most common situation.

Medial Direct Inguinal Hernia.—This variety is called *medial* because th hernia, as it leaves the abdominal cavity, is internal to the inferior epigastri artery; and *direct,* from its straight course through the abdominal parietes. Th course of this variety is as follows: the hernia enters the medial inguinal fossa stretching over it the peritoneum forming that fossa. It then passes througl the inner two-thirds of the inguinal triangle, and so reaches directly the superficia inguinal ring without traversing the inguinal canal. Having emerged througl the superficial ring, it descends into the scrotum, thus forming a complete media direct inguinal hernia, which is in front of, and medial to, the spermatic cord It is to be noted (1) that there is no natural opening in the fascia transversali over the inner two-thirds of the inguinal triangle, as there is external to the inferior epigastric artery; and (2) that the conjoint tendon covers the inner two thirds of the inguinal triangle. The coverings of this variety, enumerated ir order from within outwards, are as follows:

1. Parietal peritoneum.
2. Extraperitoneal tissue.
3. Fascia transversalis.
4. Conjoint tendon.
5. Fascia triangularis.
6. External spermatic fascia.
7. Dartos muscle.
8. Skin.

If the hernia occurs suddenly, rupture of the conjoint tendon may take place, in which cases the bowel would pass through the fissure. The seat of stricture in a medial direct inguinal hernia may be (1) at the superficial inguinal ring; (2) at the fissure in the conjoint tendon, if that structure should be ruptured; or (3) at the neck of the sac. The latter situation is the most common, and it is to be noted that the inferior epigastric vessels lie on the *outer* side of the neck of the sac.

Medial Oblique Inguinal Hernia.—This variety is called *medial* because the hernia, as it leaves the abdominal cavity, is medial to the inferior epigastric artery; and *oblique,* because it has to descend through the lower two-thirds of the inguinal canal. The course of this variety is as follows: the hernia enters the intermediate inguinal fossa, stretching over it the peritoneum forming that fossa. It then passes through the outer third of the inguinal triangle, and descends through the lower two-thirds of the inguinal canal, from which it emerges through the superficial inguinal ring into the scrotum, thus forming a complete medial oblique inguinal hernia. Practically the only difference between the course of a medial oblique and a lateral oblique inguinal hernia is that the lateral oblique variety enters the inguinal canal by its natural inlet—namely, the deep inguinal ring—whereas the medial oblique variety obtrudes itself into the upper part of the inguinal canal through its posterior wall. It is to be noted (1) that there is no natural opening in the fascia transversalis over the outer third of the inguinal triangle, as there is external to the inferior epigastric artery; and (2) that there is no conjoint tendon over the outer third of the inguinal triangle. The coverings of this variety, enumerated in order from within outwards, are as follows:

1. Parietal peritoneum.
2. Extraperitoneal tissue.
3. Fascia transversalis.
4. Cremasteric fascia.
5. External spermatic fascia.
6. Dartos muscle.
7. Skin.

If the coverings of a lateral oblique and a medial oblique inguinal hernia are compared with each other, it will be seen that the former has a tube of fascia transversalis already prepared for it—namely, the infundibuliform fascia—whereas the latter has to elongate before it a fresh portion of fascia transversalis. In some cases the fascia transversalis over the outer third of the inguinal triangle is covered by an expansion from the conjoint tendon, which is known as the interfoveolar ligament. In such cases that ligament must be added as a covering of medial oblique inguinal hernia, its position being immediately superficial to the covering formed by the fascia transversalis. The relation of a medial oblique inguinal hernia to the spermatic cord is similar to that of a lateral oblique, and the possible seats of stricture are also similar. The neck of the sac is the most common situation, and the inferior epigastric vessels lie immediately on its *outer* side. The extreme difficulty which must be experienced in diagnosing between a lateral oblique and a medial oblique hernia is explained by the fact that the former leaves the abdominal cavity immediately lateral to the inferior epigastric vessels, and the latter immediately medial to them. Hence, the practical rule followed in operating is to cut upwards and not transversely. The propriety of this rule is further enhanced if it be remembered that a lateral oblique inguinal hernia of old standing may so drag upon the deep inguinal ring as to displace it downwards and inwards to a point behind the superficial ring, and thus a hernia which is really lateral oblique may simulate one of the medial direct variety.

Varieties of Lateral Oblique Inguinal Hernia.—There are two varieties of this form of hernia, the special features of which depend upon abnormal conditions of the processus vaginalis (see p. 742). These varieties are named congenital and infantile.

Congenital Hernia.—There are two forms of congenital hernia. (1) The processus vaginalis may remain permanently open throughout, in which case the bowel descends within that process into the cavity of the tunica vaginalis at its lower extremity. The tunica vaginalis thus represents the sac of the hernia, and this form is therefore spoken of as a **hernia into the tunica vaginalis.** In such cases the bowel more or less completely envelops the testis. (2) The vaginal process may be shut off only just above the testis, the part above this remaining as a funicular process communicating above with the general peritoneal cavity. In such cases the bowel descends into the funicular process, which thus forms the sac of the hernia. This form is therefore spoken of as a **hernia into the funicular process.**

Infantile Hernia.—There are two forms of infantile hernia—**infantile hernia proper** and **encysted hernia.** In both there is a funicular process which is closed *above* towards the deep inguinal ring. It may also be closed below just above the testis, being thus distinct from the tunica vaginalis, or it may simply be an upward extension of the tunica vaginalis. In either case it is situated in front of the spermatic cord. In **infantile hernia proper** the bowel, having elongated the parietal peritoneum to form a sac, descends between the spermatic cord and the funicular process. Its importance consists in the fact that, before the bowel can be exposed in operating, *three serous layers* must be divided, two of these belonging to the funicular process and the other representing the wall of the hernial sac. In this form the descent of the bowel is arrested at the upper part of the testis. In **encysted hernia** the bowel, having elongated the parietal peritoneum to form a sac, pushes against the upper part of the funicular process so as to invaginate it in a downward direction in the form of a cup, in which the bowel, enclosed in its sac, lies. The condition of matters is therefore very much like an egg set in its cup, assuming that the top of the shell is removed, and that the wall of the cup is formed of two layers. To bring out this simile, the contents of the egg may be taken as representing the bowel, the shell of the egg being the sac of the hernia, and the assumed two layers of the wall of the cup representing the two serous layers of the doubled-down or invaginated funicular process, the cavity thus formed representing the inside of the cup. In this form, as in infantile hernia proper, *three serous layers* must be divided before the bowel

is exposed in operating, two of these belonging to the invaginated funicular proce and the other representing the wall of the hernial sac.

Umbilical Hernia.—By an umbilical hernia is meant a protrusion of bow or of greater omentum from the abdominal cavity in the neighbourhood of t umbilicus. The protrusion rarely occurs through the umbilicus, and is mo frequent above the umbilicus than below. The coverings of an umbilical hern are as follows:

1. Parietal peritoneum.
2. Extraperitoneal tissue.
3. Fascia transversalis.
4. An expansion from the decussating fibres of the aponeuroses of the abdominal muscles of opposite sides.
5. Superficial fascia.
6. Skin.

There is no vessel liable to be injured in operating on this form of hernia, t inferior epigastric artery being about 1½ inches from the linea alba.

The **congenital form** of umbilical hernia (exomphalos) consists in a protrusi of bowel or omentum through the centre of the umbilicus into the umbilical cor in which it may descend for some distance. Its possible presence will show t propriety of carefully examining the cord before ligaturing it after **birth.**

The anterior abdominal wall above the umbilicus has attached t it posteriorly, an inch or so to the right of the middle line, an anter posterior fold of parietal peritoneum, which represents a part of th upper border of the falciform ligament of the liver. This fold contai at its lower margin a portion of the obliterated umbilical vein, the so called ligamentum teres of the liver, which extends upwards from th umbilicus to the umbilical notch on the anterior border of the live through which it passes to enter the fissure for ligamentum teres o the under surface of the viscus. As the round ligament ascends to th liver the peritoneum, within which it lies, is being gradually elongate in the form of two closely applied laminæ, which form a part of th falciform ligament. The apex of this ligament is therefore at th umbilicus.

The Tunica Vaginalis and Testis.

Tunica Vaginalis Testis.—This is a closed serous sac, behind whic the testis lies. It is formed by the lower part of the *vaginal process* or peritoneal diverticulum, which precedes the descent of the testi from the abdomen. Like all serous membranes, it is composed of tw layers, parietal and visceral. The **parietal layer** is known as the *tunic vaginalis scroti*, from the circumstance that it lines the scrotal chambe of its own side. It is much larger and looser than the visceral layer with which it is continuous along the posterior border of the testis and on the spermatic cord about ½ inch above the organ. The **viscera layer** closely invests the tunica albuginea of the testis, to which it is inseparably united. It also invests the epididymis except at its posterior border, where the constituents of the spermatic cord enter or leave the testis. Between the epididymis and the testis it forms a recess, called the **sinus of epididymis (digital fossa)**, and it extends upwards on the spermatic cord for about ½ inch above the testis.

Along the posterior border of the organ, where this layer becomes continuous with the parietal layer, there is a narrow strip which is free from serous investment. The portion of the tunica vaginalis which is related to the spermatic cord is called the *funicular part.* When fluid accumulates between the parietal and visceral layers, the condition is known as hydrocele of the tunica vaginalis.

Testis.—The testis is suspended obliquely by the spermatic cord in its scrotal compartment, to the bottom of which it is loosely attached by the fibrous remains of the gubernaculum testis. The left testis is a little lower than the right. The organ is oval, and compressed from side to side. Its exterior, which is smooth, is closely invested by the visceral layer of the tunica vaginalis, except where the constituents of the cord enter or leave the organ. The surfaces are lateral and medial, the former looking slightly backwards and the latter forwards. The extremities are superior and inferior, the former being inclined forwards

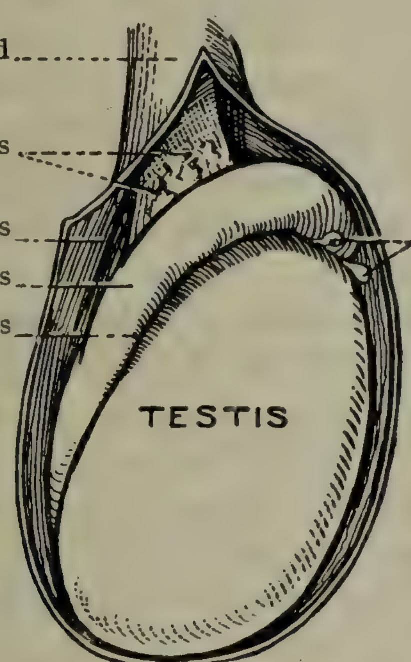


Fig. 438.—The Testis and its Coverings.

and the latter backwards. The borders are anterior and posterior. The anterior border looks slightly downwards and outwards, and is free. The posterior border looks upwards and inwards, and is attached. The average weight of the testis is about 7 drachms.

Epididymis.—This is an elongated narrow body, composed of the convolutions of the canal of epididymis, and lying along the posterior border and adjacent portion of the lateral surface of the testis. Its upper extremity, which is above the upper end of the testis, is enlarged, and is called the **head (globus major)**; the lower and smaller end is called the **tail (globus minor)**; and the intervening narrow portion represents the **body.** The head and tail are connected to the testis by fibrous tissue, and by a reflection of the tunica vaginalis, the former being further connected to the organ by the efferent ducts. The body, except at its posterior border, is free, being separated from the testis by the sinus of epididymis. The epididymis is completely invested by the visceral layer of the tunica vaginalis except at its posterior

border, where there is a duplicature of that membrane containin bloodvessels and attaching it to the testis.

Appendices Testis (Hydatids of Morgagni).—These are small pyramid bodies which are situated on the anterior aspect of the head of epididym at its lower part, or on the front of the upper end of the testis belo the head; they vary in position, number, and size; they may be pedunc lated or sessile. They are composed of connective tissue and bloo vessels, covered by the visceral layer of the tunica vaginalis, and a to be regarded as vestiges of the mesonephros.

Paradidymis (Organ of Giraldès).—This organ is situated on th front of the spermatic cord, immediately above the head of epididymi and under cover of the funicular part of the tunica vaginalis. It co sists of a few irregular nodules of convoluted tubules, lined with ciliate columnar epithelium. These nodules are remains of the mesonephros.

Arterial Supply of the Testis and Epididymis.—The testis derive its arterial supply from the glandular branch of the testicular (whic enters the posterior border of the organ), and the epididymis derives it supply from the epididymal branch of the testicular, which vessel arise from the abdominal aorta about 1 inch below the renal artery. Th tail of the epididymis also receives a few twigs from the artery to th vas, which is usually a branch of the superior vesical from the intern iliac.

The **veins** of the testis issue at the upper part of the posteri border, and, along with those of the epididymis, enter the spermat cord, where they form the pampiniform plexus. The *right* testicul vein, in which the right plexus ultimately ends, opens directly into th inferior vena cava, and the *left* into the left renal vein.

Lymphatics.—These ascend in the spermatic cord, and accompan the spermatic vessels as high as the aortic *groups of lumbar glands* i which they terminate. On the right side the glands to which the pass lie in front of the inferior vena cava.

Nerve-supply.—The testicular plexus of the sympathetic syste which derives its fibres from the aortic and renal plexuses.

The testis is homologous to the ovary of the female (testis muliebris)

General Structure of the Testis and Epididymis.—The **testis** is an aggregatio of convoluted seminiferous tubules collected into lobes, which are encased withi a capsule called the *tunica albuginea*. This tunic is a dense, bluish-white, in elastic membrane, composed of bundles of fibrous tissue. Its outer surface i closely covered by the tunica vaginalis testis. Its inner surface is invested by copious vascular network, known as the *tunica vasculosa*. At the posterio border of the testis the tunica albuginea passes for a certain distance into th interior, this inflection being called the **mediastinum testis.** This mediastinu extends into the organ for one-fourth of its antero-posterior measurement, an from its sides and anterior border a number of *septa*, containing plain muscula tissue, pass off, which extend in various directions as far as the inner surface o the tunica albuginea, to which they are attached. By means of these the interio of the testis is mapped out into a number of lobes, the septa which enclose the containing the branches of the testicular artery as they make their way to th tunica vasculosa. These compartments contain the **convoluted seminiferou tubules** collected into bundles called the *lobes of the testis*, which vary in numbe from 100 to 200. Each lobe contains from two to four tubules, and is conical

the base being directed towards the circumference of the testis and the apex towards the mediastinum. Each tubule is about $\frac{1}{120}$ inch in diameter and is convoluted. When the coils are undone the tubule measures about 2 feet in length. The tubules of each lobule unite into one, and the tubules of adjacent lobules unite in turn, and so give rise to the **straight tubules,** each of which is about $\frac{1}{400}$ inch in diameter, and about $\frac{1}{10}$ inch in length. These straight tubules enter the mediastinum, where they form by their division a network, called the **rete testis.** From this rete, tubules called **efferent ducts** proceed, which are about $\frac{1}{30}$ inch in diameter, their number varying from twelve to twenty. These leave the testis at the upper part of its posterior border. For a short distance they remain straight, but they are soon thrown into convolutions, which form conical masses, called **lobules of the epididymis.** The length of each lobule of epididymis is about $\frac{1}{3}$ inch, and its apex is directed towards the testis. When the convolutions are undone, the tube assumes a length of about 8 inches, its diameter gradually diminishing from about $\frac{1}{20}$ inch at its commencement to about $\frac{1}{60}$ inch at its termination. The lobules open by separate orifices into the canal of the epididymis.

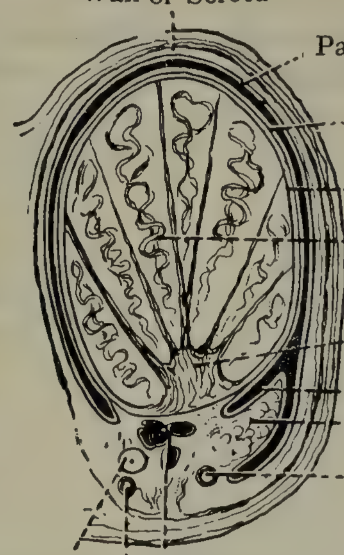


FIG. 439.—DIAGRAM SHOWING A TRANSVERSE SECTION OF THE TESTIS AND SCROTUM.

The **epididymis** consists of one tube, having a diameter of about $\frac{1}{16}$ inch in the head, where it commences in a blind extremity. In the body it diminishes a little in diameter, and in the tail it again enlarges. The tube presents a great number of convolutions, which, being folded upon themselves and connected together by loose tissue, give rise to a series of lobules. When the convolutions are undone the length of the epididymis has been variously estimated at from 12 to 20 feet. At its upper extremity it receives the lobules, and beyond the tail it terminates in the vas deferens. At the point where it terminates in the vas deferens there is a diverticulum connected with it, called the **aberrant ductules,** which extend upwards in a convoluted manner between the epididymis and the adjacent part of the vas deferens. The aberrant ductule, when the coils are undone, is from 8 to 12 inches in length.

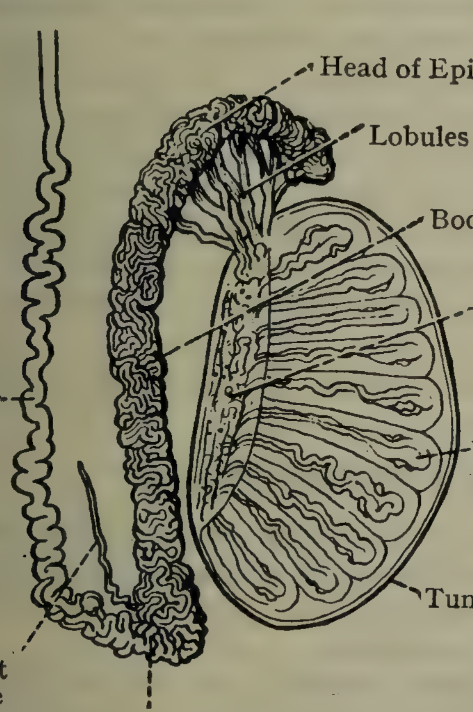


FIG. 440.—THE STRUCTURE OF THE TESTIS AND EPIDIDYMIS.

Minute Structure.—The **convoluted seminiferous tubules** are composed o hyaline basement membrane, lining which there are several layers of epithel cells. (1) The most external layer consists of cubical cells, known as the **parie cells.** They line the basement membrane of the tubule, and are of two kin The majority of them give rise to the spermatozoa, and these are called t **spermatogenic cells,** or **spermatogonia.** Others are of a supporting nature, a are called the **sustentacular cells,** or **cells of Sertoli,** which subsequently form t *columns of Sertoli.* (2) The spermatogonia undergo mitotic division and gi rise to a second layer of cells, called the **primary spermatocytes,** or *mother-ce*

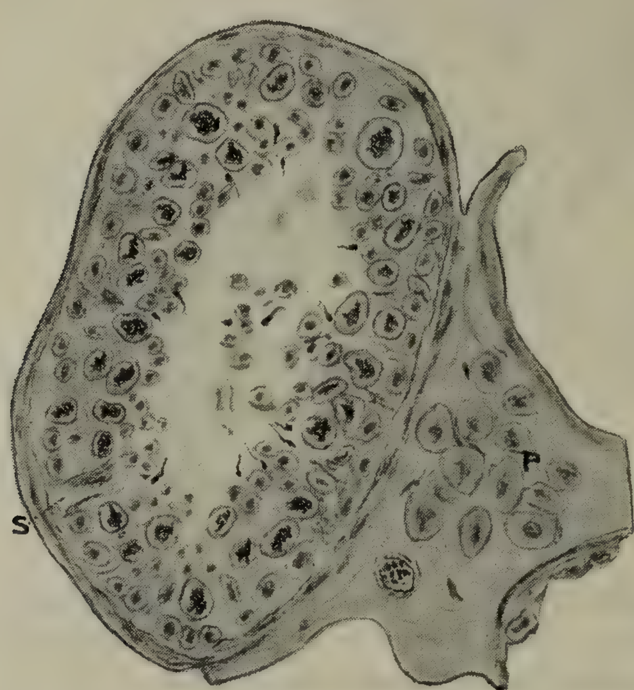


FIG. 441.—SECTION THROUGH SEMINIFEROUS TUBULE (MAGNIFIED), SHOWING VARIOUS STAGES OF DEVELOPMENT OF SPERMATOZOA.

S, Sertoli cell; P, interstitial cells.

(3) The primary spermatocytes a undergo mitotic division, and give rise a third layer of cells, called the **second spermatocytes,** or *daughter-cells.* T mitosis which the primary spermatocy undergo is of the heterotypical varie and results in the chromosomes present the secondary being half the number those present in the primary sperma cytes. (4) The secondary spermatocy also undergo mitotic division, and gi rise to a fourth layer of cells, called t **spermatoblasts,** or **spermatids.** The spermatids, having undergone consid able modifications, give rise to the **sp matozoa.** These *spermatozoa* lie wi their heads buried between the mo deeply placed cells, their long tails pr jecting free into the lumen of the tubu The enlarged ends or heads of the sp matozoa, whilst they lie buried betwe the deeper cells, are connected with t sustentacular cells of the lining epitheliu The **straight tubules** are composed of basement membrane lined with a sing layer of cubical epithelium. The **tubu of the rete testis** are destitute of a basement membrane, its place being taken the connective tissue of the mediastinum. The lining membrane of the tubul consists of a single layer of cubical cells. The **efferent ducts** and **the lobules epididymis** are composed of a basement membrane, external to which there is layer of plain muscular fibres arranged in a circular manner. The lining epith lium is of the ciliated columnar variety.

The **structure of the epididymis** is similar to that of the efferent ducts ar lobules.

Development of the Internal Sexual Organs.

A short account is given on p. 100 of the formation of the male and fema glands from the *indifferent stage.* In the testis are found **medullary** or **sex cord** composed of small epithelioid and large **sex cells. Rete cords** connect these wi the tubular structures of a part of the mesonephros.

Development of the Testis.—The **medullary cords** form cylindrical colum in which the cells slowly arrange themselves, so that lumina begin to appe in them about the seventh month. At the same time, or earlier, lumina a found in the **rete cords,** and by extension in each case those of the medulla and rete cords become continuous. Of the set of tubules formed in this wa those derived from the rete cords make the *straight tubules* and network of t *rete testis,* while the larger parts, formed from the medullary cords, constitu the *seminiferous tubules.* The cells between the cords condense to form t *septa,* continuous at the surface with the tunica albuginea. The *tunica albugin* is recognizable at a much earlier stage, half-way through the second mont

development at this time ensures that, from now on, no further ingrowth cells from the surface layer can take place. Here and there, between the astomosing cell cords, are certain epithelioid cells, which seem to have been t off from the neighbouring cords; these are said to develop at a late stage into e interstitial cells of the testis.

The seminiferous tubes of the growing testis of later stages are lined by several yers of cells, as described above. Spermatozoa remain quiescent in their sition up to the time of puberty, when, becoming motile, they free themselves d pass into the lumen, which has become considerably larger at this period.

The structure and development of spermatozoa are dealt with on pp. 12 and , and the nuclear (reduction) changes on p. 17.

The convoluted canal of the *epididymis*, the *vas deferens*, and the *ejaculatory ct* are developed from the **mesonephric duct.** The **seminal vesicle** is formed rly in the fourth month as a blind diverticulum of the caudal part of the esonephric duct, and the aberrant ductule is a slender diverticulum of that rtion of the mesonephric duct which forms the tail of the epididymis; it is remnant of the mesonephros, as is also the paradidymis at a higher level.

Development of Ovary.—**Medullary cords** become apparent in the ovary at much later stage than in the testis, and are not so well defined, giving the im-ession of being little more than rudimentary formations. The same may be id of the **rete cords,** which, however, seem to be better formed, and even develop mina in some cases. The rete cords effect junction with the glomerular struc-res of the neighbouring part of the mesonephros, at any rate in some instances, ıd are said to join also with the rudimentary medullary cords, but the whole t of structures is only of temporary existence. During the third month vessels ow into the hilum of the organ, and by their extension produce the appearance of *complete septa* within it. About a month later cells begin to invade the gland om its covering ' peritoneal ' cells, and this ingrowth displaces the rudimentary ord ' structures towards the hilum, where they ultimately break up and dis-ppear. *Ova* are formed in the cells of the cords before the secondary ingrowth kes place from the surface, but when this occurs they degenerate, and ova e then derived from *the ingrowing cells.* Degeneration occurs even among ese, it being asserted, in fact, that the majority of ova degenerate after their rmation. It is not impossible that more than one invasion of cells may take ace from the surface, even during the first years of life, but nothing is certainly ıown about this matter in the human subject.

In some animals the ingrowth from the surface takes place in the form of rds of cells, known as **Pflüger's cords,** but this does not seem to be the case man, the appearance of such cords being produced only later by the aggre-tion of cells, which, being surrounded by indifferent cells as a tunic, make the rly stages of the *follicles* of the ovary. Each follicle, then, contains cells derived om the surface, surrounded by indifferent mesodermal cells of the ovarian roma. One of the surface cells enlarges as the *ovum*, the rest, proliferating pidly, making the *stratum granulosum* and *discus proligerus* in which the ovum embedded, and also secreting the fluid (*liquor folliculi*) filling the follicle. The rrounding stroma cells make the *theca folliculi.*

Development of the Epoöphoron.—The **horizontal tubule,** which lies parallel the uterine tube, is a persistent part of the mesonephric duct, and represents the nal of the epididymis in the male. In some animals—*e.g.*, the sow—the meso-phric duct remains persistent, and, under the name of the *duct of epoöphoron ärtner's duct*), can be traced from the broad ligament of the uterus along the le of that organ to the lateral wall of the vagina in its upper part, where it sappears. In the human female it sometimes takes a similar course, and the rtion of it on the uterine and vaginal walls is to be regarded as representing e vas deferens in the male. The **transverse tubules** of the epoöphoron, extend-g from the region of the ovary to the horizontal tubule (so-called duct of epo-horon), into which they open at right angles, are vestiges of the anterior gmental tubes of the mesonephros, and represent the straight tubules, rete stis, efferent ducts, and lobules of epididymis of the testis in the male.

Development of the Paroöphoron.—These vestigial tubules are derived f the more posterior segmental tubes of the mesonephros, and they represent paradidymis in the male.

ABDOMINAL CAVITY.

The abdominal cavity is somewhat ovoid, the vertical meas ment greatly exceeding the transverse. Its superior boundary formed by the diaphragm, which here presents a concave surf The inferior boundary is formed by the levatores ani and cocc muscles, covered superiorly by the visceral pelvic fascia and inferi by the anal fascia. This boundary is concave on its upper asp

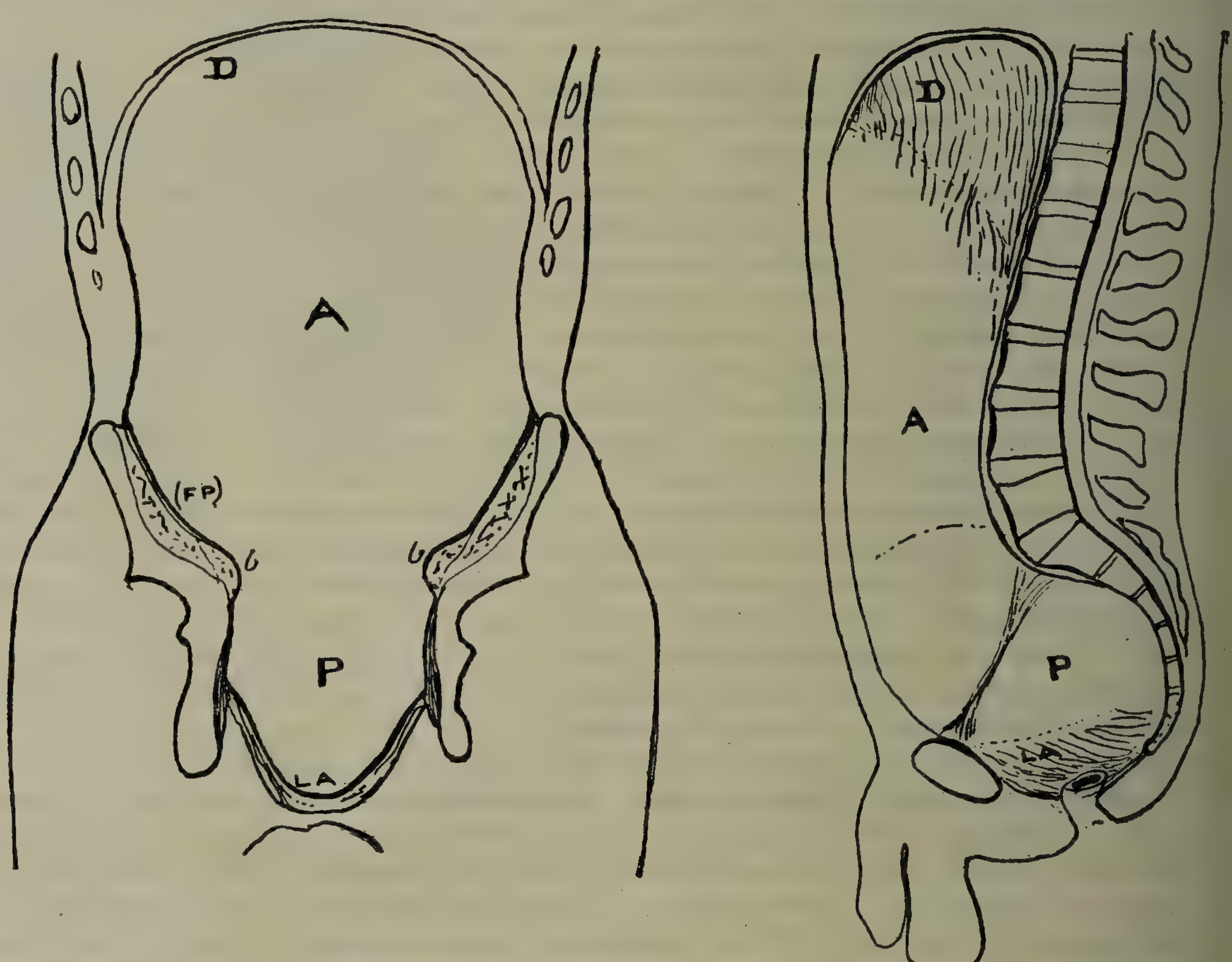


Fig. 442.—Diagrams to show Extent and Disposition of Abdominal Ca from Reconstructions in Coronal and Sagittal Planes.

D, diaphragm; LA, levator ani; A, abdominal cavity; P, pelvic cavity; FP, f pelvis; *b*, brim of pelvis, made by psoas major muscle.

The superior and inferior boundaries, being fleshy, are capable of c tracting and relaxing alternately. During contraction the diaphra descends on each side and the levatores ani ascend, thus diminish the vertical measurement of the cavity. During relaxation the reve takes place, the diaphragm ascending and the levatores ani descendi and so the cavity is increased in its vertical measurement. anterior and lateral boundaries are partly osseous and partly musc aponeurotic; the osseous boundaries are formed by the lower

oove and the pelvis below; elsewhere these boundaries are formed by ıe musculo-aponeurotic planes of the abdominal muscles. The osterior boundary is formed by the bodies and discs of the lumbar ertebræ, psoas major and quadratus lumborum muscles with their ıscial investments, the sacrum and coccyx. The cavity is divided ıto two regions, the abdomen proper and the pelvis. The **abdomen roper** is limited below by the brim of the pelvis, and its visceral con- ents are the abdominal portion of the alimentary canal, with the xception of the pelvic colon and rectum; the liver, pancreas, spleen, idneys, and suprarenal bodies. The **pelvis** is situated below the level f the brim, and contains the pelvic colon, rectum, and internal uro- enital organs.

Abdomen Proper.

Division into Regions.—The abdomen proper is divided into nine egions by means of two horizontal and two vertical lines, with their orresponding planes. The horizontal lines are called subcostal and ıtertubercular. The **subcostal line** encircles the abdomen proper on level with the lowest parts of the tenth costal cartilages, and the lane corresponding to it is called the **subcostal plane.** The **inter- ubercular line** connects the tubercles of the iliac crests, which can sually be felt about $2\frac{1}{2}$ inches behind the anterior superior iliac spine. 'he plane corresponding to this line is called the **intertubercular plane.** 'he vertical lines are called the **lateral lines,** right and left, and each xtends vertically upwards from the centre of the inguinal ligament. 'he subcostal and intertubercular lines, with their corresponding lanes, map out the abdomen proper into three horizontal zones, alled costal, umbilical, and hypogastric. The two lateral lines, with heir corresponding planes, subdivide each of these zones into three egions—two lateral, right and left, and a central. The abdomen roper is thus eventually divided into nine regions, three in each of he three horizontal zones, as follows: the **costal zone** is subdivided nto *right hypochondriac, epigastric,* and *left hypochondriac regions*; he **umbilical zone** is subdivided into *right lumbar, umbilical,* and *left umbar regions*; and the **hypogastric zone** is subdivided into *right iliac, ıypogastric,* and *left iliac regions.*

The regions just described and named are in general clinical use, ınd serve the purpose of allowing clinical description of location vith great exactitude. Where more accurate placing is desirable, and n surface-marking of organs, it is customary to adopt the system ntroduced by Addison. This is a simple method, in which the whole trunk is halved and quartered horizontally, while vertical lines are only right and left lateral in addition to the median plane; here also the right and left lines are obtained by halving the distance between the middle line and the anterior superior iliac spine.

Fig. 443 shows **Addison's lines** in position. The *median* plane is flanked by *lateral* lines, each half-way between it and the anterior superior spine. It is evident, therefore, that these lines do not corre-

spond with mid-Poupart lines. The *transpyloric plane* (TP) is half-w between the symphysis pubis and the suprasternal notch, dividi the trunk into upper and lower halves, each of which is again bisect The upper plane (TT) gained in this way is the *transthoracic*, which not used, being put in or to complete the system. T lower plane (IT) is t *intertubercular*, extending b tween the tuberculated pr minences on the iliac cres it usually corresponds mo or less with Cunninghan 'intertubercular' plane, b is not obtained in the sar way, and should not be co fused with it.

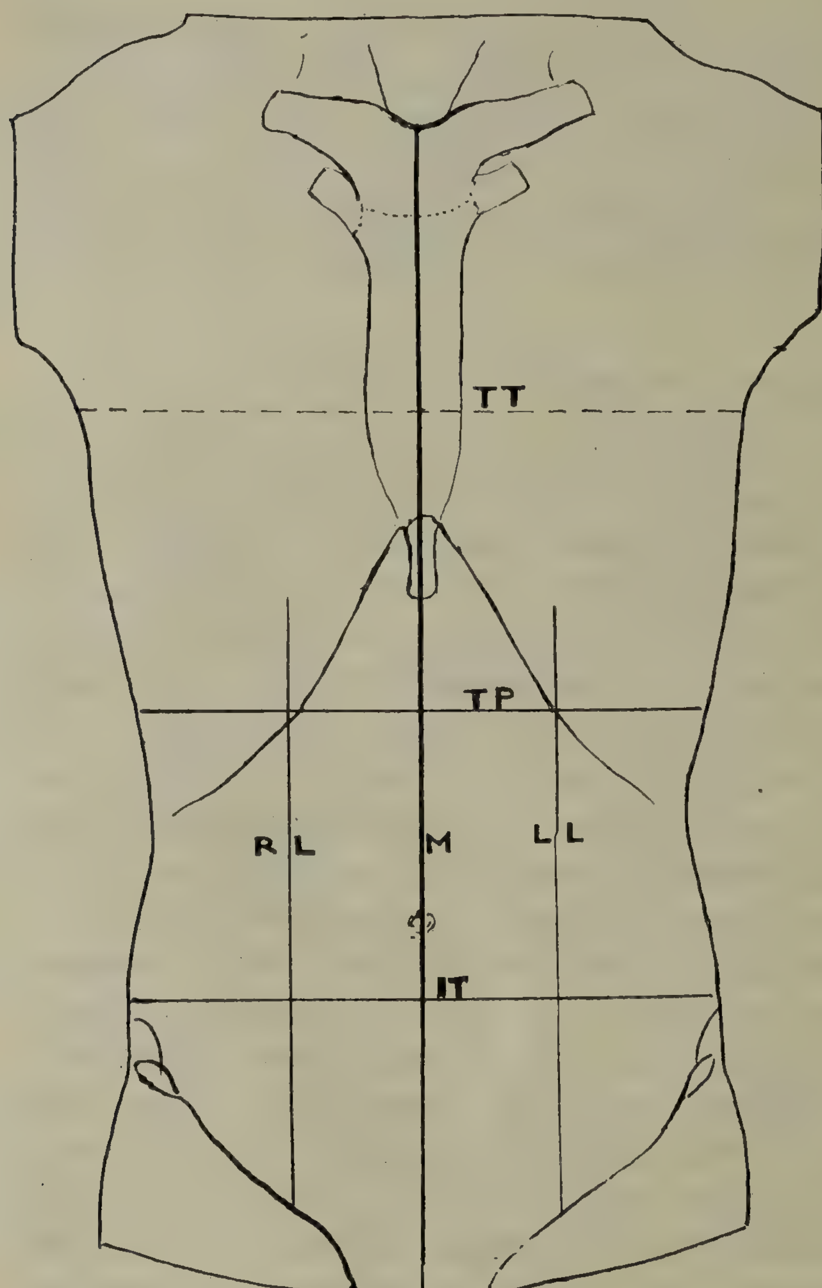


FIG. 443.—ADDISON'S LINES ON THE ABDOMEN, AS DESCRIBED IN TEXT.

It may be mentioned he that the transpyloric plane is the level of the first lumb vertebral body. For clinic purposes it can be found practice by taking a level ha way between the umbilicus a the infrasternal notch—not t xiphoid cartilage; this is only way of getting the level witho exposure, but it is not the actu transpyloric plane, which is ha way between the symphysis ar suprasternal notch.

Superficial View of th Contents. — On taking superficial view of the con tents of the abdomen prope the sharp anterior border o the liver is seen on the righ side projecting beyond th right costal margin, and als beyond the xiphoid process. The great bulk of the organ, howeve lies concealed in the right hypochondrium, and the extent t which it passes into the left hypochondrium usually corresponds t the left mammary line. In the middle line it projects beyond th xiphoid process for about 2 inches, but along the right costal margi it does not usually project more than about $\frac{1}{4}$ inch. The anterio border presents two notches. One, which is well defined, is called th **umbilical notch.** It is situated fully 1 inch to the right of the middl line, and transmits the obliterated umbilical vein or ligamentum tere of liver. The other, which is situated about 2 inches to the right of th umbilical notch, is usually somewhat indefinite, and is called th **cystic notch.** It allows the fundus of the gall-bladder to come forwar

posite the ninth right costal cartilage at a point coinciding with the ter border of the right rectus muscle. The falciform ligament is nspicuous as it takes attachment to the supero-anterior surface of e liver, which it divides into two lobes, right and left.

On the left side a portion of the stomach is visible, though a large rt of the viscus lies deeply in the left hypochondrium. The portion ich is seen in the epigastrium is partially covered by the left lobe of e liver, but a part of it in contact with the anterior abdominal wall, ovided the viscus is not empty. Descending from the greater curva-

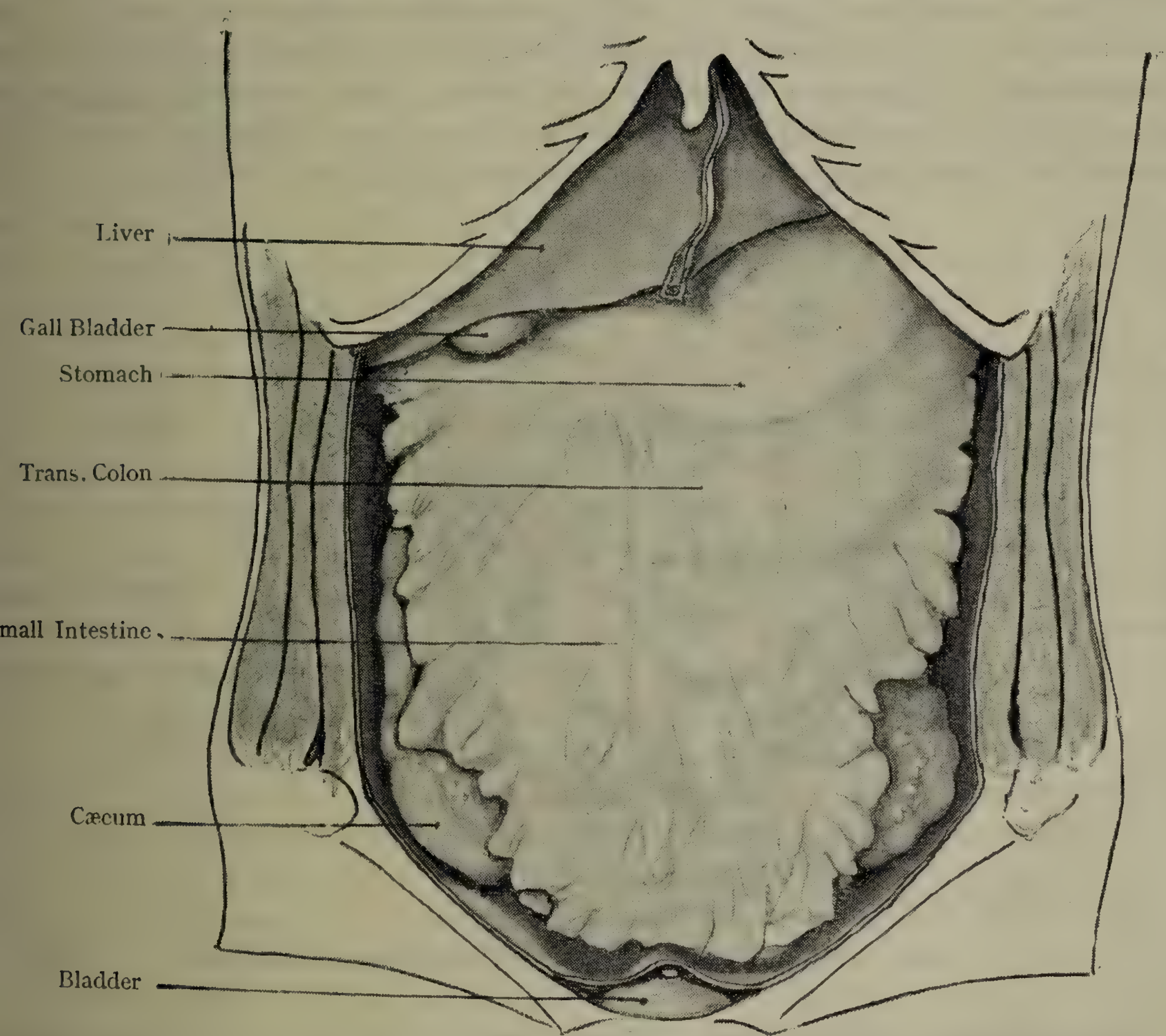


FIG. 444.—ANTERIOR VIEW OF THE ABDOMINAL VISCERA IN SITU.

ıre of the stomach there is an extensive fold of peritoneum, which ıngs down in the form of a curtain, and so conceals the jejunum and eum. This fold is called the **greater omentum.*** In normal circum-ances it descends as low as the level of the sacral promontory upon ıe left side, but it stops a little short of that level on the right side. he condition of the greater omentum is subject to much variety. ı some bodies it is very narrow, and much puckered in the vertical ırection, so as to leave exposed the viscera which are normally covered y it. In other cases it is displaced to one or other side, or it may

* For the distinction between an omentum, a mesentery, and a peritoneal gament, see p. 779 *et seq.*

even be raised into the left hypochondrium. In normal circumsta a few coils of the ileum are visible beyond the greater omentum on right side, and, more especially in the female, one or two loops of ileum may descend into the pelvic cavity to occupy the recto-uter In the right iliac fossa the cæcum is in part seen, and in the left fossa the iliac part of descending colon is partially visible.

When the greater omentum is raised and laid over the costal mar the coils of the jejunum and ileum come into view, occupying umbilical and hypogastric regions, and extending into the right left lumbar and iliac regions. The transverse colon is also seen cros in an arched manner from the right to the left hypochondriac regio

Stomach.—When moderately distended, the stomach is *pyrif* and *curved.* It presents for consideration the following parts: extremities, two surfaces, two curvatures, and two orifices.

Fig. 445.—The Stomach (External View).

Extremities.—The extremities are left and right. The *left extren* is known as the *cardiac end* or *fundus.* It is large and round, and fo a cul-de-sac. Its direction is *upwards, backwards,* and to the *left,* it is related to the left half of the diaphragm posteriorly and to spleen. The *right extremity* is known as the *pyloric end.* It lies neath the quadrate lobe of the liver, and is directed *backwards.* I narrow and tubular, and is continuous with the first part of the d denum. Its position is indicated superficially by a well-marked circu constriction, called the *pyloric constriction,* in which lies a small vei the *prepyloric vein* (Mayo).

Surfaces.—These are antero-superior and postero-inferior. **antero-superior surface** is convex, and, though mainly directed wards, has a slight inclination forwards. It is closely related (1) the under surface of the left lobe and frequently the quadrate l

the liver, (2) the left half of the diaphragm, (3) the anterior abminal wall, and (4) when the viscus is empty the transverse colon. e **postero-inferior surface** is somewhat flat, and has a slight innation backwards. Its relations are as follows:

1. The diaphragm.
2. The gastric surface of the spleen.
3. The left suprarenal gland.
4. The gastric area at the upper part of the front of the left kidney.
5. The antero-superior surface of the pancreas.
6. The upper surface of the transverse colon.
7. The upper surface of the transverse meso-colon.

Curvatures.—The curvatures, also known as **borders,** are lesser and eater. The **lesser curvature,** or **posterior border,** extends at first nost vertically downwards from the œsophagus, and then passes wards and to the right to the pyloric constriction. It is concave, d is directed backwards and towards the right. The lesser omentum nnects the lesser curvature with the lips of the porta hepatis of the er, and between the two layers of the lesser omentum, along the sser curvature, there are the left gastric artery and the pyloric branch the hepatic artery, with the corresponding veins, and near the sophageal extremity a number of lymphatic glands. Towards its loric extremity the lesser curvature presents a notch, which is proced by the stomach being bent upon itself. This notch is called the **gular notch.** It indicates the division of the stomach into cardiac d pyloric parts, and lies in or near the middle line. The **greater rvature, or anterior border,** extends from the left side of the lower d of the œsophagus to the duodeno-jejunal constriction. It is conx, and much arched. At first it arches over the fundus, passing wards, backwards, and to the left. It then passes downwards and rwards, and finally extends from left to right. The direction of the eater part of the greater curvature is forwards and towards the left. gives attachment to the greater omentum and the gastro-splenic gament. The greater omentum is attached to the greater part of the eater curvature, from which it depends. Between its two layers ere are the right gastro-epiploic artery and the left gastro-epiploic tery, together with the gastro-epiploic veins, right and left, and in e region of the pylorus the subpyloric lymphatic glands. The gastrolenic ligament is attached to the greater curvature to the left of the tachment of the greater omentum, one being directly continuous with e other, both being part of the same peritoneal fold. The transverse lon lies immediately below the greater curvature, under cover of e greater omentum. About $1\frac{1}{4}$ inches from the pyloric end the greater rvature may present a notch, called the *sulcus intermedius*, which dicates the subdivision of the pyloric part of the stomach into a yloric canal and a pyloric antrum; the sulcus is, however, very inonstant in position, and may be found at variable points along the reater curvature; it is not infrequently absent, and when present is ought to be the result of a transitory contraction.

Orifices.—These are two in number—namely, cardiac and pylo The **cardiac orifice** is also known as the **œsophageal orifice,** and thro it the œsophagus opens into the stomach. It is situated at the up and left extremity of the lesser curvature, fully 2 inches to the righ the highest part of the fundus. The **pyloric** or **duodenal orifice,** thro which the stomach communicates with the duodenum, is small variable, and is situated at the right extremity of the stomach. I directed backwards, and is guarded by the pyloric sphincter, which be described in connection with the structure of the stomach. Its posit is indicated superficially by the pyloric constriction already referred

Divisions of the Stomach.—The stomach is divided into two pa —cardiac and pyloric—by means of a line connecting the *angular no* on the lesser curvature with the opposite point on the greater curvatu The **cardiac part** lies to the left of this line, and is of large size. consists of the *fundus* and *body* of the stomach, the separation betw these two parts being indicated by a line connecting the cardiac ori with the opposite point on the greater curvature. The **pyloric pa** which is short, is subdivided into two portions—namely, the pylo canal and the pyloric antrum—by means of the *sulcus intermed* on the great curvature. The *pyloric canal* adjoins the pyloric co striction. It is about $1\frac{1}{4}$ inches in length, and is narrow and cylindri in outline, like a portion of the small intestine. Its walls are thi and it is directed *backwards.* The *pyloric antrum* is a dilatation situa to the left of the pyloric canal, from which it is separated by the *sul intermedius.*

Position of the Stomach.—When the stomach is *empty* it is co paratively small, due to the contracted state of its walls during li It is situated in the left hypochondrium and the left part of the e gastrium, and is falciform in outline. The fundus is directed upwa and backwards; the cardiac portion, somewhat saccular, is direct downwards, forwards, and slightly to the right; the pyloric porti tubular in outline, passes backwards and to the right; the pylorus l about $\frac{1}{2}$ inch to the right of the median line; the surfaces look upwa and downwards; and the greater curvature looks forwards, and t lesser curvature backwards.

When the stomach becomes *distended* it usually assumes an *obliq position,* its long axis being directed *downwards, forwards* and to t *right.* The organ increases in length; the pylorus is carried towa the right side, assuming a position from $1\frac{1}{2}$ to 2 inches on the right si of the median plane; the pyloric canal is bent backwards; the fund becomes enlarged and directed upwards and towards the left; a the upper surface acquires an inclination forwards, and the und surface an inclination backwards. The position of the cardiac orifi is practically unaltered. The stomach still occupies the left hypocho drium and the epigastrium, but, when much distended, part of may enter the umbilical and left lumbar regions. It is along t greater curvature that the main change occurs in distension; litt alteration takes place along the lesser curvature.

Typography of the Stomach.—The **cardiac orifice** is situated behind he *seventh left costal cartilage* about an inch from the sternum. It is bout 4 inches distant from the anterior abdominal wall, and is on a evel with the upper part of the body of the *eleventh thoracic vertebra.*

The *pyloric orifice*, or *pylorus*, is on a lower level and more anterior lane than the cardiac orifice, and, moreover, usually lies to the right f the median line. Relatively to the vertebral column it is on a level ith the upper part of the body of the *first lumbar vertebra*, and is pposite the tip of the ninth right costal cartilage. When the stomach s *empty*, the pylorus usually lies about ½ inch to the right of the median ne, but this distance is increased during *distension* to 1½ or 2 inches, r even more. The pylorus lies about 4 inches below the junction of he seventh right costal cartilage with the sternum, on a horizontal ne drawn midway between the suprasternal notch on the upper border f the manubrium sterni and the upper border of the symphysis pubis, he so-called transpyloric line (Addison). The pylorus usually lies n the transpyloric plane, about ½ inch to the right of the middle line.

Peritoneal Relations.—The stomach is almost completely invested by peri- oneum, the anterior surface deriving its covering from the peritoneum of the eneral cavity, and the posterior surface from that of the lesser sac. The parts ncovered by peritoneum are as follows: a narrow line along the lesser curvature etween the two layers of the lesser omentum for the passage of the left gastric nd pyloric vessels; a narrow line along the greater curvature between the two ayers of the greater omentum for the passage of the right and left gastro-epiploic essels; and the **uncovered area or trigone.** This latter area is situated on the osterior surface below, and a little to the left of the cardiac orifice. It is about inches in breadth, and rather less from above downwards, its shape being riangular. This part of the stomach is in contact with the left crus of the iaphragm, and sometimes with the left suprarenal gland. The reflection of he peritoneum on the left of this area is carried upwards as a pointed process o the diaphragm, and is known as the gastro-phrenic ligament. The bare area ermits of the passage to and from the lesser curvature of the left gastric artery nd vein.

For the structure and development of the stomach, see pp. 856 nd 862.

Position, Connections, and Component Parts of the Intestinal Canal.— he intestinal canal commences at the pyloric end of the stomach nd terminates at the anus. It is divided into small intestine and large ntestine.

The **small intestine** commences at the pyloric extremity of the tomach, and terminates in the right iliac fossa by opening obliquely nto the large intestine. It measures in the cadaver about 23 feet n length, and is divided into three parts, which, from above downwards, re called the duodenum (twelve fingers' breadth), jejunum (' empty '), nd ileum (' coiled '). In the living this measurement is reduced by third, and in formalin-hardened bodies by a half. The **duodenum** s from 10 to 11 inches in length, and its limits are the pyloric extremity f the stomach and the duodeno-jejunal flexure on the left side of he body of the second lumbar vertebra. Since it is deeply placed, its osition and connections will be described later (p. 803). Of the

remainder of the small intestine the upper two-fifths constitute th jejunum, and the lower three-fifths the ileum. There is no eviden external mark of separation between the three divisions of the sma intestine, so that they merge imperceptibly into each other; but ther are internal characters which serve to distinguish them. On the le side of the body of the second lumbar vertebra, where the duodenur terminates in the jejunum, the bowel describes a bend in a downwar and forward direction, called the **duodeno-jejunal flexure,** which suspended from the right crus of the diaphragm by a fibro-muscula band, called the *suspensory muscle of duodenum.* The **jejunum** an **ileum** are very much convoluted, their coils being covered to a greate or less extent by the greater omentum. They lie below the transvers colon, and occupy the umbilical, hypogastric, right and left lumba and right and left iliac regions. A few coils of the ileum sometime dip into the pelvis, and when this occurs they occupy, in the femal the recto-uterine pouch. The jejunum and ileum are attached to th vertebral column by a fold of peritoneum, called the mesentery prope which contains their bloodvessels, nerves, and lymphatics, and is o such a nature as to permit of great mobility in this part of the intestina tube. They are surrounded by peritoneum except along a narro interval corresponding with the attachment of the mesentery prope this border of the bowel being called the attached or *mesenteric borde* as distinguished from the free or *anti-mesenteric border.* The smal intestine is a smooth cylindrical tube, which gradually diminishes i size from above downwards. The terminal portion of the ileum, a it is about to join the large intestine, is directed upwards and to th right, with a slight inclination backwards.

Diverticulum Ilei (Meckel's Diverticulum).—This is a protrusion which i sometimes found connected with the free or anti-mesenteric border of the ileun from 1 to 10 feet above the ileo-colic valve. It represents the persistent proxima part of the **vitelline** or **vitello-intestinal duct,** which connects the yolk-sac with tha portion of the primitive alimentary canal from which the lower part of the ileun is formed. It usually measures from 2 to 3 inches in length, and its calibr generally corresponds with that of the tube from which it springs. It is ver rarely attached to the umbilicus. In most cases it resembles the finger of glove, but occasionally is reduced to the condition of a cord. It is rarely provide with a mesentery.

The **large intestine** commences in the right iliac fossa, and terminate at the anus. It measures about 6 feet in length, and gradually diminishe in size from its commencement to its termination. It is composed o the colon and the rectum. The **colon** is subdivided into the cæcun (with the vermiform appendix), ascending or right colon, hepatic flexure transverse or middle colon, splenic flexure, descending colon, and pelvi colon.

Cæcum.—The cæcum is the commencement of the large intestine It represents that part of the gut which extends below the ileo-coli orifice, and is situated in the right iliac fossa, where it rests upon th ilio-psoas muscle with the intervention of the fascia iliaca. Its lowe end or fundus has an inclination inwards towards the pelvic brim, clos

o which it usually lies. The average length of the cæcum is about $2\frac{1}{2}$ inches, its breadth being about 3 inches. When empty it is more or ess covered by coils of the ileum. In the distended state it comes nto contact with the anterior abdominal wall, and at the same time t descends as low as the outer half of the inguinal ligament. At its nner and back part, at a point about $2\frac{1}{2}$ inches from its lower end, it eceives the termination of the ileum, the opening being guarded by he ileo-colic valve. The position of this valve corresponds with a oint on the right spino-umbilical line between $1\frac{1}{2}$ and 2 inches from the nterior superior iliac spine (*McBurney's point*). In normal cases the æcum is very movable, being completely covered by peritoneum. The

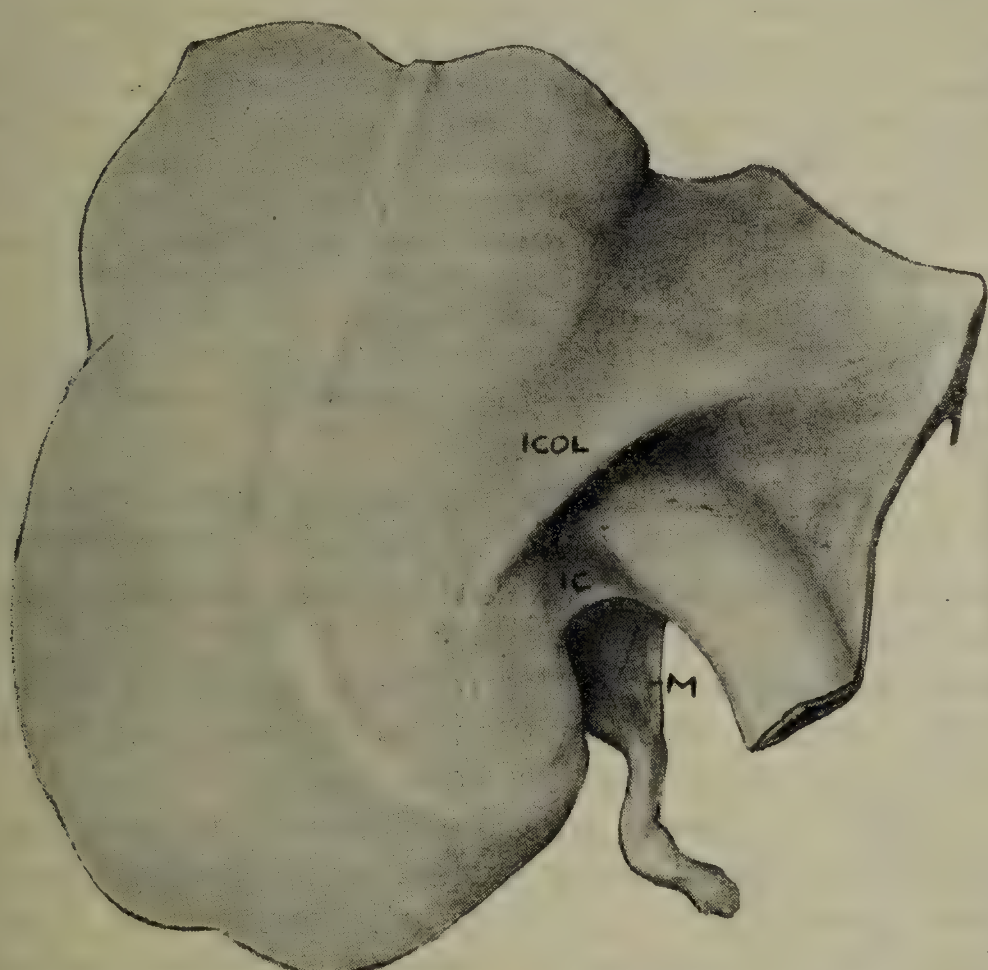


FIG. 446.—CÆCUM WITH APPENDIX AND TERMINAL PIECE OF ILEUM.
M, meso-appendix; IC, ileo-cæcal fold; ICOL, ileo-colic fold.

line of reflection of the peritoneum posteriorly may correspond with the level of the ileo-colic orifice. In some cases, however, the peritoneum, after having invested the posterior aspect of the cæcum, gives a covering to the posterior wall of the ascending colon for $1\frac{3}{4}$ inches (Treves), after which the reflection takes place. The line of reflection may be transverse or oblique, and the peritoneum so reflected is continuous with the left or interior layer of the mesentery proper.

In a few cases (about 6 per cent.) the upper part of the posterior surface of the cæcum is destitute of peritoneum, and is bound down by connective tissue to the subjacent fascia iliaca. Under these circumstances its mobility is more or less curtailed.

The cæcum is subject to much variation in its position, due, no

doubt, to the fact that at its first appearance it lies high in the a domen to the left of the middle line. It varies both in the direction which it descends and in the level to which it attains.

Varieties of Cæcum.—The cæcum is characterized by extreme variablen as regards form, but the variations may be grouped into the following th principal types:

First Type.—The cæcum is conical, as in the fœtus, the vermiform appenc springing from the apex of the cone. The three longitudinal muscular tæn are disposed as follows: one is situated on the postero-medial aspect; a seco lies along the postero-lateral aspect; and the third is placed on the anterior aspe They are nearly equally distant from each other, and meet at the junction of t cæcum and vermiform appendix.

Second Type.—The cæcum is divisible into two parts, an upper tubular anc lower conical, with the apex of which last part, the conus appendicis, the appenc is continuous. The tæniæ are situated as in the preceding type.

Third Type.—In this variety the part of the cæcum to the *right* of the anter tænia becomes more developed, and consequently more prominent, than t part to the left of that band, and the anterior wall undergoes greater grow than the posterior wall. During these changes the apex is being gradua shifted backwards and to the left, until finally it takes up a position near t ileo-colic junction, where it adjoins the origin of the vermiform appendix. T part to the right of the anterior tænia becomes so much developed, especia in a downward direction, as to give rise to a false apex. This is the most comm form of cæcum, the origin of the appendix being transferred to the left a posterior aspect.

The cæcum is large in herbivora with simple stomachs—*e.g.*, t horse and rabbit—but small in herbivora with complicated stomachs- *e.g.*, ruminants. It is usually small in carnivora—*e.g.*, the cat—b may be relatively large, as in the dog.

Vermiform Appendix.—The vermiform appendix is a small dive ticulum of the cæcum, which opens into its inner and back part rath more than 1 inch below the ileo-colic orifice. The cæcal end of t appendix is called its **base,** and the guide to it is rather more tha 1 inch below McBurney's point. Its diameter corresponds with th of an ordinary goose-quill, and its length varies from 2 to 6 inches, more. Its outline is serpentine; while the lumen is originally co tinuous along the whole length, a tendency to obliteration makes i appearance after adult age, the apical portion being the first to b closed. The opening by which the appendix communicates with th cæcum is occasionally guarded by an indistinct fold of mucous mem brane, known as the **valve of Gerlach.** The appendix is provided wit a mesentery, called the *appendicular mesentery* or *meso-appendix.* I seldom reaches more than half or two-thirds along the appendix, whic latter is thus rendered more or less convoluted or serpentine. Th meso-appendix and its variations will be found described on p. 787.

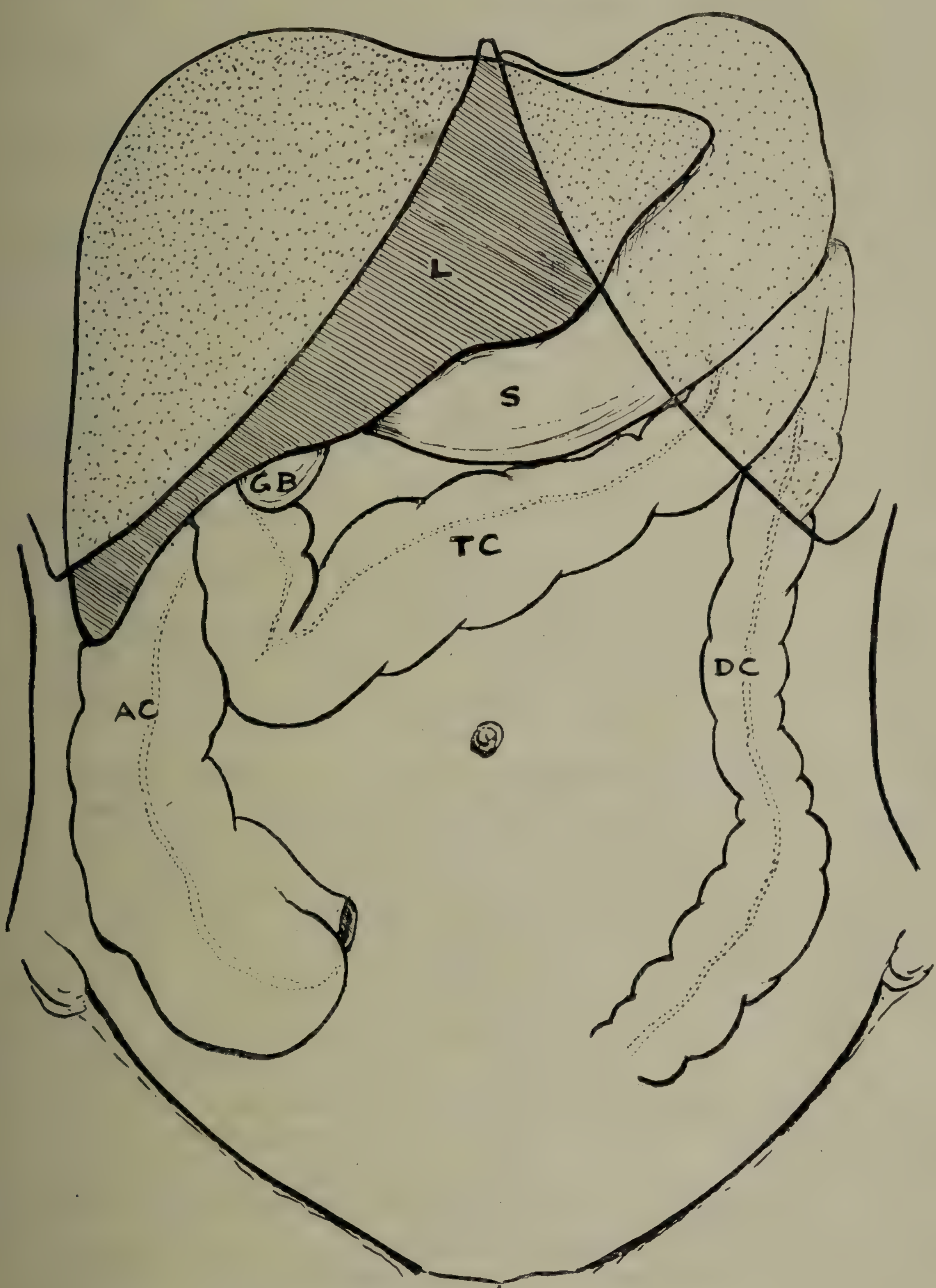
The position occupied by the appendix is extremely variable. The norm positions may be tabulated as follows:

1. The vermiform appendix often lies under the left or inferior layer of th mesentery, where it takes a course upwards and to the left in the direction of th spleen. (According to Treves this is its usual position.)

2. It may lie on the brim of the pelvis, along the external iliac vessels, or ma project into the pelvic cavity.

3. It may lie to the right of the cæcum and ascending colon, occupying the teral paracolic fossa and ascending over the right kidney towards the right be of the liver.

4. It may lie free among the coils of small intestine.



G. 447.—To show the Positions and Relations to One Another of the Liver (L), Stomach (S), Gall-bladder (GB), and Colon (AC, TC, DC).

Based on the average positions of these structures given by Addison.

5. It may lie free underneath the cæcum in a retro-cæcal fossa. (This is the ond most common situation according to Treves.)

6. It may extend horizontally inwards to the promontory of the sacrum. e ascending type of appendix is usually only partially covered by peritoneum, l is believed to be the result of an early fixation to the abdominal wall.

Ascending Colon.—This extends from the cæcum, on a level wi the ileo-colic orifice, to the under surface of the right lobe of tl liver at a point to the right of the gall-bladder. Here it describes bend, called the right colic flexure, which indents the liver, and gives rise to the colic impression. The ascending colon is abo 5 inches in length, and occupies a part of the right iliac, right lumba and right hypochondriac regions, in which it lies deeply, being contact with the posterior abdominal wall. Posteriorly it rests up a portion of the right iliacus muscle covered by the fascia iliaca, tl right quadratus lumborum invested by its sheath, and the front the right kidney in its lower and outer part. Anteriorly it is more less covered by the coils of the jejunum and ileum, but is often contact with the abdominal wall near its commencement. Medial it has the coils of the jejunum and ileum, and the right psoas maj muscle, covered by its fascia. The ascending colon in most cases covered by peritoneum in front and at the sides, but not behin Sometimes, however, it is completely invested by the serous membran which then forms behind it a mesentery, called the ascending mes colon. Occasionally peritoneal folds are to be found extending fro the front of the ascending colon to the abdominal wall; one of thes more constant than the rest, is attached at, or a little above, the lev of the iliac crest, and is called the *sustentaculum hepatis*; it occurs about 18 per cent. of cases (Treves); it presents anteriorly a free co cave border, and measures about 1½ inches in width, and about 2 inch from before backwards.

Right Colic (Hepatic) Flexure.—This is the bend formed by tl gut between the termination of the ascending colon and the commenc ment of the transverse colon. The bend takes place in a directi forwards, downwards, and to the left, and so brings the bowel in fro of the second or vertical part of the duodenum. The right colic flexu has the colic impression on the inferior surface of the right lobe of tl liver above it, the sharp anterior margin of the liver on its outer sid and the second part of the duodenum on its inner side. Posteriorly is in contact with the right kidney in the same locality as the upp part of the ascending colon, and it is here uncovered by peritoneum.

Transverse Colon.—This, which is comparatively long and ve arched, commences in the right hypochondrium in front of the secon part of the duodenum, and terminates in the left hypochondrium the left colic flexure. Its length varies from 5 to 10 inches or mor Its extremities are deeply placed, the right being a little lower ar more superficial than the left, and both being comparatively fixed account of the shortness of the transverse meso-colon at these point The greater part of it descends into the umbilical region, where usually lies just above the umbilicus. The transverse colon is com pletely invested by peritoneum, except occasionally for 1 inch more posteriorly at its right extremity. The serous membrane form an extensive fold behind it, called the *transverse meso-colon*, whic passes backwards to the anterior border of the pancreas, and is

very limited extent at its right and left extremities. The transverse colon is covered in front by the great omentum. Above it, from right to left, are the liver, gall-bladder, greater curvature of the stomach, and colic surface of the spleen; behind it are the second part of the duodenum, head of the pancreas, and transverse meso-colon; and below it are the coils of the jejunum and ileum.

Left Colic (Splenic) Flexure.—This is situated in the left hypochondrium in contact with the colic surface of the spleen, and behind the cardiac end of the stomach. It occupies a higher and deeper position than the right flexure, and its posterior surface is uncovered by peritoneum. Connected with its left aspect there is a triangular fold of the serous membrane, which attaches it to the diaphragm opposite the tenth or eleventh left rib. This fold is called the *phrenico-colic ligament*; it forms a platform upon which the colic surface of the spleen rests, and is hence sometimes called the *sustentaculum lienis* ("support of the spleen"). It will be found described on p. 789.

Descending Colon.—This, which is of comparatively small calibre, owing to its being usually empty and contracted, commences in the left hypochondrium at the left colic flexure, and terminates in the lower part of the left lumbar region on a level with the back part of the iliac crest, where it passes into its iliac portion. It measures about 5 inches in length, and lies deeply in the left hypochondriac and left lumbar regions, being directed at first downwards and slightly inwards, and subsequently vertically downwards. Posteriorly it is in contact, from above downwards, with the front of the left kidney at its lower and outer part, and the left quadratus lumborum muscle invested by its sheath. Anteriorly it is covered by coils of the jejunum and ileum. Medially coils of the jejunum and ileum form a superficial relation, whilst more deeply there are the lower part of the left kidney and the left psoas major muscle covered by its fascia. The descending colon in most cases is covered by peritoneum in front and at the sides, but not behind. Sometimes, however, it is completely invested by the serous membrane, which then forms behind it a mesentery, called the *descending meso-colon.*

The ascending, transverse, and descending parts of the colon form an arch, within the concavity of which the coils of the jejunum and ileum are disposed.

Iliac Part of Descending Colon.—This commences on a level with the back part of the iliac crest, and terminates at the inner border of the left psoas major anterior to the left sacro-iliac articulation. At this point it enters the pelvic cavity and becomes the pelvic colon. It measures about 6 inches, and is situated in the left iliac fossa, where it lies upon the ilio-psoas muscle with the intervention of the fascia iliaca, its direction being downwards and inwards. Anteriorly it is covered, when empty, by coils of the ileum, but when distended it lies in contact with the anterior abdominal wall. The iliac colon in most cases is covered by peritoneum in front and at the sides, but not behind. Sometimes, however, its terminal part is completely invested by the

serous membrane, which then forms behind it a mesentery, called t *iliac meso-colon.*

For the **pelvic colon** and **rectum,** see pp. 943 and 944.

The large intestine, with the exception of the vermiform appenc and rectum, is characterized by well-marked sacculations, whi present a striking contrast to the smooth cylindrical contour of the w of the small intestine. These sacculations are due to the longitudi muscular fibres being largely gathered into three longitudinal ban called *tæniæ coli,* which are shorter than the portion of bowel to whi they are applied. The sacculations are separated from each oth by constrictions filled with fat. Another characteristic of the great part of the large intestine is the presence at frequent intervals of sm projections of the peritoneal coat containing fat, called *appendic epiploicæ.* These characteristics will be found described in connecti with the structure of the large intestine on p. 870.

For the structure and development of the intestinal canal, s pp. 869 and 864 *et seq.*

Position, Connections, and Component Parts of the Spleen.—T spleen (lien) is a ductless gland which lies deeply in the epigastric a left hypochondrium opposite the ninth, tenth, and eleventh rib and extending from about the level of the ninth thoracic spine to th of the eleventh. The organ can only be seen when the stomach drawn out from the left hypochondrium. It is soft, spongy, easi torn, and exceedingly vascular, and has a dark red colour. It is liable to become enlarged that it is subject to much variety as regar dimensions and shape. The following statement, therefore, of i dimensions is only to be accepted as approximately accurate. T average length of the spleen is about 5 inches, its breadth at the wide part about 3 inches, and its thickness about $1\frac{1}{2}$ inches. The weigh which is very variable, is about 6 ounces. The organ occupies a oblique position, its long axis being directed downwards, outwards, an forwards. Its lower two-thirds are situated in the left hypochondriu and the upper third in the epigastrium. When it has been hardene *in situ* its shape resembles that of an irregular tetrahedron (Cunnin ham)—that is to say, it resembles a solid figure enclosed by fo equilateral triangles. The following description is based upon th view of its shape.

Apex.—This corresponds with the upper end, and lies in the ep gastrium about 2 inches from the median line. It is directed upward inwards, and slightly forwards, and usually touches the upper later angle of the suprarenal gland.

Surfaces.—One aspect of the organ is directed towards the dia phragm, the other looking towards the abdominal cavity and it viscera. The former aspect represents the **diaphragmatic surface,** whic is convex, and adapts itself to the concavity of the diaphragm. Thi surface looks outwards, backwards, and upwards. It is in contac with the diaphragm opposite the ninth, tenth, and eleventh ribs, th left plural sac containing in its upper part the thin basal margin of th

ft lung, descending for some distance between that part of the dia-hragm and the adjacent ribs. The **visceral surface** is complex, and resents three impressions, which are separated from each other by ıore or less well-marked ridges, radiating from the medial colic angle Cunningham). These impressions are called gastric, renal, colic, and ancreatic.

The **gastric impression** is large, concave, and somewhat semilunar. : looks forwards, inwards, and downwards, and accurately adapts self to the fundus of the stomach on its posterior aspect. It is limited nteriorly by the sharp nterior border of the pleen, which separates it om the diaphragmatic ırface, and posteriorly it separated from the renal npression by the inter-ıediate border, which xtends from the medial olic angle upwards to the pex. A little in front of ıis border, and therefore tuated on the gastric npression, there is a ssure, called the **hilum,** or the passage of the plenic vessels, lympha-cs, and nerves. Instead f a hilum there is some-imes a row of foramina. 'he narrow portion of the astric impression behind ıe hilum is, at its lower nd, in contact with the ail of the pancreas, thus ıaking the **pancreatic npression.**

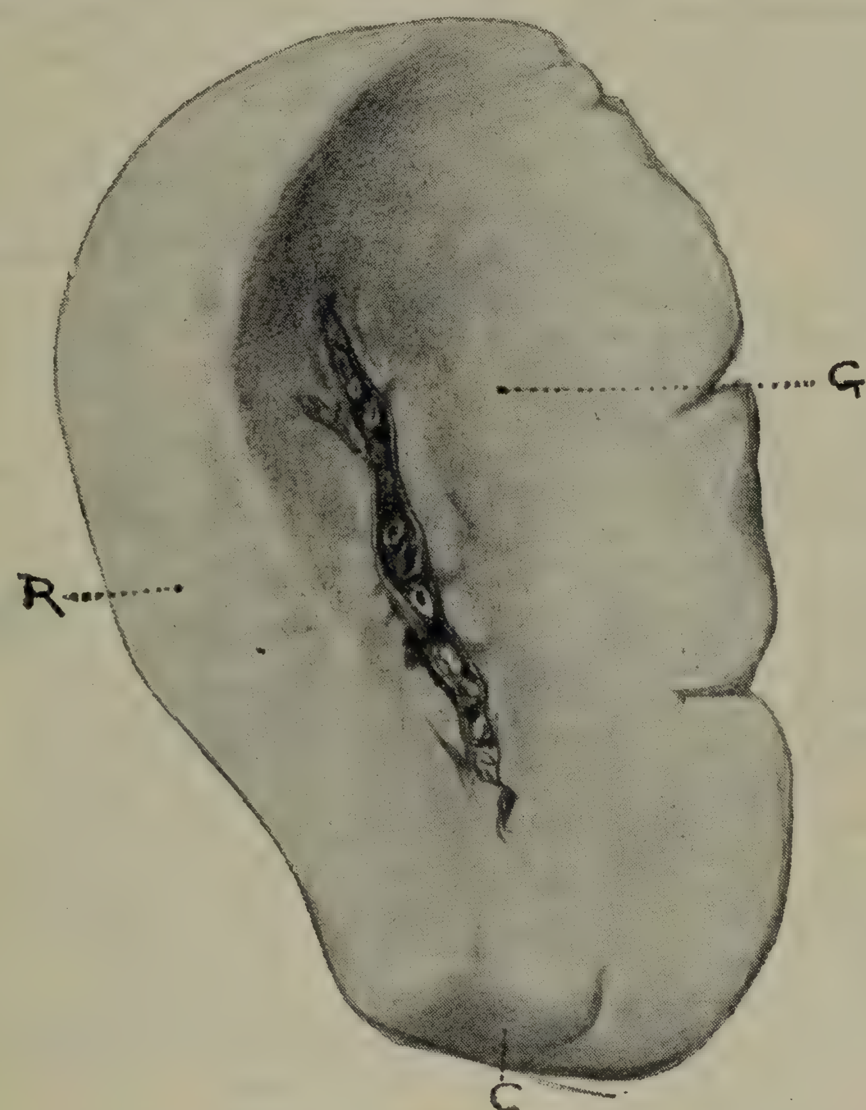


FIG. 448.—VISCERAL SURFACES OF SPLEEN.
R, renal; G, gastric; C, colic.

The **renal impression,** which is posterior to the gastric impression, s narrow. It looks inwards and downwards, and is in contact with he front of the left kidney at its upper and outer part close to the ıteral border. It is separated from the gastric impression by the ıtermediate border, and is limited behind by the posterior border, vhich separates it from the diaphragmatic surface. Inferiorly it is eparated from the colic impression by the ridge which extends from he medial colic angle to the posterior angle.

The **colic impression** is the small triangular surface which looks ownwards and inwards. It rests upon the left flexure of the colon nd upper surface of the sustentaculum lienis or peritoneal platform ormed by the phrenico-colic ligament. It is separated from the renal

impression by the ridge already referred to, and from the gastric impression by the ridge which passes between the medial and anterior colic angles. The angles of this impression are called *medial, posterior,* and *anterior,* the last being the most prominent.

Borders.—These are anterior, posterior, intermediate, and inferior. The anterior border is situated between the diaphragmatic surface and the gastric impression. It is sharp, and usually presents several notches which are of considerable diagnostic importance. The posterior border is situated between the diaphragmatic surface and the renal impression. It is blunt, and its position and direction practically

FIG. 449.—TRANSVERSE SECTION AT THE LEVEL OF THE TWELFTH THORACIC VERTEBRA (AFTER SYMINGTON).

coincide with the lowest left intercostal space. The intermediate border extends from the medial colic angle to the apex, and intervenes between the gastric and renal impressions. The inferior border separates the diaphragmatic surface and the colic impression, and is somewhat sharp.

The most fixed part of the spleen is naturally in the region of the hilum. When the spleen enlarges it does so in a forward, downward, and inward direction, moving in a circumferential manner round its most fixed point. The spleen moves in respiration, but cannot be palpated unless it is enlarged.

Peritoneal Relations.—The spleen is surrounded by peritoneum, xcept at the hilum and where the gastro-splenic and phrenico-splenic igaments are connected with it. The serous membrane forms three olds, called gastro-splenic ligament, lieno-renal ligament, and phrenico-plenic ligament. The **gastro-splenic ligament** (**omentum**) is attached y one extremity to the gastric impression of the spleen just in front f the hilum, the other extremity being connected with the cardiac end f the stomach on its posterior aspect and the left border of the greater mentum. The **lieno-renal ligament** is attached by one extremity to the astric impression along the line of the hilum, the other extremity being ttached to the front of the left kidney at its upper and outer part. 'he **phrenico-splenic** or **lieno-phrenic ligament** extends between the pleen near its upper extremity and the contiguous part of the dia-hragm. The lieno-renal and phrenico-splenic ligaments are the ower and upper parts respectively of one peritoneal fold.

Occasionally small accessory spleens, varying in number from one to twenty, re found in the gastro-splenic ligament in the neighbourhood of the hilum, r more rarely in the greater omentum or transverse meso-colon, rarely embedded 1 the pancreas.

Area of Splenic Dulness.—This area is limited posteriorly by the iid-scapular line between the ninth and eleventh left ribs, and anteriorly y the mid-axillary line as it crosses the ninth, tenth, and eleventh ibs, or by a line connecting the left sterno-clavicular joint with the ip of the eleventh left rib. The length of the area is about 3 inches, nd its breadth from 2 to 2½ inches.

For the structure and development of the spleen, see p. 897.

Position, Connections, and Component Parts of the Liver.—The liver iepar), which is the largest gland in the body, occupies almost all the ght hypochondrium, a great part of the epigastrium, and frequently mall parts of the right lumbar region and left hypochondrium. It is iaintained in position by the following peritoneal ligaments: the oronary ligament, the right and left triangular ligaments, and the ılciform ligament.

Topography.—The size of the liver is so variable that the following tatement of its limits is only to be regarded as approximately accurate. n the right mammary line it extends from the fifth to the tenth rib iclusive. In the mid-axillary line the right aspect of the organ extends om the *seventh* to the *eleventh* rib, and in the scapular line its superior nd inferior limits are on a level with the *ninth* and *eleventh* thoracic pinous processes respectively, the ribs to which it is here related being ie ninth, tenth, and eleventh. The **left limit** of the organ usually corre-ponds to the left lateral plane. In mapping out the **upper limit** the iiddle line may be taken as the starting-point. In this situation the mit is indicated by a line crossing the sternum at the level of the *sixth* ostal cartilages, this line being slightly arched downwards. The line iould then be prolonged to the left, with a slight curve upwards, to point about 2 inches to the left of the left border of the sternum nd about 1 inch below the nipple. In continuing the line to the right

it should be carried upwards so as to reach a point about $\frac{1}{2}$ inch belo the right nipple. The line, on being prolonged from this point towar the right side, must be carried slightly downwards so as to reach tl mid-axillary line at the level of the *seventh* right rib. The **lower lim** of the organ extends from a point about $\frac{1}{2}$ inch below the tip of tl bony part of the *tenth* right rib to the left extremity of the line ir dicating the upper limit. The direction of the line indicating tl lower limit is upwards and to the left.

The liver is thus to a very large extent under cover of the low ribs and costal cartilages of the right side, the xiphoid process, an the sixth, seventh, and eighth costal cartilages of the left side. It accurately moulded on the under surface of the diaphragm, whic separates it from the base of the right lung covered by pleura, and tl heart enclosed in the pericardium. The thin marginal part of the ba of the right lung, with its pleural investment, descends in the angul interval between the diaphragm and the thoracic wall, and so partiall covers the liver, a relation which has to be borne in mind in percussir the organ. In the right mammary line the lung descends as low a the *sixth* rib, whilst the liver ascends to the upper border of the *fift* In the right mid-axillary line the lung descends as low as the *eigh* rib, whilst the liver ascends as high as the *seventh*. In the rigl scapular line (inferior angle of scapula) the lung descends as low a the *tenth* rib, whilst the liver ascends as high as the *ninth*. The live comes nearest to the surface below the right costal margin and belo the ensiform process. In the former situation it projects about $\frac{1}{4}$ incl and in the latter about 2 inches, and in each situation is in contac with the anterior abdominal parietes.

Various circumstances affect the position of the liver. During respiratic the liver descends in inspiration and ascends in expiration. In the horizont posture it ascends, and in the sitting or upright posture it descends. In di tension of the stomach and intestines, as well as in ascites, it ascends. In rigl hydro-thorax, hypertrophy of the heart, and hydro-pericardium it descend Long-continued pressure, as in tight lacing, causes the liver to be displaced dowr wards. Finally, when the abdomen proper is encroached upon by the gravi uterus or by an ovarian tumour the liver is displaced upwards.

The liver has a reddish-brown colour, and presents for the mos part a smooth surface. It is firm to the touch, but under pressure friable—that is to say, easily crumbled. The dimensions of the orga can only be stated approximately. In the transverse direction (fror right to left) it measures from 7 to 10 inches, the measurement fror before backwards at its right extremity being about 6 inches, whic also represents its vertical measurement at the thickest part of th right lobe. Its weight in the adult ranges from 45 to 60 ounces, c from 3 to 4 pounds, the weight in the female being rather less, and it relation to the body weight being in the proportion of one to forty i the adult. In early life the liver is proportionately larger than in th adult, and in a child at the period of birth its relation to the bod weight is as one to twenty.

Surfaces.—These are superior, anterior, inferior, right, and posterior. [I]t is not to be supposed, however, that these surfaces are all clearly [s]eparated from one another by well-defined borders, only one margin [b]eing in reality distinct—namely, the anterior border, which has a [v]ery sharp outline.

The **superior surface** is markedly convex in its right portion, and [a]ccurately adapts itself to the concavity of the diaphragm, with which it [i]s in contact. To the left of this convex part there is a depression, called [t]he *cardiac impression*, produced by the heart with the intervention of [t]he diaphragm. To the left of this impression the superior surface [a]gain becomes convex, and adapts itself to the concavity of the left [h]alf of the diaphragm. The superior surface is separated from the [p]osterior, anterior, and right surfaces by round, somewhat indistinct [b]orders.

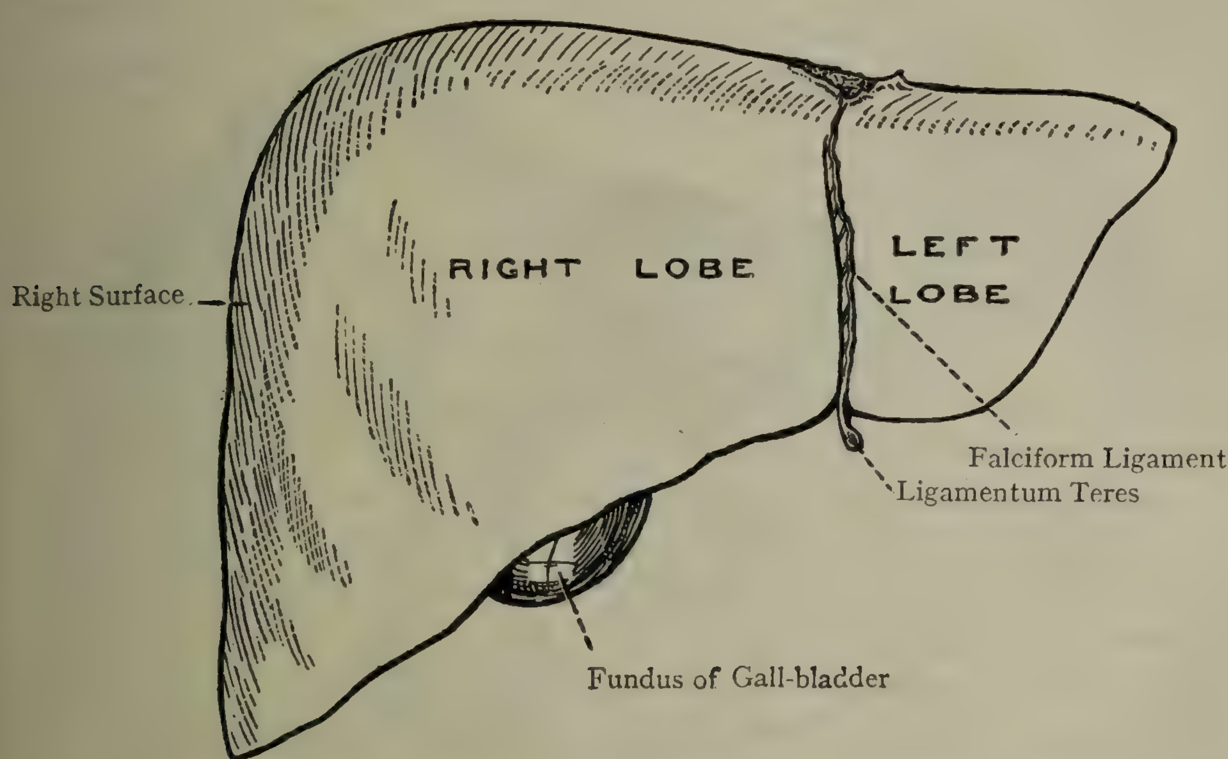


FIG. 450.—THE LIVER (ANTERO-SUPERIOR VIEW).

The **anterior surface** looks forwards and is triangular. The apex [i]s directed towards the left extremity of the liver, whilst the base is [t]owards the right extremity. One side of the triangle corresponds to [t]he anterior border, the other side being formed by the round border [w]hich separates the anterior from the superior surface. The anterior [s]urface is mainly in contact with the diaphragm and the right and [l]eft costal margins, but at the middle line it is in relation with the [x]iphoid process, and for about 2 inches below that process it is in [c]ontact with the anterior abdominal wall. The superior and anterior [s]urfaces are divided into two lateral parts by the falciform ligament, [t]he part to the right of this ligament being called the **right lobe,** and the [p]art to the left the **left lobe.** The right lobe forms about four-fifths [o]f the entire supero-anterior surface in the adult, but in early life the [t]wo lobes are very nearly of equal size.

The **inferior** or **visceral surface** looks downwards with an inclination

to the left. It is divided into two parts, right and left, by the fiss for ligamentum teres. The part to the left of this fissure represent portion of the left lobe. It lies in front of the cardiac orifice of stomach, the anterior surface of that organ close to the lesser curvatu and the lower part of the lesser omentum. The part related to stomach presents an area called the **gastric impression.** The part the right of this impression, close to the back part of the fissure ligamentum teres, presents a smooth round eminence, called the *tu omentale.* This eminence projects in a backward direction over lesser curvature of the stomach, and so abuts against the anter layer of the lesser omentum. The part of the inferior surface to

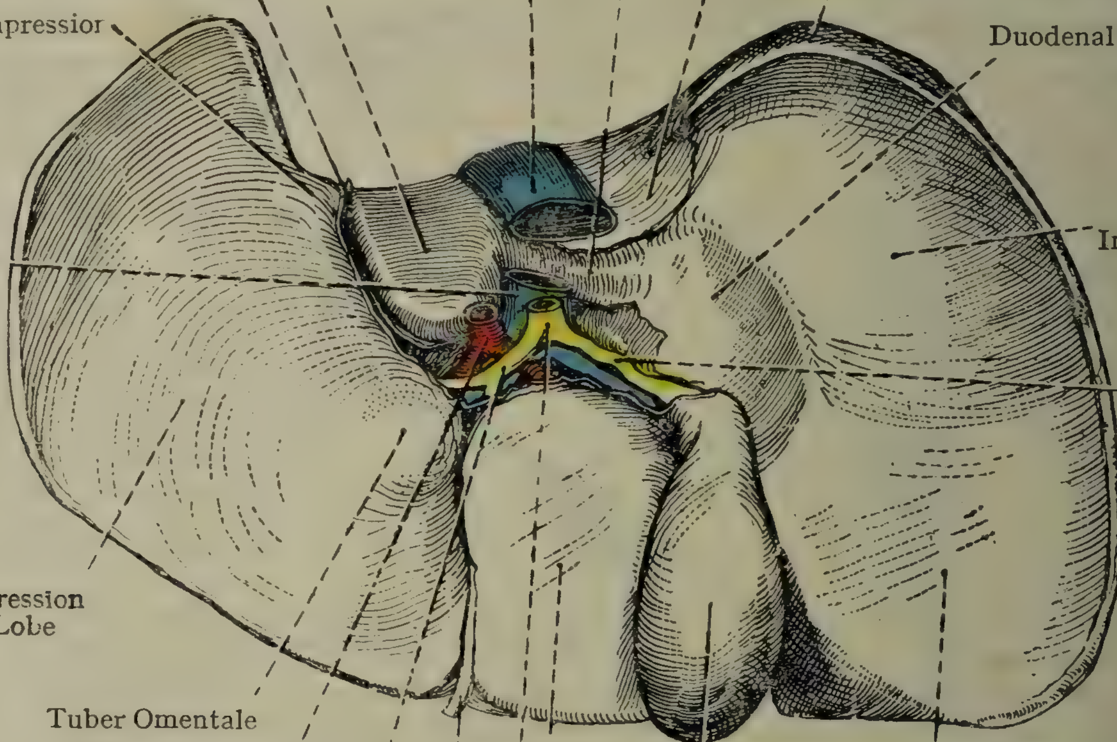


FIG. 451.—THE INFERIOR SURFACE OF THE LIVER.

right of the fissure for ligamentum teres presents, as its most striki object, the gall-bladder, which occupies the **fossa for gall-bladd** This fossa extends from the anterior border of the porta hepatis. has the quadrate lobe on its left side, and a large part of the right lo on its right side. The portion of the inferior surface of the right lo to the left of the gall-bladder includes the following parts: the quadra lobe, the porta hepatis, the caudate process, and the lower margin the caudate lobe.

The *quadrate lobe,* which is elongated from before backwards, bounded anteriorly by the anterior border of the liver; posterio by the porta hepatis; on the right side by the gall-bladder and fossa; and on the left by the fissure for ligamentum teres. It is

ntact with the pyloric end of the stomach and first part of the odenum.

The *porta hepatis* forms a right angle with the back part of the ure for ligamentum teres, from which it extends over the inferior face of the right lobe for a distance of about 2 inches. It is unded in front by the quadrate lobe, and behind by the caudate ocess and the lower margin of the caudate lobe. The two layers of the ser omentum are attached to its anterior and posterior lips. It ves for the passage of the following structures, in order from before ckwards: (1) the common hepatic duct; (2) the hepatic artery, accomnied by the hepatic sympathetic plexus of nerves and lymphatic ssels; and (3) the portal vein, all surrounded by the capsule of liver.

The *caudate process* is the narrow portion of liver substance which nnects the right extremity of the lower margin of the caudate lobe th the adjacent part of the inferior surface of the right lobe. It s behind the porta hepatis, and has the portal vein in front of it, d the inferior vena cava behind it. It forms the upper boundary the opening into lesser sac.

The *lower margin of the caudate lobe*, like the caudate process, is uated behind the porta hepatis. It is divided by a notch into two inences of unequal size. The right eminence, which is the smaller the two, is continuous with the caudate process. The left eminence of large size, and is known as the *papillary process*. The part of e inferior surface of the right lobe which lies to the right of the gall-adder is of large extent, and presents three impressions—namely, lic impression, renal impression, and duodenal impression. The *lic impression*, which looks downwards, is situated in front, where it s to the right side of the body of the gall-bladder. It is in contact th the right flexure of the colon. The *renal impression*, which is of rge size, looks backwards as well as downwards, is posterior to the lic impression, and is in contact with a large part of the front of e right kidney. The *duodenal impression* is situated on the inner de of the renal impression, just lateral to the neck of the gall-bladder. is in contact with the commencement of the second part of the odenum.

The *fissure for ligamentum teres* is so named because it contains the mains of the umbilical vein, now known as the *ligamentum teres of the ver*. It commences at the anterior border of the organ in the interlobar otch, and extends as far back as the left extremity of the porta hepatis, ith which it forms a right angle. It separates the quadrate lobe om the inferior surface of the left lobe. Sometimes the porta is more less completely bridged over by a portion of hepatic substance, which us forms a *pons hepatis*. The obliterated umbilical vein terminates y joining the left division of the portal vein opposite the point at hich the obliterated ductus venosus, with which in the fœtus the nbilical vein was continuous, is attached.

The **right surface** is convex, and is in contact with the diaphragm nd right ribs from the *seventh* to the *eleventh*, the margin of the base

of the right lung and pleura here descending between the ribs and diaphragm as low as the *eighth* rib. There is no well-marked line demarcation between this surface and the posterior, superior, anterior surfaces, but it is distinctly separated from the inferior surf by the right portion of the anterior border.

The **posterior surface** presents a concavity corresponding with convexity of the bodies of the tenth and eleventh thoracic verteb It is related to the diaphragm, and its component parts from left right are as follows: the posterior part of the left lobe; the œsophag impression; the fissure for ligamentum venosum; caudate lobe, exc

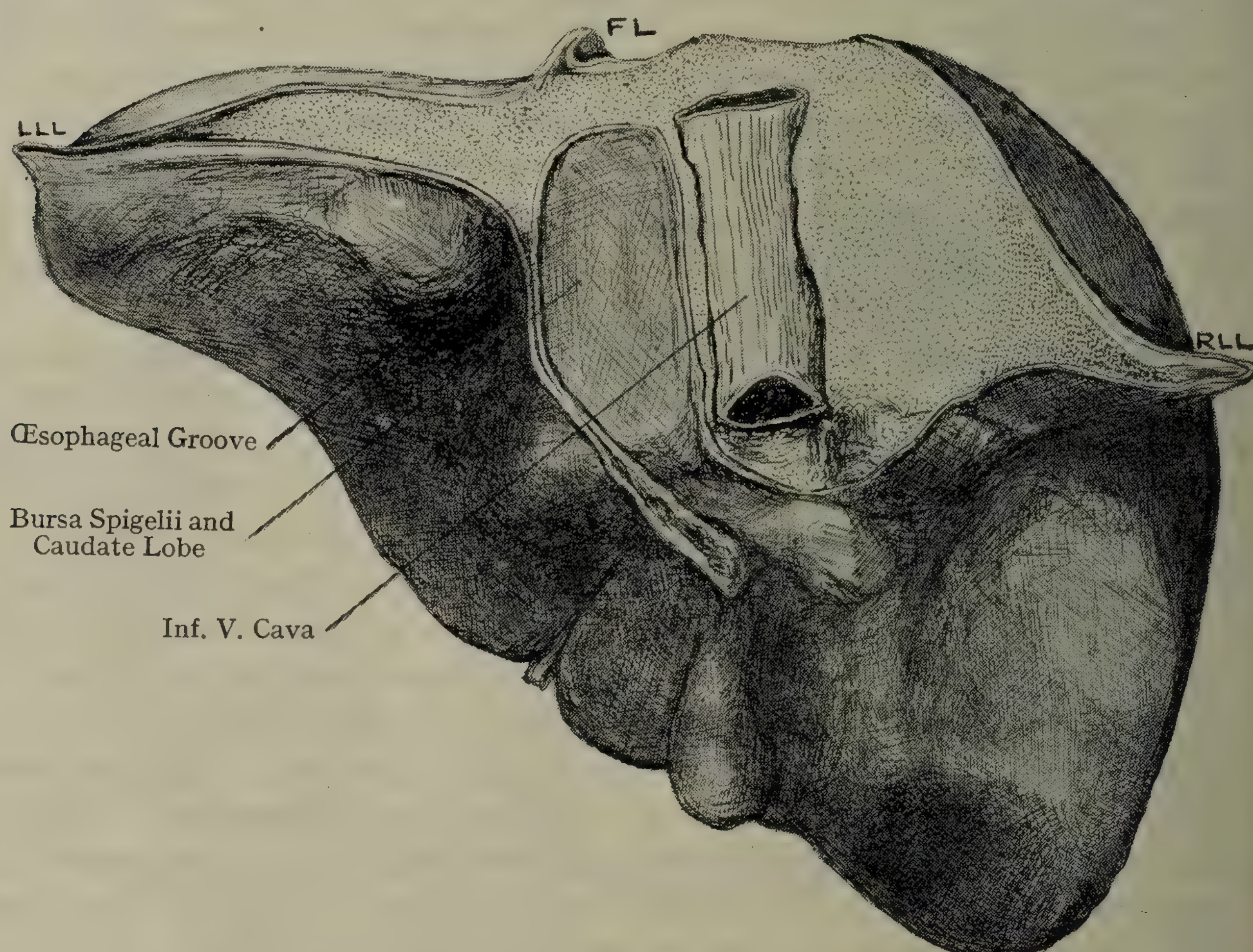


FIG. 452.—POSTERIOR ASPECT OF LIVER, SHOWING BARE AREA.
FL, falciform ligament; RLL, LLL, right and left triangular ligaments.

its lower margin; the fossa for the inferior vena cava; and the b area of the right lobe.

The *posterior part of the left lobe* at its left extremity is a m margin overlying the fundus of the stomach, but elsewhere it prese a distinct surface marked by the *œsophageal impression*, which is contact with the right side of the lower end of the œsophagus.

The *fissure for ligamentum venosum* lies vertically on the poster surface, having the caudate lobe on its right, and the œsophageal groo on the left lobe on its left. Inferiorly it meets the left extremity of t porta hepatis and the posterior extremity of the fissure for ligamentu teres, and superiorly it passes to the right and meets the fossa f inferior vena cava. It lodges the ligamentum venosum, which is co

:cted below with the left division of the portal vein, and above with e inferior vena cava. The fissures for the ligamenta venosum et teres parate the right and left lobes on the posterior and inferior surfaces spectively.

Caudate lobe (*Spieghel's lobe*), with the exception of its lower margin, :s vertically on the posterior surface. It is bounded on the right side / the fossa for vena cava, on the left by the fissure for ligamentum :nosum, and inferiorly by the porta hepatis. It looks backwards and little inwards, and is in contact with the right crus of the diaphragm pposite the tenth and eleventh thoracic vertebræ. Its lower margin is been already described (p. 775). The lobe lies in front of the upper id of the lesser sac of the peritoneum.

The *fossa for vena cava* lodges a part of the inferior vena cava. It :s vertically, and somewhat deeply, on the posterior surface, having ie bare area of the right lobe on its right side, caudate lobe on its left de, and the caudate process below. This fossa is sometimes bridged /er by a portion of liver substance, called a *pons hepatis*. At the upper irt of this fossa the hepatic veins open into the inferior vena cava.

The *bare area* of the right lobe represents its back part. It measures om $2\frac{1}{2}$ to 3 inches in the transverse direction, and fully 2 inches from bove downwards, except at the extreme right, where it tapers to a oint. It is destitute of peritoneum, and is enclosed between the two :rous layers which form the coronary ligament, being attached to the aphragm by areolar tissue. Its direction is backwards and a little wards. The extreme left end of this area, at a point immediately the right of the lower end of the fossa for vena cava and near the iudate process, presents a somewhat triangular impression, called the *iprarenal impression*, for the right suprarenal body.

Borders.—The chief borders are three in number—namely, postero-iperior, postero-inferior, and inferior. The *postero-superior* and *ostero-inferior borders* give attachment to the two layers of peritoneum hich form the coronary ligament, and they enclose between them the osterior surface. The *inferior border* is sharp. At its right extremity passes backwards so as to separate the inferior from the right surface. t its left extremity it also passes backwards, and so forms the thin ft margin of the left lobe. Its anterior portion presents two notches, iterlobar and cystic. The *interlobar notch* is situated fully 1 inch to ie right of the middle line, and transmits the ligamentum teres. The *stic notch*, often hardly perceptible, is situated about 2 inches to the ght of the interlobar notch, and allows the fundus of the gall-bladder come into contact with the anterior abdominal wall.

Peritoneal Relations.—The liver is covered by peritoneum except i the following regions: the bare area of the right lobe; a small tri-ngular area at the posterior extremity of the hepatic attachment of ie falciform ligament; the porta hepatis; and the fossa for gall-bladder, xcept in those rare cases in which the gall-bladder is completely in-ested by peritoneum.

For the ligaments of the liver, see p. 788.

Excretory Apparatus of the Liver.—This consists of the hep ducts, the gall-bladder, the cystic duct, and the bile-duct.

The **common hepatic duct** is formed by the union of a right and branch which issue from the respective lobes at the porta hepatis. is the most anterior of the structures in the porta, and after a vari course of 1 to 3 inches downwards and to the right, it joins the cy duct, and so gives rise to the bile-duct. The diameter of the comr hepatic duct is about $\frac{1}{6}$ inch.

The **gall-bladder** is a reservoir for the bile. It is pyriform, an situated obliquely on the inferior surface of the right lobe, wher occupies the fossa for gall-blad having the quadrate lobe on its side, and a large part of the ri lobe on its right side. It exte from the anterior border of the li to near the porta hepatis, and sents a fundus, body, and ne The *fundus*, which is round, lo downwards, forwards, and to right. It occupies the cystic no on the anterior border, and is contact with the anterior abdomi wall opposite the *ninth* right co cartilage at the outer border of right rectus abdominis muscle. *body* is directed upwards, ba wards, and to the left. Its infer and lateral surfaces are free, superiorly it is attached by areo tissue to the fossa for gall-bladd It rests in front upon the right of the transverse colon, and behi on the first part of the duoden near its junction with the stoma The *neck* describes a sigmoid cu first to the left, then to the rig and finally again to the left to come continuous with the cystic duct. The gall-bladder is usua covered by peritoneum, except on its upper surface. Sometimes, ho ever, the serous membrane entirely surrounds it and forms a li mentous fold above it, by which it is loosely and movably suspend from its fossa. The gall-bladder measures about 3 inches in length, breadth at the widest part being $1\frac{1}{2}$ inches. Its capacity is from 1 $1\frac{1}{2}$ ounces. For the structure of the gall-bladder, see p. 890.

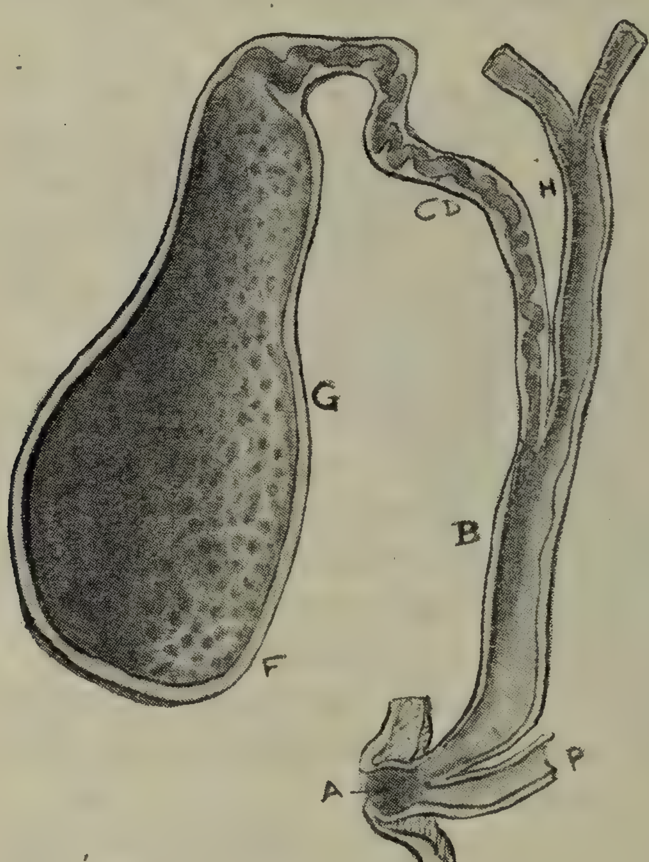


FIG. 453.—EXCRETORY DUCTS, ETC., OF LIVER.

G, gall-bladder; F, fundus; CD, cystic duct; H, common hepatic duct; B, bile-duct; P, pancreatic duct; A, ampulla in duodenal wall into which both ducts open.

The **cystic duct** is 2 inches or more long, its diameter being abo $\frac{1}{12}$ inch. Its course is backwards, downwards, and to the left, a it ends by joining common hepatic duct an inch or less above t duodenum to form the bile-duct. For some distance the cystic a

ommon hepatic ducts run parallel and in close contact with each ther.

The **bile-duct** (**ductus communis choledochus**) is formed by the nion of the common hepatic and cystic ducts. Its length varies ccording to the level at which the cystic and common hepatic ducts nite, from 1 to 3 inches, its diameter being about ¼ inch. It lies beveen the two layers of the lesser omentum in front of the opening into sser sac, where it has the hepatic artery on its left side and the portal ein behind. It afterwards descends behind the first part of the duoenum, and subsequently between the second part of the duodenum and e head of the pancreas. It next enters the wall of the second part f the duodenum in company with the duct of the pancreas, and runs bliquely in the wall for ¾ inch. It then joins the pancreatic duct, the sulting duct forming a dilatation, called the *ampulla*, which, having ecome constricted, pierces the mucous membrane and opens on the p of a papilla at the junction of the inner and posterior walls of the cond part of the duodenum, where the upper two-thirds and lower ird of that part meet. The distance of this opening from the pylorus about 3½ to 4 inches. The bile-duct sometimes opens into the uodenum independently of the pancreatic duct, but close to it.

It is in the ampulla that a gall-stone frequently becomes lodged and elayed in its downward progress towards the duodenum.

The size of the liver in early life is much greater than in the adult, the left be in particular assuming large dimensions and reaching to the spleen. As ge advances, however, the left lobe undergoes a marked diminution in size.

In the rabbit the openings of the two ducts are usually far apart; they are so separate but close together in ornithorhynchus, the pancreatic duct opening bove the bile-duct.

Accessory bile-ducts are not uncommon in man; they are found leaving the ver at the extreme right end of the porta hepatis, and may join the right hepatic uct, the common hepatic duct, or the bile-duct.

For the structure and development of the liver, see pp. 884 and 888.

Peritoneum.—The peritoneum is the serous membrane which lines e abdominal parietes, and invests more or less completely most of e viscera. It is composed of two layers, parietal and visceral, the ontiguous surfaces of which are smooth and moist. In the male the terval between the two layers forms a closed sac, but in the female, the fimbriated extremity of each uterine tube, the sac communicates ith the lumen of that tube, and through it with the cavity of the uterus nd the vagina. It is at the margin of the fimbriated extremity of ach uterine tube that the endothelium of the peritoneum undergoes sudden transition into the columnar ciliated epithelium of the uterine ibe.

The peritoneum forms certain reflections or folds which are of ree kinds—namely, omenta, mesenteries, and ligaments.

An **omentum** is *a particular fold of peritoneum passing between the omach and another abdominal viscus.* The omenta are two in number -namely, the greater omentum, which passes between the greater

curvature of the stomach and the transverse colon; the lesser omentum, which passes between the lesser curvature of the stomach and porta hepatis of the liver.

A **mesentery** is *a fold of peritoneum passing between a portion intestine and the posterior abdominal wall.* The mesenteries in adult are normally as follows: the mesentery proper, which connects the jejunum and ileum to the vertebral column; the appendicular mesentery or meso-appendix, which is connected with the vermiform appendix; the transverse meso-colon, which extends between the transverse colon and the posterior wall of the abdomen at anterior border of the pancreas; and the pelvic meso-colon, which connects the pelvic colon to the anterior surface of the sacrum low as the third sacral vertebra. Occasionally the ascending colon, descending colon, and iliac colon are each provided with a mesentery called respectively the ascending meso-colon, descending meso-colon and iliac meso-colon.

A **ligament** is *a fold of peritoneum which connects a viscus not of the alimentary canal to the abdominal or pelvic parietes or viscera of any kind to each other or to the diaphragm.* The peritoneal ligaments are as follows: (1) the ligaments of the liver—namely, the falciform ligament, the coronary ligament, and the right and the left triangular ligaments; (2) the gastro-phrenic ligament; (3) the gastro-splenic ligament; (4) the lieno-phrenic ligament; (5) the false ligaments of urinary bladder—namely, two posterior, two lateral, and superior; (6) the broad ligaments of the uterus.

Course of the Peritoneum.—The parietal and visceral layers of peritoneum are in unbroken continuity with each other, and this continuity is shown by tracing the membrane in the vertical and transverse directions.

Vertical Course.—Commencing at the porta hepatis of the liver, layers of peritoneum descend to the lesser curvature of the stomach forming the lesser omentum. On reaching the lesser curvature the two layers separate, one passing over the anterior surface and other over the posterior surface of the stomach. At the greater curvature they come together, and descend in the form of a curtain over coils of the jejunum and ileum to the lower part of the abdomen, forming the two anterior or descending layers of the greater omentum. The two layers are then folded backwards, and ascend to the transverse colon, thus forming the two posterior or ascending layers of the greater omentum. On reaching the transverse colon they separate, one layer passing in front of and above the bowel, and the other layer below and behind it. Having enclosed the transverse colon, the two layers meet, and are prolonged backwards to the posterior wall of the abdomen at the anterior border of the pancreas, thus forming the transverse meso-colon. On reaching the anterior border of the pancreas the two layers of the transverse meso-colon take leave of each other, and form an ascending and a descending layer. The **ascending layer** passes upwards over the anterior surface of the pancreas, and the poste

tion of the under surface of the diaphragm, from which it passes the postero-inferior border of the liver, thus forming the inferior er of the coronary ligament. Having covered the caudate lobe, it ves at the posterior lip of the porta hepatis, where it is continuous h the posterior layer of the lesser omentum.

The **descending layer** of the transverse meso-colon passes at first kwards upon the inferior surface of the pancreas, and then down-rds over the third part of the duodenum, at the lower border of

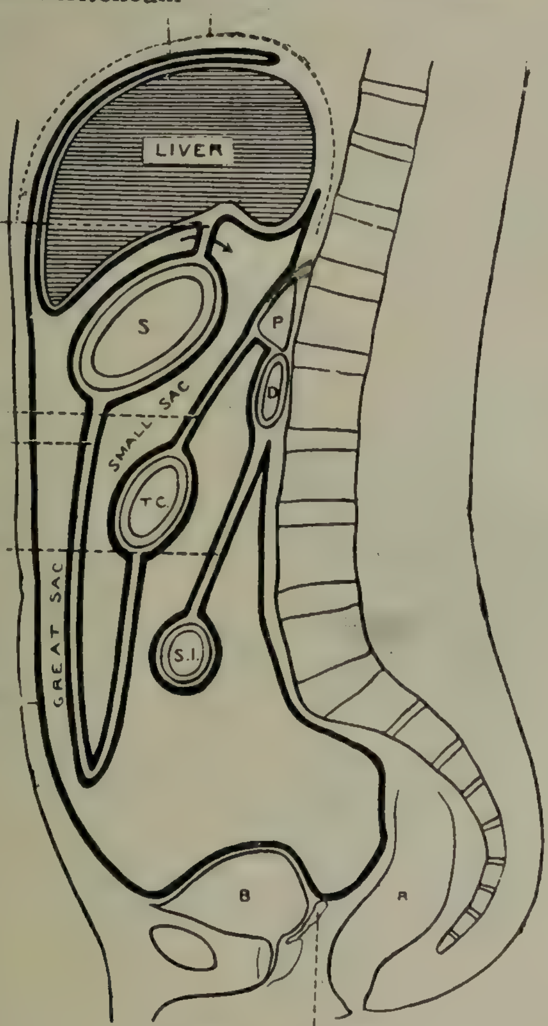


FIG. 454.—DIAGRAM OF THE PERITONEUM IN THE ADULT MALE (VERTICAL SECTION).

S. Stomach
P. Pancreas
D. Duodenum
T.C. Transverse Colon
S.I. Small Intestine
B. Urinary Bladder
R. Rectum

The arrow is through the Opening into Lesser Sac.

ich it is conducted off to the jejunum and ileum by the superior senteric vessels. Having surrounded these portions of the small estine, it passes to the posterior abdominal wall upon the other ect of the superior mesenteric vessels, and so forms the mesentery per. It then descends over the abdominal aorta and inferior vena a into the pelvis, where its course will be subsequently traced. om the apex of the urinary bladder this layer of the peritoneum is ected on to the posterior surface of the anterior abdominal wall, er lining which it passes to the anterior portion of the under surface

of the diaphragm, whence it is reflected on to the postero-supe border of the liver, thus forming the superior layer of the coron ligament. It then passes over the superior and anterior surfaces of liver, and, turning round its anterior border, it arrives at the ante lip of the porta hepatis, where it is continuous with the anterior la of the lesser omentum.

Transverse Course.—The peritoneum may be traced in the tra verse direction at two levels—namely, (1) above the transverse col or at the level of the op ing into lesser sac, whicl situated behind the right free border of the les omentum; and (2) below transverse colon, or at level of the umbilicus.

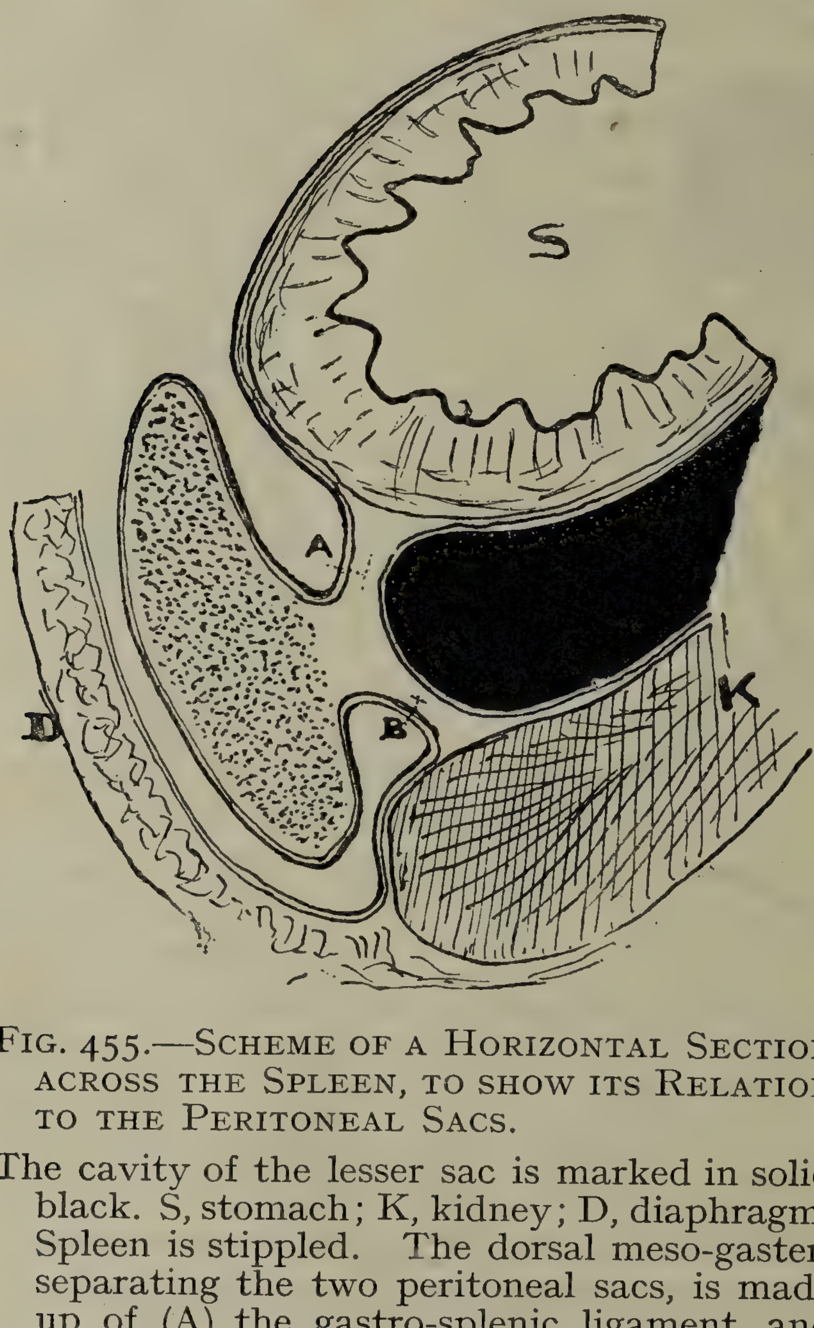


FIG. 455.—SCHEME OF A HORIZONTAL SECTION ACROSS THE SPLEEN, TO SHOW ITS RELATION TO THE PERITONEAL SACS.

The cavity of the lesser sac is marked in solid black. S, stomach; K, kidney; D, diaphragm. Spleen is stippled. The dorsal meso-gaster, separating the two peritoneal sacs, is made up of (A) the gastro-splenic ligament, and (B) the lieno-renal ligament.

Above the Transve Colon, or at the Level of Opening into Lesser Sac In front of the opening i lesser sac there are the t layers of peritoneum, anter and posterior, which fo the right or free border the lesser omentum, a which contain between th the bile-duct, the hepa artery, and the portal ve Tracing the lesser oment from this point to the le its two layers separate enclose the stomach, af which they pass to the gast impression on the spleen the gastro-splenic ligame The two layers of this lig ment are anterior and p terior, and they contain b tween them the short gast branches of the splenic arte At the spleen the two lay are immediately in front of the hilum. The anterior layer now tal temporary leave of the posterior layer, and turns completely round t spleen, covering its gastric, colic, diaphragmatic, and renal surfaces succession. On leaving the renal surface of the organ it again pass to the gastric surface, but it is now behind the hilum. Here it mee the posterior layer of the gastro-splenic ligament, which had remain meanwhile stationary immediately in front of the hilum. These t layers now pass backwards to the anterior surface of the left kidn

its upper extremity, and close to its lateral border, thus forming the no-renal ligament. The two layers of this ligament are disposed as ght and left, and between them are the splenic branches of the splenic tery. The right layer corresponds with the posterior layer of the stro-splenic ligament, and the left layer with the anterior layer of at ligament. The *right layer* of the lieno-renal ligament, after

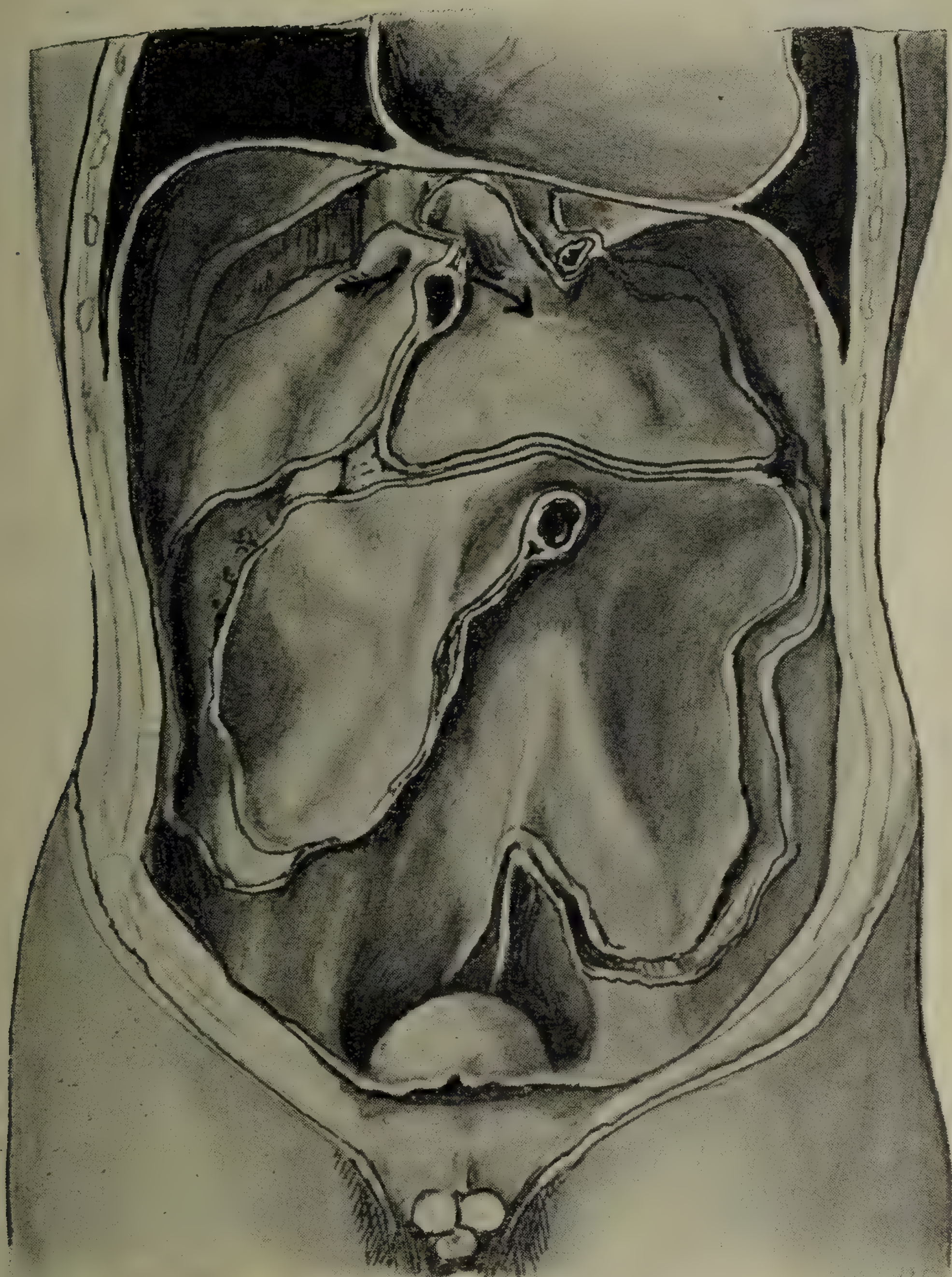


FIG. 456.—LINES OF REFLECTION OF PERITONEUM FROM THE POSTERIOR ABDOMINAL WALL (FROM A RECONSTRUCTION).

The arrow passes through the opening into lesser sac.

ving the left kidney, passes to the right over the aorta and inferior na cava. As it covers the latter vessel it is placed *behind* the opening o the lesser sac. It then continues its course to the right, and, ving given a partial covering to the front of the right kidney, it sses over the right lateral and anterior walls of the abdomen as far the middle line. The *left layer* of the lieno-renal ligament, after ving the left kidney, passes over the left lateral and anterior walls

of the abdomen, and, on arriving at the middle line, it becomes c tinuous with the right layer, which has just been traced as far as middle line. Along the posterior surface of the anterior wall of abdomen, in the middle line, above the level of the umbilicus, the p toneum meets with the ligamentum teres of the liver, around wh it is reflected, and here it is carried off from the abdominal wall to fo part of the falciform ligament.

Below the Transverse Colon, or at the Level of the Umbilicus.—Co mencing at the middle line and passing to the right, the peritone covers the right half of the anterior abdominal wall and the ri lateral wall as far as the lumbar region. It next covers the right si anterior surface, and left side of the ascending colon, whence it pas over the front of the right kidney at its lower and inner part. I

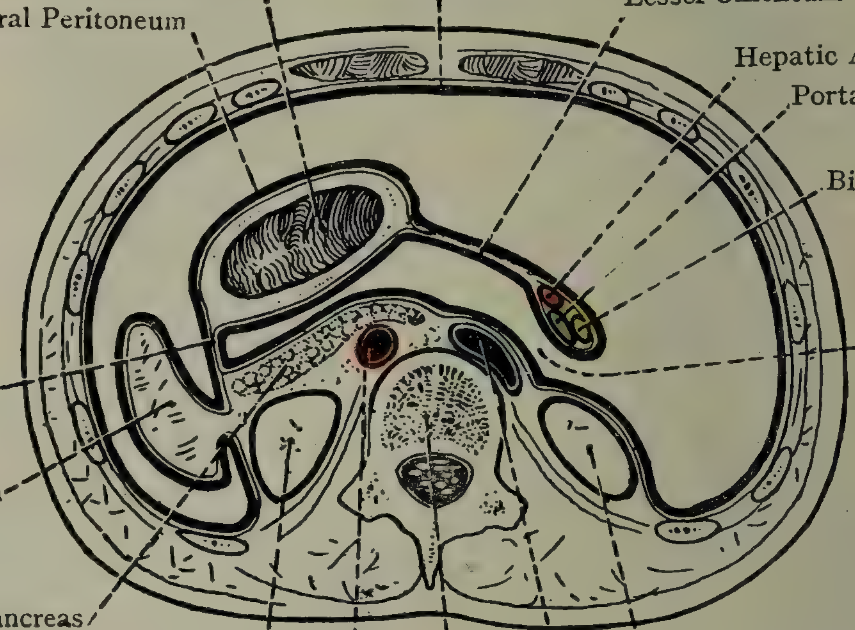


FIG. 457.—DIAGRAM OF THE PERITONEUM AT THE LEVEL OF THE OPENING I LESSER SAC (TRANSVERSE SECTION).

then reflected over the inferior vena cava, and, meeting with t superior mesenteric vessels, is carried off by them to the jejunum a ileum, both of which it invests. It is conducted back again to t vertebral column by the superior mesenteric vessels, thus forming t mesentery proper. It next passes to the left over the aorta, a having partially covered the front of the left kidney at its lower a inner part, it meets the descending colon in the left lumbar regi which it covers on the right side, anterior surface, and left si Finally, it is reflected over the left lateral and left half of the anter wall of the abdomen as far as the middle line.

The relations of the peritoneum to the duodenum, pancreas, a kidneys will be described when these viscera fall to be considered.

Omenta.—The **greater omentum** extends from the greater curvat

the stomach and first inch of the first part of the duodenum to the ansverse colon, descending in its course usually as low as the pelvic im, and lower on the *left* side than on the right, which accounts for e greater frequency of an omental hernia on the left side. It covers e coils of the jejunum and ileum. Near the greater curvature of the omach it contains between its two layers the right and left gastro- iploic arteries, and the epiploic branches of these vessels, which are ng and slender, descend into it. The greater omentum is often of nall size, thus leaving many of the coils of the small intestine uncovered, it may even be displaced into the left hypochondrium. It is com- osed of *four* layers of peritoneum, two of which, inseparably united, escend from the greater curvature of the stomach to the region of e pelvic brim, these being called the *anterior* or *descending layers.* ne other two layers, also inseparably united, ascend from the region

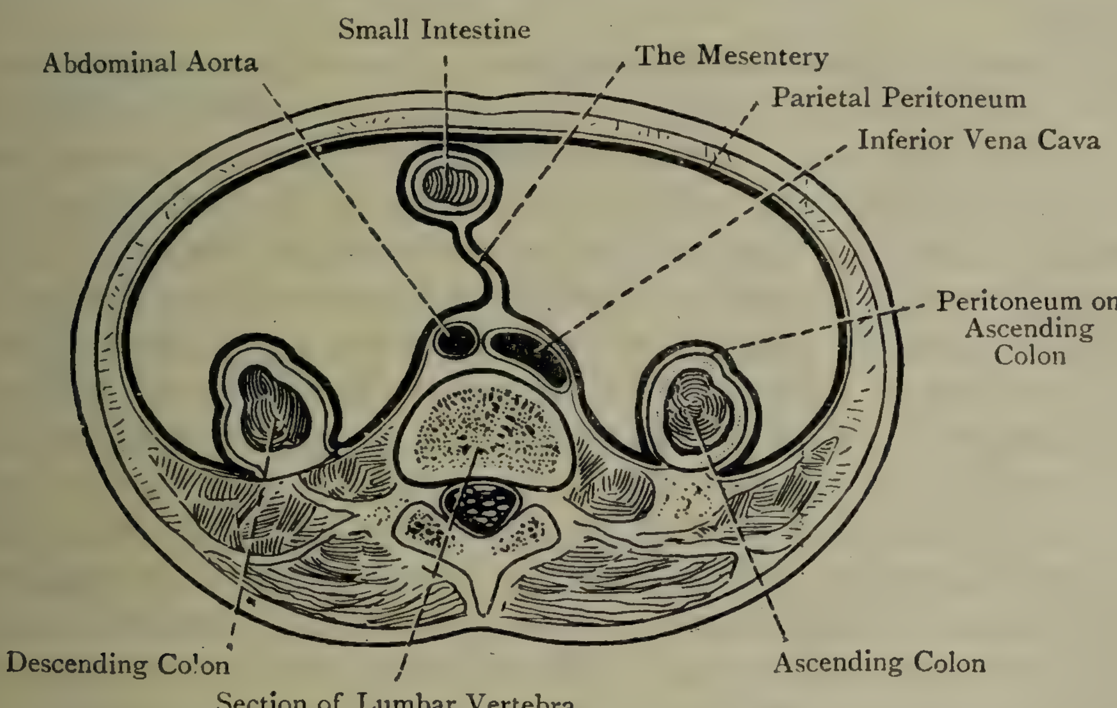


FIG. 458.—DIAGRAM OF THE PERITONEUM AT THE LEVEL OF THE UMBILICUS (TRANSVERSE SECTION).

the pelvic brim to the transverse colon, these being called the *osterior* or *ascending layers.* Between the two anterior and the two osterior layers there is usually, in healthy persons, a space which epresents a part of the small cavity of the peritoneum, and is known the **lesser sac of peritoneum.** In many cases, however, this space scarcely demonstrable on account of adhesions. It is most con- icuous a little below the greater curvature of the stomach.

The **lesser omentum** extends from the lesser curvature of the stomach nd first inch of the first part of the duodenum to the porta hepatis f the liver, and also to the fissure for ligamentum venosum. It is omposed of two layers of peritoneum which, at the lesser curvature f the stomach, contain between them the anterior and posterior ranches of the left gastric and pyloric arteries. For the most part s two layers are inseparably united, but at its right border, which is ee, there lie between them the following structures: (1) the bile-duct

to the right side; (2) the hepatic artery, invested by the hepatic ple of sympathetic nerves, to the left side; (3) the portal vein, which l between these two, and on a plane posterior to both; (4) a small super pancreatico-duodenal tributary of the portal vein, which lies close the free margin of the omentum, and is usually the most anterior the structures enclosed; (5) lymphatic vessels; and (6) nerves. T right or free border, with the foregoing contents, lies in front of t opening into lesser sac. The left border of the lesser omentum is sh on account of the oblique position of the stomach, and is attached the diaphragm between the caval and œsophageal openings. T *anterior layer* of the lesser omentum is formed by peritoneum belongi to the greater sac, and the *posterior layer* by that belonging to t lesser sac, these two layers becoming continuous with each ot round the right or free border of the omental fold in front of the openi into lesser sac.

Mesenteries.—The **mesentery proper** is the fold of peritoneum whi attaches the jejunum and ileum to the vertebral column. Its verteb border is called the *root*, and is comparatively short, measuring fr 5 to 6 inches in length. Its line of attachment extends from the co mencement of the jejunum on the *left* side of the body of the seco lumbar vertebra, at the anterior border of the pancreas, to the termi tion of the ileum in the right iliac fossa near the right sacro-iliac arti lation. This line of attachment passes obliquely from left to rig and in this course the root of the mesentery proper crosses in successi the third part of the duodenum, aorta, inferior vena cava, and rig psoas major. The other border of the mesentery proper is called t *intestinal border*, and is attached to the jejunum and ileum througho their whole length. This border is of considerable length, and equ that of the jejunum and ileum. The widening of the mesentery prop takes place gradually, so that it is thrown into a number of fol an arrangement which accounts for the coils of the jejunum and ileu Its average breadth, from the root of the intestinal border, is abo 8 inches. The fold is composed of two layers of peritoneum, right superior, and left or inferior. The right or superior layer is continuo with the inferior layer of the transverse meso-colon, and with the pe toneum which covers the ascending colon, whilst the left or infer layer is continuous with the peritoneum which covers the descendi colon. Both layers are formed by peritoneum belonging to the **grea sac.** The two layers contain between them the following structur (1) the superior mesenteric vessels, and the jejunal and ileal arteri (2) the superior mesenteric plexus of sympathetic nerves, and secondary offshoots; (3) the lacteal vessels; (4) the mesenteric lympha glands, and a variable amount of fat.

In some cases the mesentery proper presents one or more openin known as mesenteric holes, which may be congenital or traumat If a portion of intestine slipped through one of these holes a mesente hernia would result, and if the hole is situated in one layer only, t herniated portion of intestine would take up a position in the spa

tween the two layers. These openings are liable to be met with in at portion of the mesentery proper which is attached to the lower rt of the ileum, within the arch formed by the ileo-colic branch of e superior mesenteric artery and the last ileal artery.

In the mesentery of the jejunum, as distinct from that of the ileum, e fat is not uniformly distributed; near the intestinal border of this rt of the mesentery areas are usually to be observed relatively free om fat, and consequently translucent, the so-called 'windows' of e mesentery.

The **mesentery of vermiform appendix** or **meso-appendix** is a fold peritoneum which is derived from the left or inferior layer of the esentery proper near the terminal part of the ileum. It is triangular, d usually lies obliquely. Its *right end* reaches in a pointed manner the ileo-colic junction, and its *left end* forms a concave free border ich transmits the appendicular vessels and sympathetic plexus of rves. It seldom extends for more than half or two-thirds along the pendix, which is thus rendered more or less convoluted or serpentine. may, however, extend along its entire length. In some cases it lies rtically, and then it loses its hold upon the mesentery proper, its tachment being transferred to the cæcum, or right fascia iliaca, or en to the back of the ascending colon. The base of the appendix is metimes destitute of a mesentery, in which cases that portion of it closely connected to the posterior aspect of the cæcum. Occasionally e entire meso-appendix is wanting, and then the appendix is found hering to the back of the cæcum. The meso-appendix may present small opening, through which a portion of bowel may pass and become angulated. In very rare cases the meso-appendix is disposed in ch a manner as to divide the ileo-colic fossa into an upper and a lower mpartment.

The **transverse meso-colon** is a broad fold of peritoneum which tends between the transverse colon and the posterior abdominal ll at the anterior border of the pancreas. Its layers contain between em the middle colic vessels, sympathetic nerves, and the lymphatics the transverse colon. Mesenteric holes may be present in the transrse meso-colon, under which circumstances a meso-colic hernia may cur.

The **pelvic meso-colon** is a fold of peritoneum which attaches the lvic colon to the lateral and posterior walls of the pelvis. It extends om the inner border of the left psoas major (covered by the left scia iliaca) near the left sacro-iliac articulation upwards and inwards the front of the promontory, and then downwards in the middle e to the front of the third sacral vertebra; its length is such as to nder the pelvic colon freely movable. It is composed of two layers dissed laterally, and containing between them the superior rectal vessels, mpathetic nerves, lymphatic vessels, and a certain amount of fat.

The ascending and descending colons are each, in normal circumances, devoid of a mesentery. Occasionally, however, an ascending eso-colon and a descending meso-colon are present.

Peritoneal Ligaments—Ligaments of the Liver.—The perito ligaments of the liver are four in number (the ligamentum teres being regarded as of a peritoneal nature), and are as follows: falciform ligament, the coronary ligament, the right triangular ligam and the left triangular ligament.

The **falciform ligament** is also known as the **suspensory ligam** It extends between the inferior surface of the diaphragm and posterior surface of the anterior abdominal wall on the one hand, the superior and anterior surfaces of the liver on the other. Its b which is free, extends from the umbilicus to the interlobar notcl the liver, and contains between its two layers the ligamentum te The line of attachment of the ligament to the anterior and supe surfaces of the liver map the organ out into a right and left lobe, along this line the two layers of the ligament separate from each ot the right layer extending over the right lobe and the left over the lobe. Near the postero-superior border of the liver the two la of the ligament diverge somewhat abruptly, and leave between tl a small triangular area which is destitute of peritoneum; they bec continuous on either side with the superior layer of the coronary l ment.

The **coronary ligament** is also known as the **posterior ligam** It is composed of two layers of peritoneum, superior and infer which are attached to the postero-superior and postero-inferior bor of the liver on the one hand, and the diaphragm on the other. Tl layers are separated from each other by an interval, which correspo with the bare area of the right lobe of the liver. The *superior l* is continuous with the falciform ligament, and the *inferior laye* continuous with the peritoneum which covers the inferior vena c and the front of the right kidney.

The **right** and **left triangular ligaments** are situated at the extr right and left ends of the coronary ligament, and are formed by meeting at these points of the two layers of that ligament.

The **ligamentum teres** (**round ligament**) of the liver, though no peritoneal ligament, may here be described. It is a fibrous cord for by the obliterated umbilical vein, and is contained within the bas the falciform ligament between the umbilicus and the interlobar no of the liver, its course between these points being upwards, backwa and to the right. At the interlobar notch it enters the fissure ligamentum teres on the inferior surface of the liver, and terminates joining the left branch of the portal vein.

Although usually described as formed from a part of the (left) umbil vein, the ligamentum teres, where it lies in relation with the lower aspect of liver, is really the remnant of a secondary channel formed by communica between the umbilical vein and the left vitelline vein. The two umbilical v run up in the body-wall and bulge into the small abdominal cavity, and in young embryo of the third week the left vein comes into association, through caudal part of septum transversum, with the left vitelline vein, establishin connection through which the umbilical blood of this side can pass directly to liver and ductus venosus. When the right umbilical vein atrophies later, all

od returned from the placenta is thus carried to the inferior vena cava by the nmunication. That part of the ligamentum teres lying in the abdominal ll (canal of Richet) is a remnant of the umbilical vein, but that portion ex-ıding between this and the left division of the portal vein is the elongated ondary umbilico-vitelline communication.

On the surface of, or within, the ligamentum teres of the liver there are a few y small veins, called **para-umbilical veins.** These anastomose at the umbilicus h the epigastric veins of the anterior abdominal wall, and superiorly are con-ted with the left division of the portal vein. The anastomosis between these ns and the epigastric veins explains the enlargement of the veins of the anterior lominal wall in cases of portal obstruction within the liver.

The **gastro-splenic ligament** extends between the posterior surface the cardiac end of the stomach and the gastric surface of the spleen st in front of the hilum. It is formed of two layers, anterior and sterior, and is continuous with the greater omentum. The *anterior yer* is formed by peritoneum belonging to the greater sac, and the *sterior layer* by that belonging to the lesser sac. The fold contains tween its two layers the short gastric branches of the splenic artery.

The other ligament of the stomach is called the **gastro-phrenic ament.** It is of small size, and extends between the region of the covered trigone of the stomach and the inferior surface of the ıphragm, lying immediately to the left of the lower end of the œso-agus.

The **ligaments of the spleen** are two in number—namely, phrenico-lenic or lieno-phrenic, and lieno-renal.

The **phrenico-splenic** or **lieno-phrenic ligament** is also called the **spensory ligament.** It extends between the spleen, near its upper tremity, and the contiguous part of the diaphragm. The **lieno-nal ligament** extends from the hilum of the spleen to the front of e left kidney at its upper and outer part. Its direction is backwards, d it is composed of two layers of peritoneum, right and left, which ntain between them the splenic branches of the splenic artery. The ght layer corresponds with the posterior layer of the gastro-splenic ament, and the left with the anterior layer of that ligament.

The **phrenico-colic ligament (sustentaculum lienis)** extends between e splenic flexure of the colon and the diaphragm opposite the tenth eleventh left rib. It is triangular, and its surfaces are superior ıd inferior, its anterior border being free. It forms a platform upon ıich the colic surface of the spleen rests.

The **sustentaculum hepatis** is a fold of peritoneum which is sometimes met th in connection with the ascending colon. (Treves found it in eighteen out one hundred bodies.) When present, it extends from the right side of the cending colon to the abdominal wall at a point a little above the level of the ıc crest. Its free border looks forwards, and it forms a shelf which supports e right margin of the liver.

Cavity of the Peritoneum.—The peritoneal cavity is divided into ᵥo compartments, greater and lesser, which communicate with each her through the opening into lesser sac behind the right or free border the lesser omentum.

The **greater sac of peritoneum** is the space which is exposed to view

after opening the abdominal cavity. It is separated from the le sac by the liver, lesser omentum, stomach, greater omentum, gas splenic ligament, lieno-renal ligament, and transverse meso-co Its deepest parts with the subject lying in the supine position are, i exclude the pelvic recess, immediately lateral to the superior p of the kidneys, and it is to these parts that free fluid in the gen peritoneal cavity tends to gravitate.

The **lesser sac of peritoneum (omental bursa)** is an offshoot f the greater sac, the introversion taking place at the opening into le sac. It extends upwards behind the stomach to the posterior pa the inferior surface of the diaphragm and the caudate lobe of the li and downwards into the greater omentum.

Boundaries of the Lesser Sac—*Anterior.*—From below upwa the two anterior or descending layers of the greater omentum, posterior surface of the stomach, the lesser omentum, and the poste surface of the caudate lobe of the liver. *Posterior.*—From be upwards, the two posterior or ascending layers of the greater oment the transverse colon, the transverse meso-colon, and the ascend layer of the transverse meso-colon. *Superior.*—The posterior par the inferior surface of the diaphragm. *Inferior.*—The bend of greater omentum, where the two anterior or descending layers folded backwards, to become the two posterior or ascending lay *Left.*—The spleen; the gastro-splenic ligament; the lieno-renal ligame and the left border of the greater omentum.

In a great many cases that part of the lesser sac which is contai within the greater omentum is very limited in its downward ext on account of adhesions having formed between the layers of the gre omentum.

Opening into Lesser Sac (Foramen of Winslow).—This is the open by which the greater and lesser sacs of the peritoneum communic with each other. It is situated behind the right or free border of lesser omentum, on a level with the body of the twelfth thor vertebra. Its direction is forwards and to the right, and it adn of the passage of one finger, and in some cases of two fingers. It however, often blocked by inflammatory products.

Boundaries—*Anterior.*—The right or free border of the les omentum, containing between its two layers (1) the bile-duct to right side; (2) the hepatic artery, invested by the hepatic plexus sympathetic nerves, to the left side; (3) the portal vein, which between these two, on a plane posterior to both; and (4) lympha vessels. *Posterior.*—The inferior vena cava covered by peritone *Superior.*—The caudate process of the liver. *Inferior.*—The first p of the duodenum, and the hepatic artery in the first part of its cou as it curves forwards and upwards from the cœliac axis. If the open is blocked by inflammatory products, and fluid is effused into lesser sac, the condition known as *hydrops saccatus* results. It is poss for a loop of bowel to pass through the foramen, thus forming variety of internal hernia.

Peritoneal Recesses or Fossæ.—The peritoneum presents in certain situations ıall pockets, which are known as peritoneal recesses. Their importance con-ts in the fact that a small portion of intestine may enter one or other of them d become strangulated, thus constituting an internal hernia, which, except in e cases of the inguinal recesses, is called a retro-peritoneal hernia. The recesses, cording to their situation, are called duodenal, duodeno-jejunal, peri-cæcal, d intersigmoid.

Duodenal Recesses.—Four varieties of duodenal recesses are met with in con-ction with the terminal part of the duodenum—namely, inferior duodenal, perior duodenal, para-duodenal, and retro-duodenal (Jonnesco).

The **inferior duodenal recess** is the most common and largest. It is situated the left side of the terminal part of the duodenum, and opens *upwards*. It is unded in front by a thin triangular portion of peritoneum, called the inferior

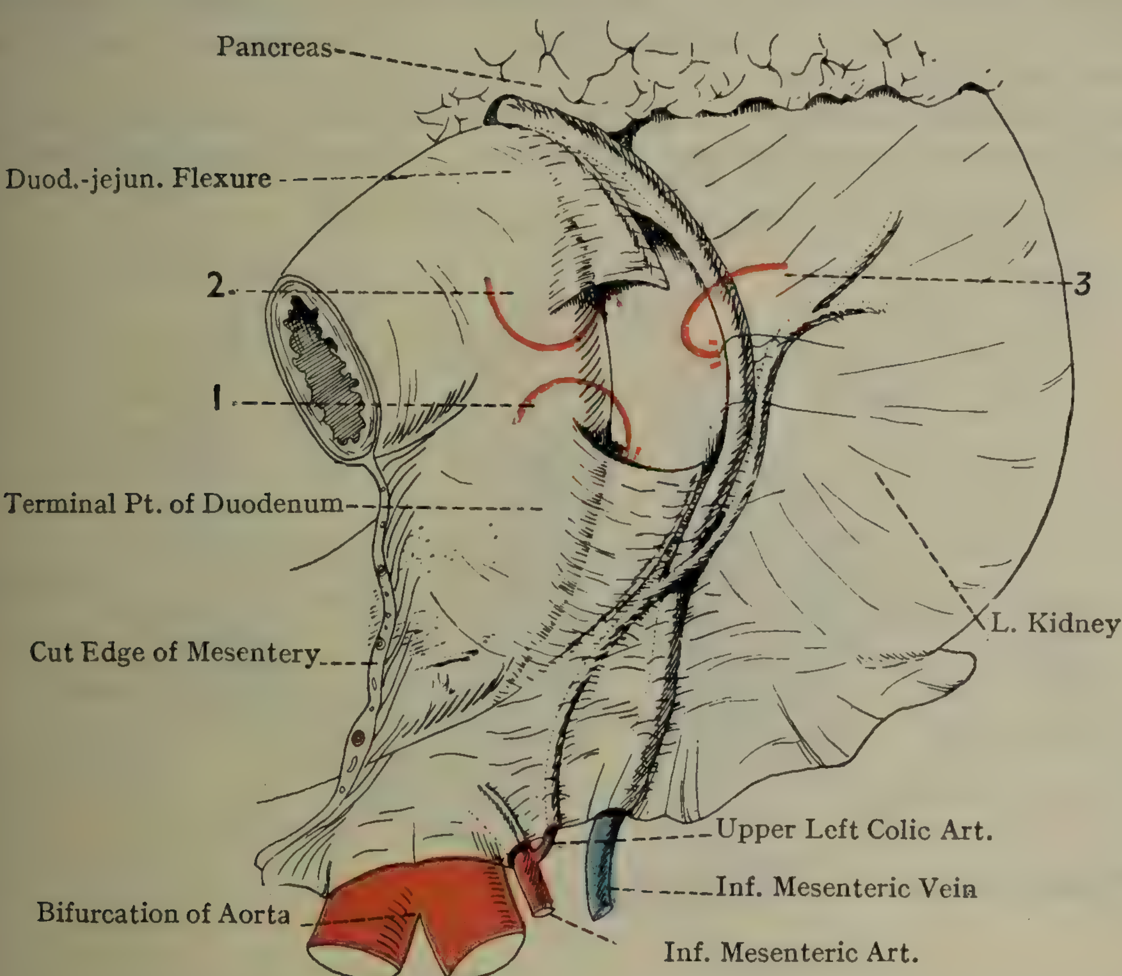


FIG. 459.—DUODENAL RECESSES: DUODENUM TURNED TOWARD THE RIGHT.

Arrows: 1 and 2, inferior and superior duodenal recesses, overhung by corresponding folds; 3, para-duodenal recess.

ıodenal fold, which presents a free crescentic border or base superiorly. The ssa may admit the thumb, and may be nearly an inch deep. It is said to be esent in 75 per cent. of cases (Jonnesco).

The **superior duodenal recess** is less constant, and of smaller size, than the ferior, and lies about an inch above it. It opens *downwards*, and its orifice ces that of the inferior duodenal recess. It may admit the tip of a finger. is bounded in front by a thin triangular portion of peritoneum, called the perior duodenal fold, which presents a free crescentic border or base inferiorly. ıe recess is said to be present in 50 per cent. of cases (Jonnesco).

The **para-duodenal recess** is situated a little to the left of the terminal part the duodenum. It is bounded on the left side by a fold of peritoneum, pro-ıced by the inferior mesenteric vein.

The **retro-duodenal fossa** is situated behind the terminal part of the duo-ɛnum.

Duodeno-jejunal Recess.—This recess, when present, contains the duode jejunal flexure, and leads upwards and towards the left side. It is bounc by two free portions of peritoneum, called the duodeno-meso-colic folds, and has the pancreas above, the left kidney on the left, and the aorta on the rig It is said to be present in from 15 to 20 per cent. of cases.

Peri-cæcal Recesses.—These recesses are three in number—namely, super ileo-cæcal, inferior ileo-cæcal, and retro-cæcal.

The **superior ileo-cæcal recess** is situated in the angle between the terminati of the ileum and the commencement of the ascending colon in front of the adjace part of the mesentery proper. It opens *inwards*, and is bounded in *front* b portion of the peritoneum, called the **vascular fold of cæcum,** which is produc by the anterior cæcal artery; *behind*, by the mesentery proper; *below*, by ileum; and, on the *right side*, by the commencement of the ascending colon. size and depth the recess is small. The vascular fold of cæcum in some ca reaches downwards as in Fig. 461 to the cæcum, and may then be more prope called an ileo-cæcal fold.

The **inferior ileo-cæcal recess** is situated in the angle of junction of the ile and cæcum, and opens downwards and inwards. It may extend upwards fo

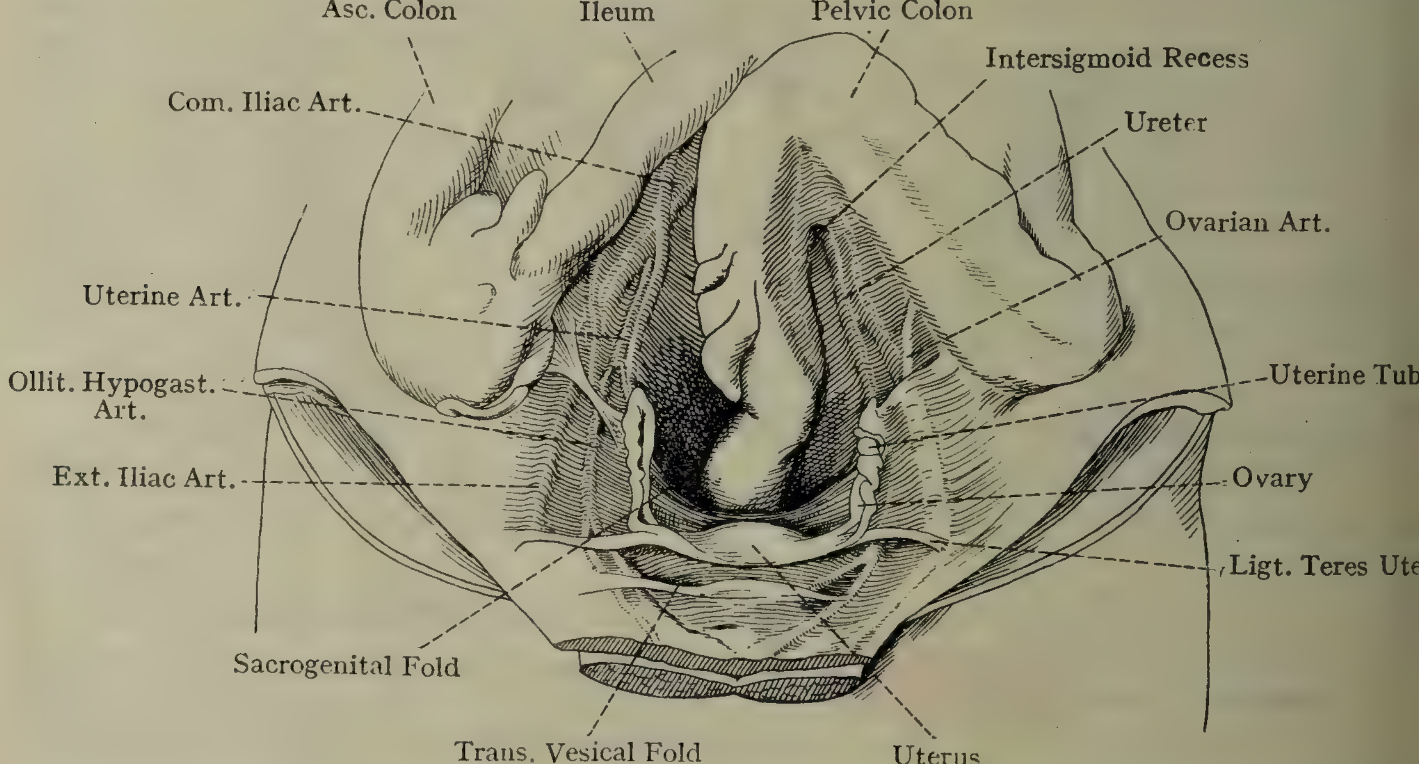


FIG. 460.—INTERSIGMOID FOSSA IN A CHILD (AFTER POIRIER).

variable distance behind the ascending colon, and sometimes is capable admitting two fingers. It is bounded *anteriorly* and *inferiorly* by a portion peritoneum, called the **ileo-cæcal fold** (bloodless fold of Treves); *posteriorly,* the meso-appendix; *laterally*, by the cæcum; and *superiorly* by the posteri aspect of the terminal part of the ileum and the inferior layer of the mesente proper. The importance of this recess consists in the fact that it often contai the vermiform appendix, or a portion of it. The ileo-cæcal fold in certain cas is attached more to the appendix than to the cæcum, and is often then called t ileo-appendicular fold. It may contain a small recurrent branch of the a pendicular artery.

The **retro-cæcal recess** is situated behind the cæcum, on the outer side of t meso-appendix. It may extend upwards for a variable distance behind t ascending colon, and is sometimes divided vertically into two or more compar ments. It occasionally contains the vermiform appendix, or a portion of it.

Intersigmoid Recess.—This recess is of rare occurrence in the adult, but frequently present in early infancy. It is situated behind the pelvic meso-col near the bifurcation of the left common iliac artery, at the point where t

ached border of the meso-colon changes its direction. It opens downwards l towards the left side. In its anterior wall one of the lower left colic branches the inferior mesenteric artery is frequently to be found; in its posterior wall ; the ureter.

In early life the alimentary tube is *short and medium.* It does not possess rue ventral mesentery at any stage in the human embryo. The ventral and sal mesocardia, though lying ventral to the fore-gut, are derived from the icardial walls, and are not properly concerned with the alimentary tube, ile the only definite ' ventral ' mesentery associated with this tube, the ventral **tro-duodenal** fold, is really a secondary drawing out and thinning of the *tum transversum.* This septum (*q.v.*), however, might in itself be looked on in some ways representing a broad ventral mesentery, connecting the fore-gut h the ventral body-wall (see pp. 46 and 80).

The **ventral gastro-duodenal mesentery** extends from the ventral aspect of primitive stomach and upper part of the duodenum to the ventral body-ll on the cephalic side of the umbilicus. It is the lower layer of the *septum*

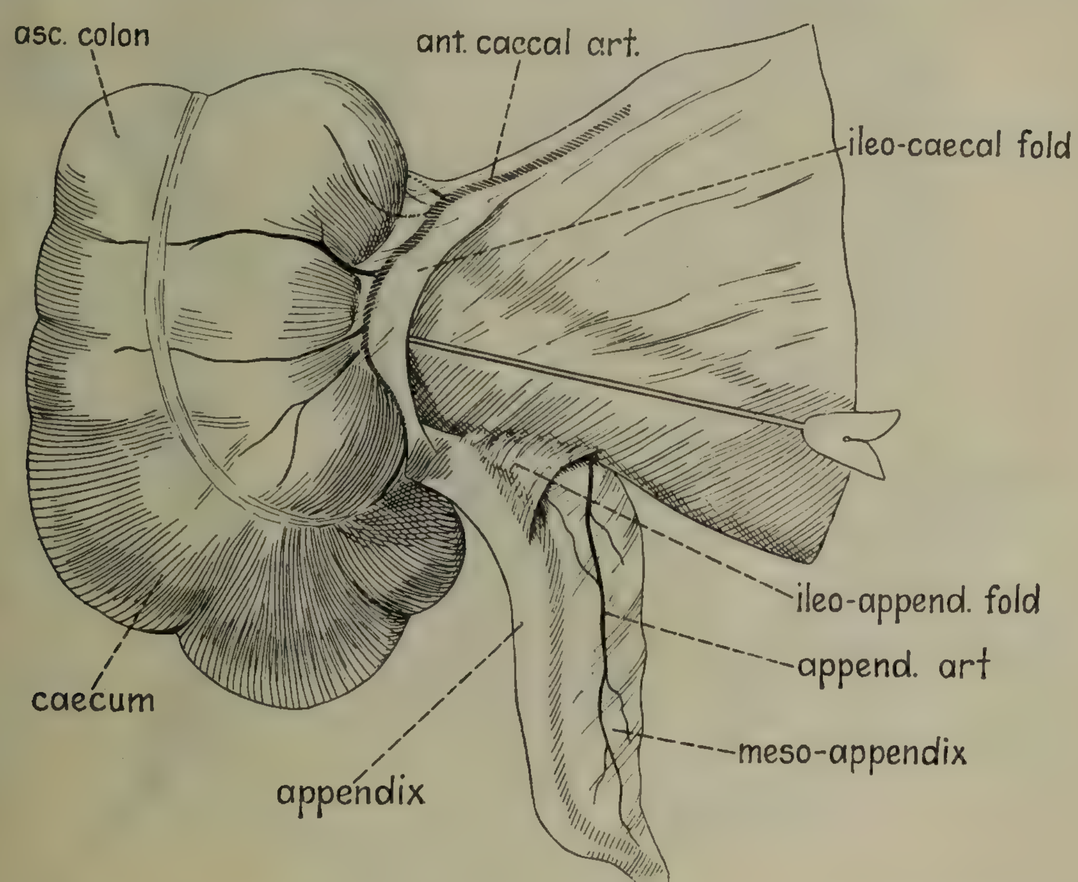


FIG. 461.—ILEO-CÆCAL FOLD AND RECESSES (AFTER JONNESCO).

nsversum, within which the liver undergoes development. As the liver scends, it carries with it the ventral gastro-duodenal mesentery, which it ides into two parts. The part between the liver and (1) the ventral portion the diaphragm, and (2) the ventral wall of the abdomen as low as the umbilicus, ms the **falciform ligament of the liver;** and the part between the liver (porta patis) and stomach (lesser curvature) forms the **lesser** or **gastro-hepatic entum.**

The **primitive dorsal mesentery** receives names corresponding to the parts the alimentary tube with which it is connected. Thus, in the abdomen there the meso-gastrium, meso-duodenum, meso-jejunum, meso-ileum, meso-pendix, meso-colon (ascending, descending, iliac, and pelvic), and meso-tum.

As development proceeds, these mesenteric folds undergo important changes. The dorsal **meso-gastrium,** though primitively median, is pouched out very ly to the left to form the *lesser sac;* this projects as a thin-walled sac into the t side of the abdominal cavity below the liver, carrying the stomach in its

front wall. Its opening looks to the right; it is attached here, and continu with the *meso-duodenum* and general mesentery. Otherwise it lies free betw the mesentery and left lobe of liver. When the umbilical sac discharges intestinal coils, they displace the lesser sac and stomach *to the left and upwa* and push the colon and median meso-colon *to the left and backwards,* so t these lie *behind* the coils and are overhung by the lower part of the lesser s projecting below the stomach (see Figs. 511 and 512). This projection of lesser sac, at first unattached to the colon, on which it lies, is the early **grea omentum.** The lesser sac fuses with the peritoneum of the back wall, as a does the meso-colon, so far as its originally median part is concerned; thus lesser sac is fixed above, while below this is the primitive transverse **meso-col** On referring to Fig. 463, it will be seen that in this region there are four layers peritoneum at this stage. The *upper two layers* are continuous with the two p

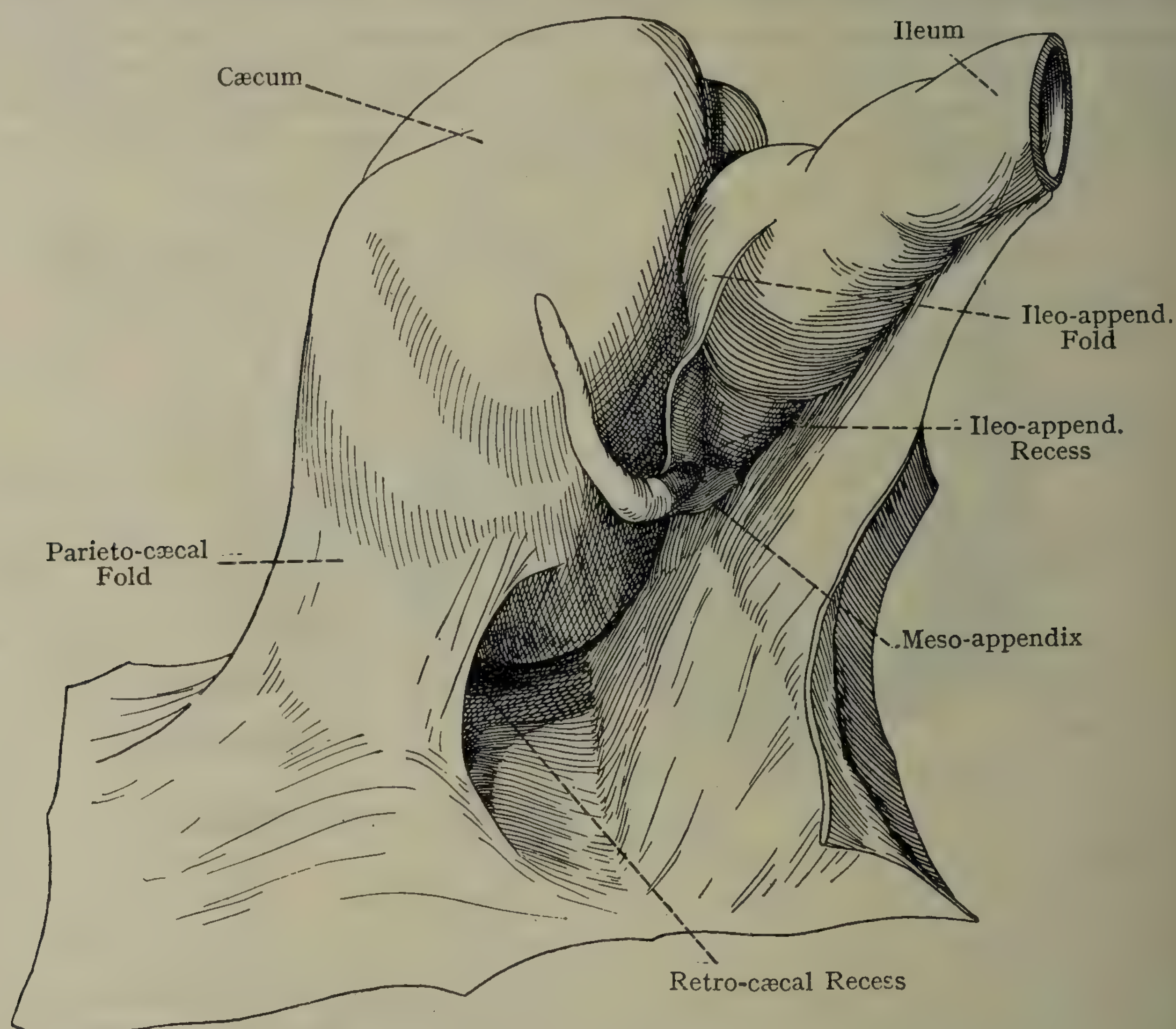


FIG. 462.—THE RETRO-CÆCAL RECESS (AFTER JONNESCO).

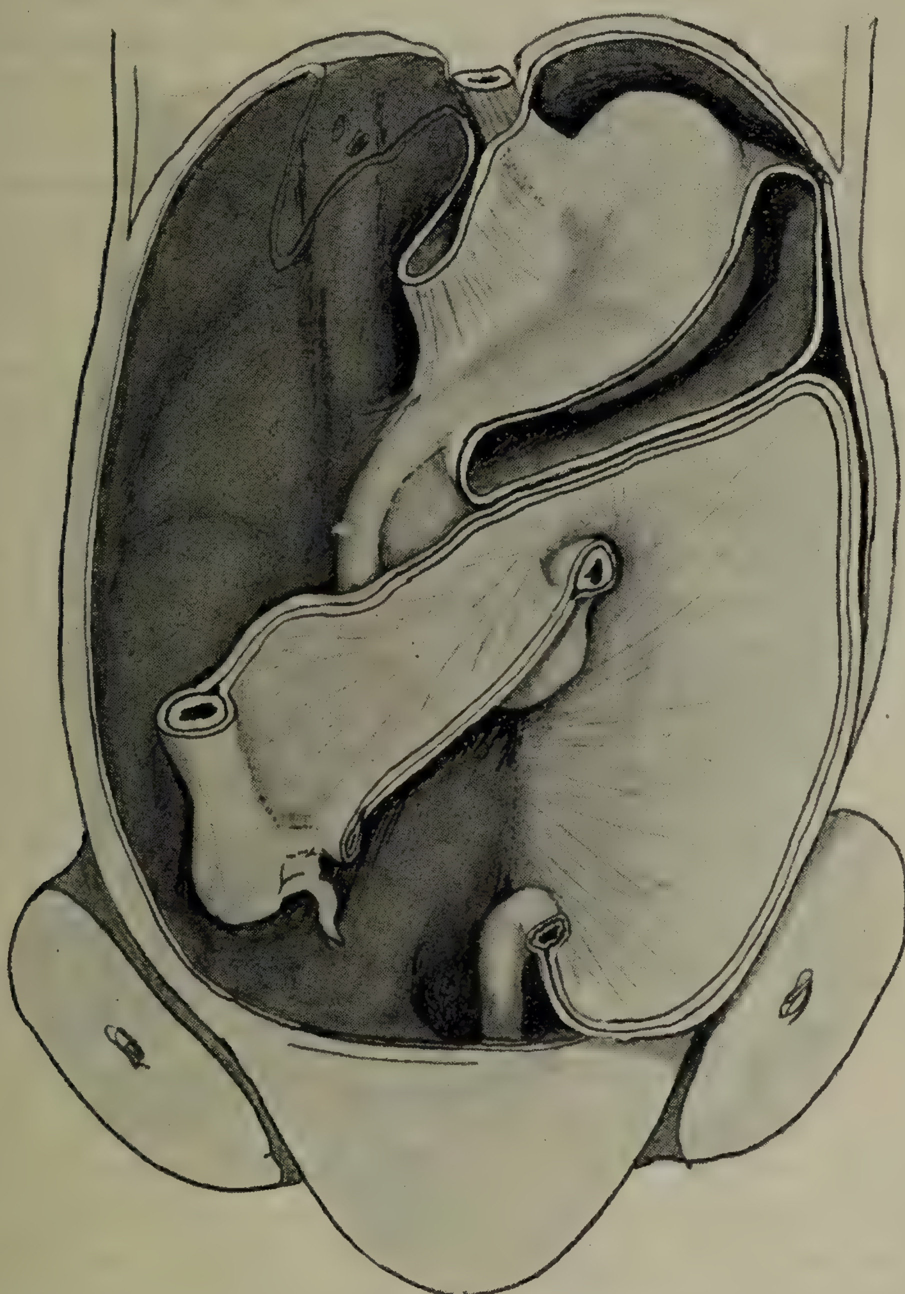
terior or ascending layers of the greater omentum, and represent the origi meso-gastrium. The *lower two layers* belong to the primitive transverse me colon. Subsequently the *lower* of the *upper two layers* and the *upper* of t *lower two layers* unite and disappear. There are thus left *only two layers* of pe toneum, which constitute the **transverse meso-colon** of *the adult,* the *lower la* of which is part of the **primitive transverse meso-colon,** whilst the *upper layer* part of the **greater omentum.** In fact, both layers are ultimately derived fr the two posterior or ascending layers of the greater omentum. As the res of these changes, the pancreas comes eventually to lie *behind* the peritoneu whereas it was originally contained between the two layers of the meso-gastri

The inferior mesenteric vessels reach the intra-abdominal colon by runn between the layers of the median mesentery (meso-colon); when this is for against the left dorsal wall by the pressure of the coils of gut, and adheres the the vessels are left behind the peritoneum.

The **ascending** and **descending meso-colon,** as a rule, disappear as a result of lhesion.

The **pelvic meso-colon** persists and the **meso-rectum** disappears.

Structure of the Peritoneum.—The peritoneum is a typical serous membrane :e the pleura, the serous portion of the pericardium, and the tunica vaginalis. :iefly stated, it consists of a homogeneous connective-tissue basement mem-ane, containing elastic tissue, and lined with endothelium.



G. 463.—Scheme, based on Embryonic Conditions, to show Fœtal Arrangements of Peritoneum and Composition of Transverse Meso-colon.

The wall of the lesser sac is really composed of two layers, but these layers are not shown in the figure.

Development.—The *parietal peritoneum* is developed from the **somatic meso-'m** of the **somatopleure** of the *body-wall.* The *visceral peritoneum* is developed m the **splanchnic mesoderm** of the **splanchnopleure** of the *primitive intestinal pe.*

Blood-supply of the Intestinal Canal.—The intestinal canal receives blood-supply from the superior and inferior mesenteric arteries, th the exception of the upper portion of the duodenum and a portion the rectum.

Superior Mesenteric Artery.—This vessel springs from the front o the abdominal aorta about $\frac{1}{4}$ inch below the cœliac artery. It is a first directed downwards behind the body of the pancreas and th splenic vein. It then passes downwards and forwards in front of th uncinate process of the pancreas and third part of the duodenum, a the lower border of which latter it takes up its position between th two layers of the mesentery proper. The vessel then passes down wards near the root of the mesentery, its course being slightly curve

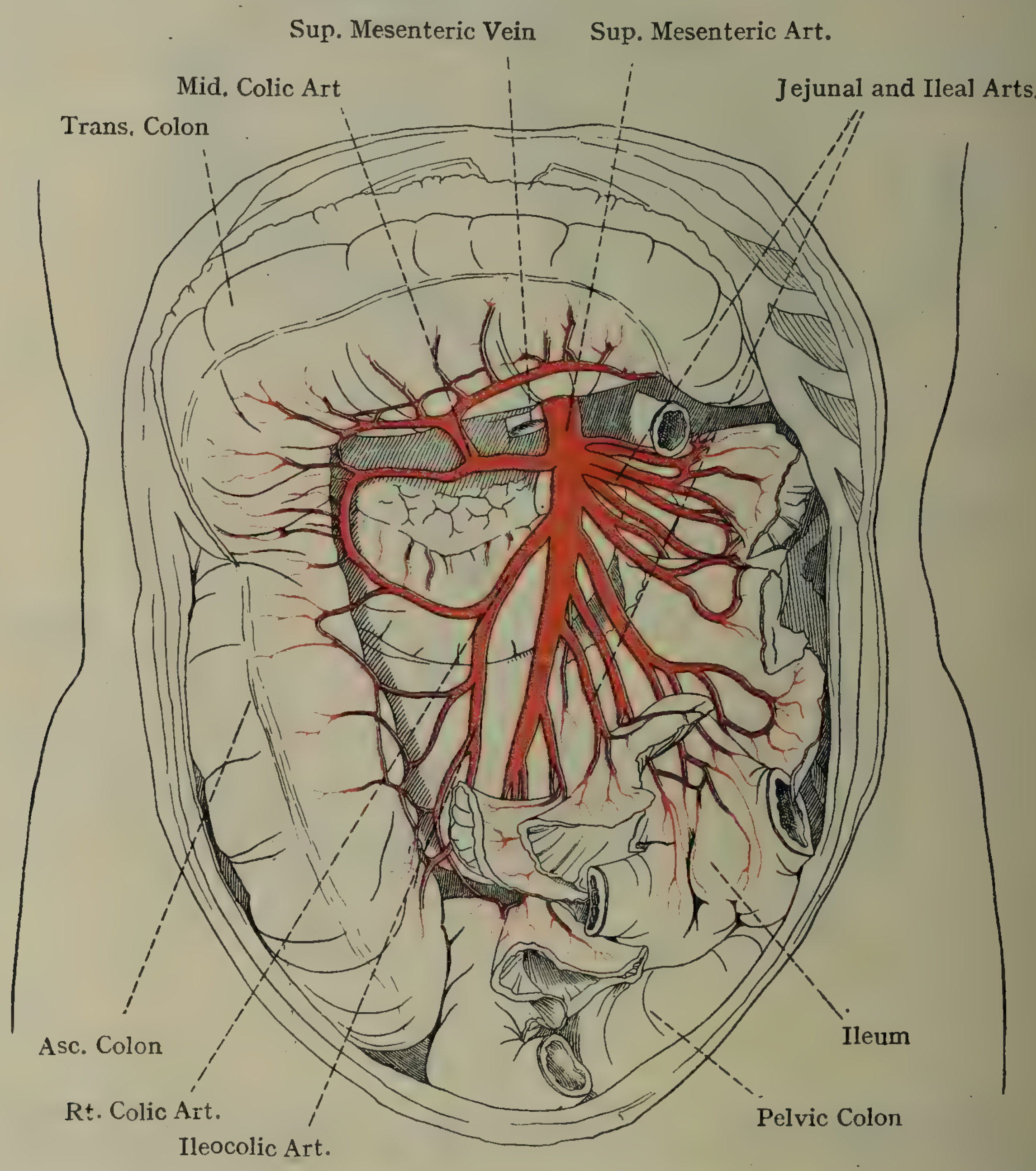


Fig. 464.—The Superior Mesenteric Artery and its Branches (after Spalteholz).

with the convexity towards the left side, and it terminates near the ileo-colic junction in the last ileal artery, which anastomoses with the ileal branch of the ileo-colic artery. The vessel is surrounded by a tough sheath formed by the superior mesenteric sympathetic plexus.

Branches—*Left Branches.*—These are called the **jejunal and ileal arteries (rami intestini tenuis)**, and are at least twelve in number. They pass downwards and to the left *between* the two layers of the mesentery proper, and supply the jejunum and ileum. After a course of about 2 inches each divides into two branches, which by their junction with

ɔntiguous branches give rise to primary arcades. From the con-exities of these arcades small branches are given off, which act in a milar manner, and give rise to secondary arcades. This disposition of rteries goes on so as to form tertiary, quaternary, and even quinary rcades. The minute vessels arising from the arcades of the last er enter the wall of the jejunum and ileum along the mesenteric order, where each divides into two branches, which encircle the owel beneath its serous covering, thus providing for an equal arterial ıpply to all parts of the wall. From the rings thus formed branches enetrate deeply to reach the mucous coat. Each jejunal and ileal rtery, as well as its various branches, conducts to the bowel an offshoot f the superior mesenteric sympathetic plexus.

The branches from the terminal arcades divide some distance away rom the intestine, and diverging leave an interval into which the ıtestine can expand without throwing undue strain on the vessels. 'his arrangement obtains generally all along the abdominal portion f the alimentary canal.

Right Branches—**Ileo-colic Artery.**—This vessel is the lowest of he right branches, and in many cases it arises in common with the ight colic. Its course is downwards and outwards towards the right iac fossa *behind* the peritoneum, and it divides into two branches, scending and descending. The *ascending branch* (*colic branch*) passes pwards and forms an arcade with the descending branch of the right olic, from which branches proceed to the lower part of the ascending olon. The *descending branch* (*ileo-cæcal branch*) passes to the upper art of the ileo-colic junction, where it furnishes the following branches: *leal*, to the terminal part of the ileum, where it anastomoses with the ıst ileal artery; *appendicular*, which, descending behind the terminal art of the ileum, passes between the two layers of the meso-appendix, nd so reaches the vermiform appendix; *anterior cæcal*, to the front of he cæcum; and *posterior cæcal*, to its posterior aspect.

Right Colic Artery.—This is the second branch in order from below ıpwards, and in many cases it arises in common with the ileo-colic. ts course is transversely to the right *behind* the peritoneum, and it livides into two branches, descending and ascending. The *descend-ng branch* anastomoses with the ascending branch of the ileo-colic, and he *ascending branch* with the right branch of the middle colic. The ırcades thus formed furnish branches to the ascending colon, which n their course form secondary and tertiary arcades.

Middle Colic Artery.—This vessel arises from the right side and ront of the main trunk about 2 inches above the right colic on a level vith the lower border of the third part of the duodenum. Its course s forwards *between* the two layers of the transverse meso-colon, and it livides into a short right and a long left branch. The *right branch* ınastomoses with the ascending branch of the right colic, and the *eft branch* with the ascending branch of the upper left colic from the nferior mesenteric. The arcades thus formed furnish branches to the niddle colon, which in their course form secondary and tertiary arcades.

Inferior Pancreatico-duodenal Artery.—This small vessel usuall arises from the right side of the main trunk opposite the upper bord of the third part of the duodenum, but it may spring from the fir jejunal artery. Its course is to the right behind the superior mesenter vein, and between the head of the pancreas and the third part of tl duodenum. It terminates by dividing into two branches, anteri and posterior, which ascend one in front of the other behind the hea of the pancreas supplying it and the adjacent portions of the duodenur and anastomosing with the anterior and posterior branches respective of the superior pancreatico-duodenal of the gastro-duodenal from tl

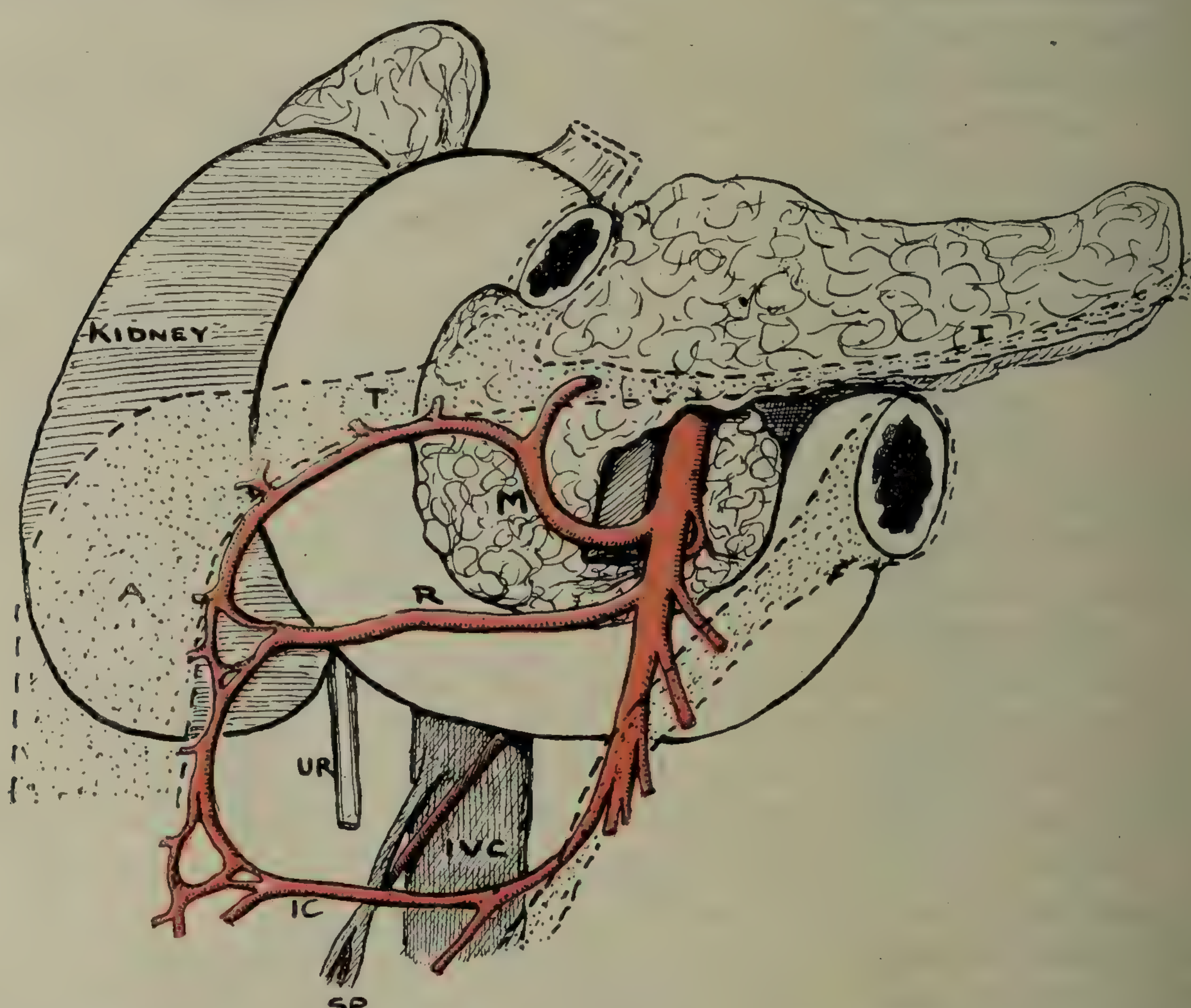


FIG. 465.—SCHEMATIC DRAWING TO SHOW UPPER BRANCHES OF SUPERIC MESENTERIC ARTERY.

Non-peritoneal area stippled; A, TT, ascending and transverse meso-colon M, middle colic; R, right colic; IC, ileo-colic; IVC, inferior vena cava.

hepatic. The vessel is accompanied by an offshoot from the superi mesenteric sympathetic plexus, and when it arises from the first jejun artery it passes behind the superior mesenteric artery.

Superior Mesenteric Vein.—This vein is formed by tributaries whic return the blood from the parts of the intestinal canal supplied by tl superior mesenteric artery, and it receives in addition the right gastr epiploic vein. It ascends on the right side of the superior mesenter artery. After leaving the mesentery it passes over the third part the duodenum and uncinate process of the pancreas, and finally, behir the neck of the latter organ, joins the splenic vein to form the port

n. The vessel and its tributaries are destitute of valves, so that the od can regurgitate in cases of portal obstruction.

Superior Mesenteric Sympathetic Plexus.—This plexus is derived n the solar plexus. It closely surrounds the superior mesenteric ery in the form of a tough sheath, and furnishes offshoots which ompany all the branches of that vessel.

Lymphatic Vessels of Small Intestine.—These, which are called **:eals,** originate in the villi of the mucous membrane of the small estine (see p. 866). They leave the wall of the bowel at the mesen- ic border, those of the jejunum exceeding in number those of the im. Within the mesentery they take a course inwards and up- rds, becoming in succession the afferent and efferent vessels of the ups of mesenteric glands. At the root of the superior mesenteric ery the lacteals, which have now emerged from the innermost

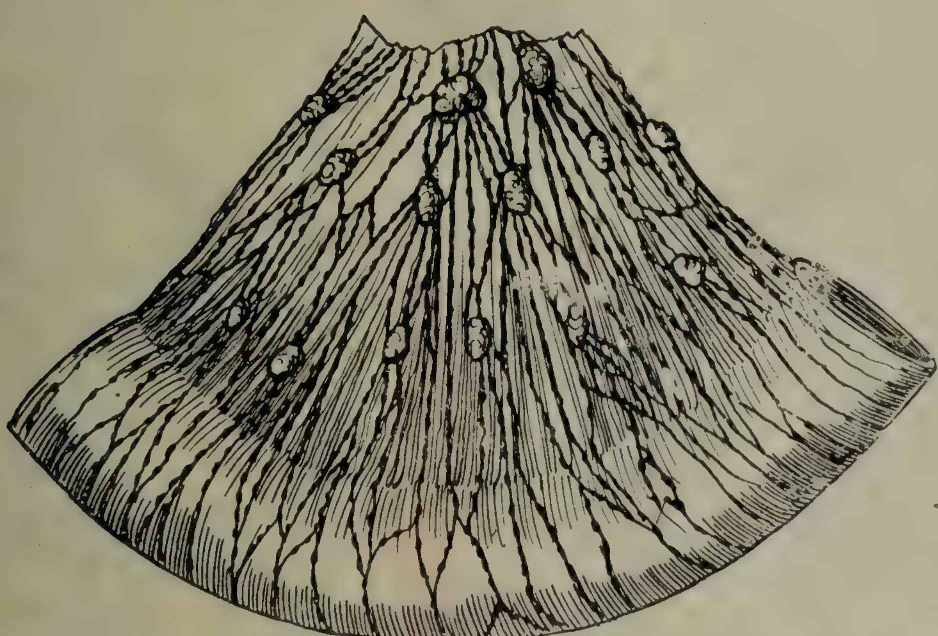


Fig. 466.—Portion of Jejunum with its Mesentery, showing Lacteal Vessels and Mesenteric Glands.

senteric glands, terminate in from one to four lymphatic trunks, ich open into the **cisterna chyli.**

Superior Mesenteric Glands.—These are about 150 in number, and situated within the mesentery proper and along the course of the nk of the superior mesenteric artery. In health their average size ibout that of a small pea, except along the course of the main artery, ere they are somewhat larger; they are more numerous in the jejunal in in the ileal mesentery. They receive the lacteals from the lower t of the duodenum, the jejunum, and the ileum, and also the lym- atics from the ascending and transverse colon. The glands may divided into three groups: a group of large and important glands the root of the mesentery, particularly numerous along the upper rt of the superior mesenteric vessels; a second group in the neighbour- od of the first arterial arcades; and a third group of small glands in neighbourhood of the terminal arcades; certain of this last group y lie, especially in the upper jejunal region, in close proximity to intestine or even upon it.

In the ileo-colic angle there is a special group of glands, called **ileo-colic glands.** These receive afferent vessels from the termi part of the ileum, the cæcum, the vermiform appendix, and beginn of the ascending colon; their efferent vessels pass to the innerm group of superior mesenteric glands. The efferent vessels of superior mesenteric glands usually unite with those of the cœl glands to form one or more intestinal trunks, which, joining the effer

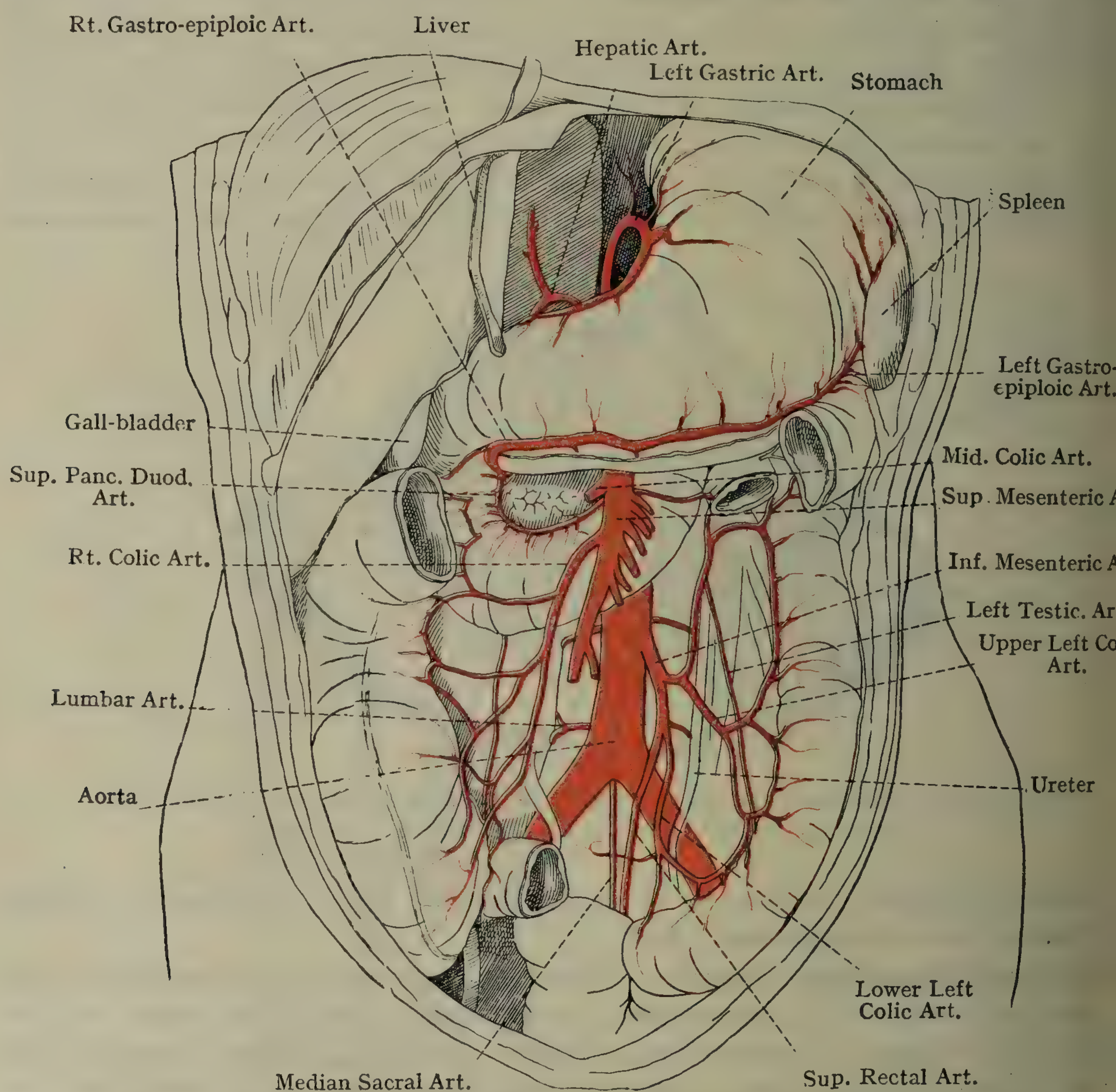


FIG. 467.—THE INFERIOR MESENTERIC ARTERY AND ITS BRANCHES (AFTER SPALTEHOLZ).

lymphatics from the pre-aortic and retro-aortic glands, form t cisterna chyli.

Lymphatic Vessels of Ascending and Transverse Colon.—The ly phatics of the ascending colon terminate in two ways as follov those from the lower part pass to the innermost group of super mesenteric glands, whilst those from the upper part go to the me colic glands. The lymphatics of the transverse colon become affere vessels of the meso-colic glands, the efferent vessels of which j

e terminal intestinal lymphatic trunks from the superior mesenteric ınds. The lymphatic vessels from the transverse colon freely com- ınicate with those in the greater omentum.

Inferior Mesenteric Artery.—This vessel arises from the front of e abdominal aorta towards its left side about $1\frac{1}{2}$ inches above the furcation. Its course is downwards and to the left towards the 't iliac fossa. It is *behind* the peritoneum, and lies first upon the rta, and then on its left side, where it is supported by the psoas ıjor. Subsequently it is continued as the superior rectal artery 'er the left common iliac vessels. The artery is surrounded by the ferior mesenteric sympathetic plexus.

Branches—Upper Left Colic Artery.—This vessel passes transversely the left, *behind* the peritoneum and over the lower part of the left dney, and divides into two anches, ascending and de- ending. The *ascending anch* anastomoses with the 't branch of the middle lic, and the *descending anch* with the ascending anch of the lower left colic tery. The arcades thus rmed supply branches to e left extremity of the ansverse colon and the scending colon, which in eir course form secondary ıd tertiary arcades.

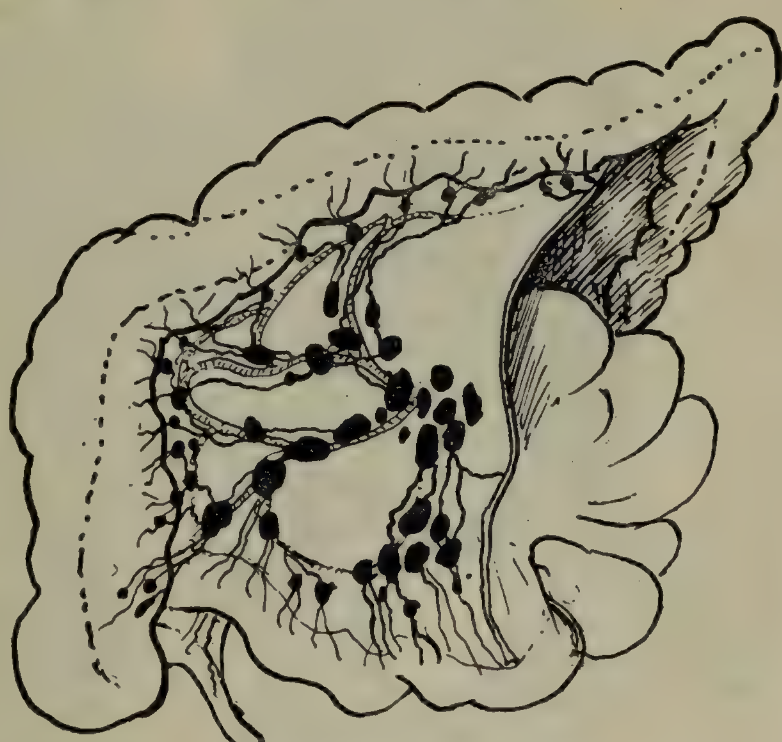


Fig. 467a.—Schematic Drawing to show the Lymphatic Arrangements for Ascending and Greater Part of Transverse Colon.

The glands are grouped along branches of the superior mesenteric artery.

Lower Left Colic Arteries igmoid Arteries).—These e usually three in number -superior, middle, and in- rior—but they are very ıriable and may arise as single trunk. They pass ›wnwards and to the left 'er the psoas major, ureter, and testicular vessels, and supply ıe lower part of the descending colon and the pelvic colon. The *perior lower left colic artery,* which lies, as a rule, *behind* the peri- ›neum, divides into two branches, ascending and descending. The scending branch forms an arcade with the descending branch of the pper left colic, and the descending branch passes between the two yers of the pelvic meso-colon, where it anastomoses with the middle wer left colic artery; this artery, or one of its branches, may lie in the ıterior wall of the intersigmoid recess. The *middle* and *inferior wer loft colic arteries* pass between the two layers of the pelvic meso- ›lon, where they form arcades with the descending branch of the ıperior lower left colic, with one another, and with the superior rectal

artery. The branches of these arcades form secondary, or eve tertiary, arcades before the terminal branches are given off.

The **superior rectal artery (superior hæmorrhoidal artery)** is tl continuation of the inferior mesenteric, and will be found describ on p. 961.

Inferior Mesenteric Vein.—This vein is formed by tributaries whi return the blood from the parts of the large intestine supplied l the inferior mesenteric artery. It lies at first near the left side of i artery, but soon leaves it and ascends on the left psoas major, whe it lies on the left side of the aorta behind the peritoneum. In th course it crosses the left testicular artery and left renal vein. It pass to the left of the duodeno-jejun flexure lying in the anterior wall the paraduodenal recess, and the curving sharply to the right, pass behind the pancreas to join the splen vein near its termination in the port vein. It may, however, open in the angle of junction of the splen and superior mesenteric veins, or in the superior mesenteric vein near i termination. The inferior mesenter vein and its tributaries are destitu of valves, so that the blood can r gurgitate in cases of portal obstru tion.

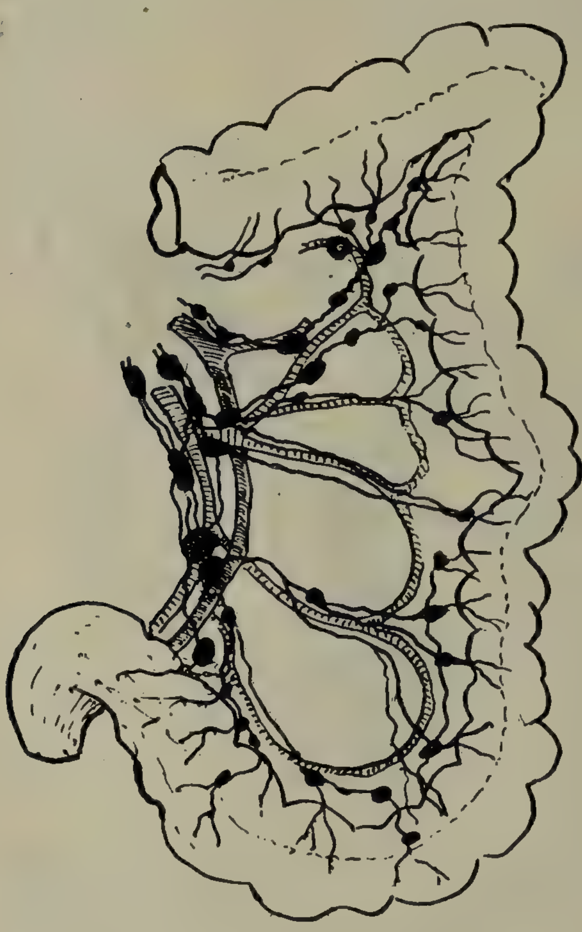


FIG. 467B.—SCHEME TO ILLUSTRATE THE LYMPHATIC DRAINAGE OF DESCENDING COLON AND ILIAC LOOP, AND TERMINAL PORTION OF TRANSVERSE COLON.

Inferior Mesenteric Sympathet Plexus.—This plexus is derived fro the left half of the aortic plexus. forms a tough sheath round th artery, and furnishes offshoots wit its branches.

Inferior Mesenteric Glands.—Thes glands are situated around the roo and along the trunk and branches c the inferior mesenteric artery. Thos around the root of the vessel con stitute the inferior mesenteric group of the pre-aortic glands.

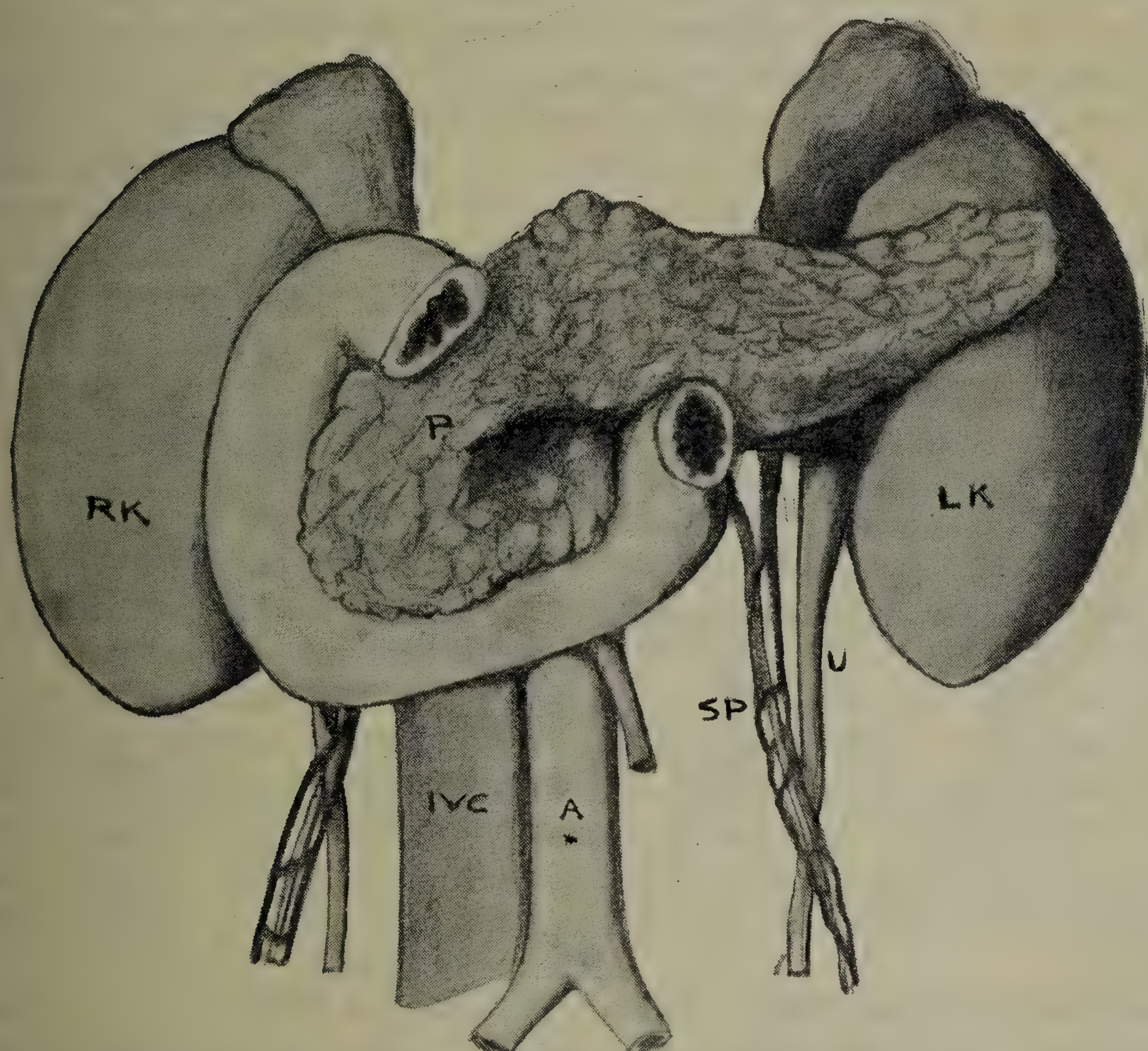
The *afferent* vessels are derived from (1) the *lower part* of the *descend ing colon,* (2) the iliac part of descending colon, (3) the pelvic color and (4) some of the lymphatics of the rectum.

Their *efferent* vessels pass to the inferior mesenteric group of pre aortic glands.

Lymphatic Vessels of Descending and Pelvic Colon.—The lymphatic of the descending colon are singularly scanty; they terminate in two way as follows: those of the upper part pass to the meso-colic glands, whils those of the lower part with the lymphatics of the pelvic colon pas to the inferior mesenteric group of pre-aortic glands.

Lymphatic Glands of Large Intestine (Colic Glands).—The glands e arranged in groups, named according to the portion of intestine which they are related, and they are situated behind the respective rts, except those belonging to the transverse colon, which lie between e two layers of the transverse meso-colon, and are known as the **so-colic glands.**

Position and Connections of the Duodenum.—The duodenum is e first part of the small intestine. It measures from 10 to 11 inches length and is the widest and least movable part. It extends from



G. 468.—Showing Relative Positions of Duodenum, Pancreas (P), and Kidneys (RK, LK).

SP, testicular vessels; U, ureter; A, aorta; IVC, inferior vena cava.

e pylorus to the left side of the body of the *second* lumbar vertebra, iere it ends in the jejunum. It describes a somewhat U-shaped rve with the concavity directed upwards and to the left in close aptation to the head of the pancreas. It is devoid of a mesentery, d is divided into three parts—first, second, and third.

First or Superior Part.—The first part extends from the pylorus the right side of the neck of the gall-bladder. It lies in the epistric region, and is about 2 inches in length, its direction being wards, backwards, and to the right when the stomach is empty, but ectly backwards when that organ is distended. The lesser omentum

furnishes a complete covering to about the first inch; the remainder i covered by peritoneum only in front. The first part is therefore com paratively movable.

Relations—*Superior.*—The caudate process of the liver and th hepatic artery. *Anterior.*—The quadrate lobe of the liver and the gall bladder. *Posterior.*—The portal vein, gastro-duodenal artery, bile duct, and neck of the pancreas. *Inferior.*—The head of the pancrea and the division of the gastro-duodenal artery into its terminal branches The first part lies below the opening into lesser sac.

Second or Descending Part.—This part extends from the right sid of the neck of the gall-bladder to the right side of the body of the thir (sometimes fourth) lumbar vertebra. It lies at first in the epigastric and subsequently in the umbilical region; its length is from 3 to 4 inches and its direction is almost vertically downwards behind the right ex tremity of the transverse colon. The anterior surface is covered b peritoneum, except opposite the transverse colon. If there is n transverse meso-colon at this point, there is a distinct area left un covered and connected to the colon by areolar tissue. If, however there is a transverse meso-colon present at this point, the bare area i trifling. The posterior surface is destitute of peritoneum. The secon part is therefore very immovable.

Relations—*Anterior.*—From above downwards the liver and th gall-bladder near its neck, the right extremity of the transverse colon and some coils of the small intestine. *Posterior.*—The anterior surfac of the right kidney near the hilum, the inferior vena cava, and th psoas muscle. *Right.*—The right flexure of the colon, and the righ lobe of the liver. *Left.*—The head of the pancreas, which may encroac upon it both anteriorly and posteriorly, the bile-duct, and the anterio and posterior branches of the superior and inferior pancreatico-duodena arteries. The bile-duct and pancreatic duct enter the wall of this par at the junction of the inner and posterior aspects a little below th centre.

Third or Inferior Part.—This part extends from the right side o the body of the third (sometimes fourth) lumbar vertebra to the lef side of the body of the second on a level with its upper border. A this point it makes a sharp bend forwards, and terminates in th jejunum, thus forming the *duodeno-jejunal flexure.* It lies at first i the umbilical, and subsequently in the epigastric region; its lengt is about 5 inches, and its direction is at first obliquely to the left an upwards, and afterwards vertically upwards. Its anterior surface i covered by peritoneum derived from the descending layer of the trans verse meso-colon, except where it has the superior mesenteric vessel in front of it. There is no peritoneum behind it, and consequently i is fixed in position.

Relations—*Anterior.*—The superior mesenteric vessels and the uppe part of the root of the mesentery, with portions of the small intestin on either side of these. *Posterior.*—The inferior vena cava, aort (below the origin of the superior mesenteric artery), left renal vei

ꞁft psoas major, and left crus of the diaphragm. *Superior.*—The ɔwer part of the head of the pancreas (including its uncinate process), nd the inferior pancreatico-duodenal vessels.

The terminal portion of the third part is sometimes spoken of as he *fourth* or *ascending part of Treves.* It is covered by peritoneum n the left side, as well as in front, and in cases where a retro-duodenal ecess is present it is partially covered by peritoneum behind towards he left side. The duodenal recesses of the peritoneum are met with n the left side of this portion. The duodeno-jejunal flexure is sus-

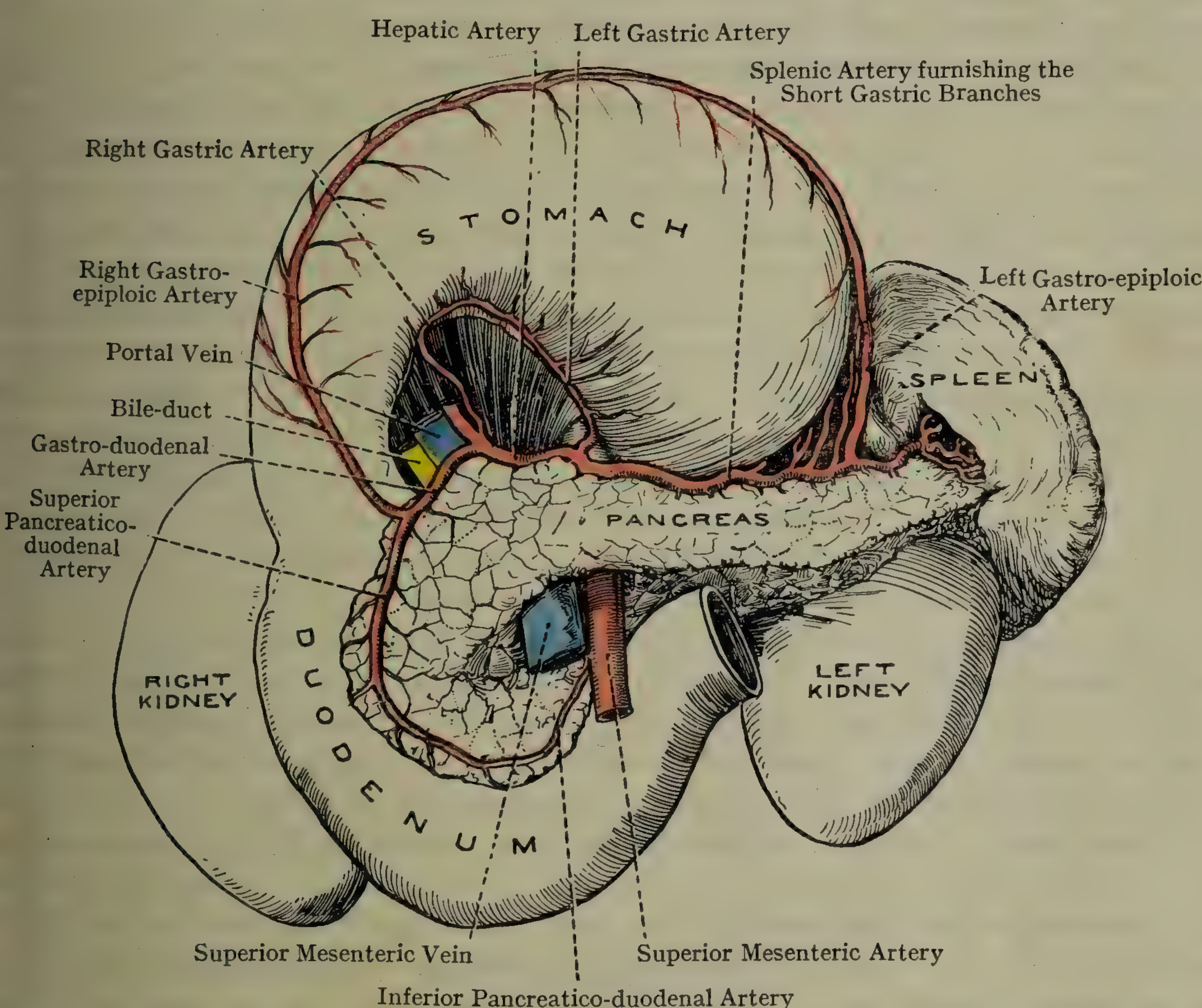


FIG. 469.—THE ARTERIES OF THE STOMACH, DUODENUM, PANCREAS, AND SPLEEN.

ended from the right crus of the diaphragm by a fibro-muscular undle, called the *suspensory muscle of duodenum.* The muscle consists f both striped and unstriped muscular fibres, as well as of elastic ssue; as it passes downwards it lies in a fold of peritoneum called the *uodeno-jejunal fold* immediately to the right of the cœliac artery. Its bres are inserted mainly into the posterior surface of the duodeno-ejunal flexure, but certain of them are continued into the mesentery.

Blood and Nerve Supply of the Duodenum.—The **arteries** of the uodenum are as follows: (1) the right gastric branch of the hepatic; 2) the superior pancreatico-duodenal branch of the gastro-duodenal

of the hepatic; and (3) the inferior pancreatico-duodenal branch of t
superior mesenteric.

The **veins** terminate in the superior mesenteric, splenic, and por
veins.

The **nerves** are derived from the hepatic and superior mesente
sympathetic plexuses.

The lymphatic vessels of the *first part* of the duodenum pass to t
retro-pyloric glands, and those of the *second* and *third* parts pass
the prepancreatico-duodenal and retro-pancreatico-duodenal glan
which lie along the anastomotic chains formed by the anterior a
posterior branches of the pancreatico-duodenal arteries.

Position and Connections of the Pancreas.—The pancreas is a lo
narrow gland which is situated behind the stomach on a level with t
first and second lumbar vertebræ. Its right extremity occupies t
duodenal curve, and its somewhat pointed left extremity is in conta
with the spleen. The greater part of the organ lies in the epigastr
region, but its left extremity is situated in the left hypochondriu
The anterior surface is covered by the ascending layer of the transver
meso-colon, and the inferior surface by the descending layer, but t
posterior surface is destitute of serous covering. The length of t
organ is from 6 to 8 inches, its depth from 1 to 1½ inches, except at t
right and left extremities, and its thickness from ½ to ¾ inch. I
weight is about 3½ ounces. It has been likened in shape to the capit
letter J laid thus ⊂ (Birmingham). For convenience of descripti
it is divided into a head, neck, body, and tail.

The **head** is the enlarged flattened right extremity. It chief
corresponds with, and is closely attached to, the second and thi
parts of the duodenum as far almost as the duodeno-jejunal flexur
The expansion of the head to the left along the upper part of the thi
portion of the duodenum is called the *uncinate process*.

Relations—*Anterior.*—The transverse colon with its meso-colo
and the superior mesenteric vessels crossing the uncinate proces
The formation of the portal vein may occur in front of the upturne
extremity of the uncinate process. *Posterior.*—The inferior vena cav
right renal vessels, right crus of the diaphragm, aorta, and left ren
vein. *Superior.*—The first part of the duodenum and the superi
pancreatico-duodenal artery. *Inferior.*—The third part of the du
denum, and the inferior pancreatico-duodenal artery. *Right.*—T
second part of the duodenum, with the bile-duct behind, as low
a little below the centre, and the anastomoses between the superi
and inferior pancreatico-duodenal arteries.

The **neck** may be defined as the part in front of the origin of the ve
portæ and the termination of the superior mesenteric vein. It sprin
from the anterior surface of the head near its upper part, and is abo
1 inch in length. Its direction is upwards and to the left, and
forms the connecting link between the head and body. The gastr
duodenal and superior pancreatico-duodenal arteries occupy groov
on its right side; the commencement of the first part of the duodenu

; in front of it, whilst the origin of the portal vein and the termination f the superior mesenteric vein are behind it.

The **body** passes to the left with a slight inclination backwards fter it has crossed the aorta. It is triangular, and presents three ırfaces (anterior, posterior, and inferior) and three borders (superior, nterior, and posterior).

The *anterior surface*, which is covered by peritoneum, is in relation ith the posterior surface of the stomach. At its right extremity, ıst below the cœliac artery, it presents a prominence, called the **ıber omentale** from its relation to the lesser omentum. The tuber mentale of the pancreas, it will be noticed, lies behind the lesser mentum, whereas that of the liver lies in front of it. The *posterior urface*, which is destitute of peritoneum, is related to the following tructures: the aorta below the cœliac artery, with a portion of the œliac plexus; the origin of the superior mesenteric artery; the left uprarenal gland; and the left kidney with its vessels. The splenic ein passes from left to right in contact with this surface near the uperior border. The *inferior surface*, which is covered by peritoneum, ; moulded on the duodeno-jejunal flexure, some coils of the jejunum, nd the left extremity of the transverse colon. The cœliac artery proects forwards over the *superior border* above the tuber omentale. To he left of this artery the splenic artery pursues its tortuous course to he spleen, and to the right of it the hepatic artery lies for a short istance. The transverse meso-colon is attached to the *anterior border*, long which its separation into ascending and descending layers takes lace, the former covering the anterior surface of the organ, and the ıtter, on its way backwards, investing the inferior surface. The *osterior border* presents nothing noteworthy.

The **tail** corresponds with the left extremity where the pancreas is arrowest, and is in contact with the lower end of the gastric surface f the spleen behind the hilum. The terminal part is in the lieno-renal igament.

For the structure and development of the pancreas, see pp. 891, 894.

Cœliac (Solar) Plexus of the Sympathetic System.—The cœliac plexus s of large size, and is situated deeply in the epigastric region, behind he stomach and in front of the crura of the diaphragm and the aorta lose to the origins of the cœliac artery and superior mesenteric artery. t extends from one suprarenal gland to the other, and is composed f nerve-fibres and ganglia. The plexus receives its chief fibres from he greater and lesser splanchnic nerves of each side, which contain a arge number of spinal fibres. The greater splanchnic nerve is formed y roots derived usually from the fifth to the ninth or tenth thoracic ympathetic ganglia inclusive, and it enters the abdomen by piercing he crus of the diaphragm. The lesser splanchnic nerve arises by two oots from the ninth and tenth thoracic ganglia, and it also enters he abdomen by piercing the crus of the diaphragm. The plexus also eceives fibres from the right vagus nerve. Two of the ganglia of the œliac plexus are of large size, and are situated one at either lateral

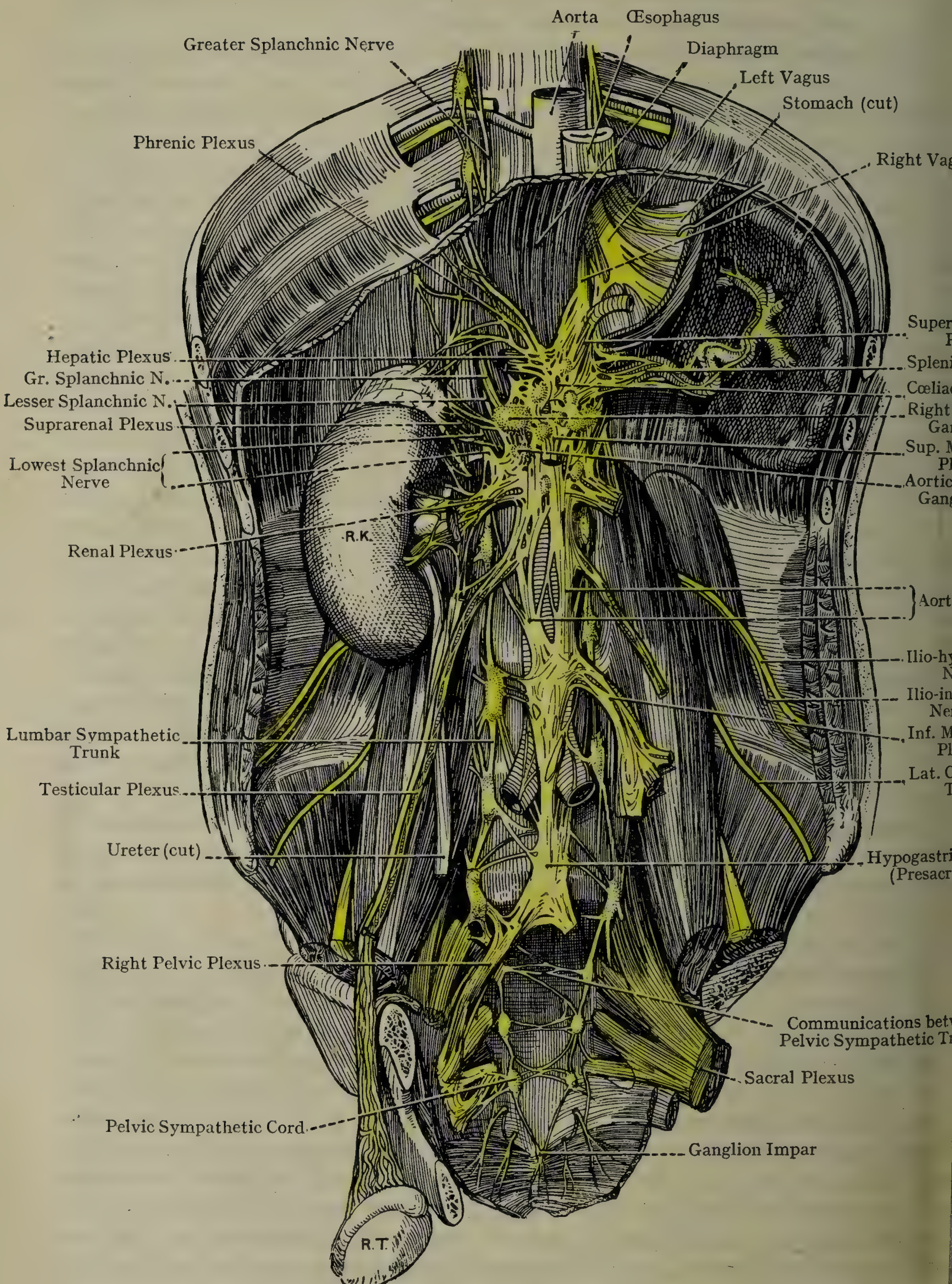


FIG. 470.—THE SYMPATHETIC SYSTEM IN THE ABDOMEN AND PELVIS (HIRSCHFELD AND LEVEILLÉ).

R.K., right kidney; R.T., right testis.

le. They are called the **cœliac ganglia (semilunar ganglia)**, right and t. Each lies over the corresponding crus of the diaphragm close the suprarenal gland, that of the right side being under cover of e inferior vena cava, and each receives at its upper part the greater lanchnic nerve. The lower part of each ganglion is more or less tached, and is known as the *aortico-renal ganglion*, which lies over e root of the renal artery, and in which the lesser splanchnic nerve rminates. From each cœliac ganglion branches proceed in a radiating anner upwards, outwards, downwards, and inwards. The inner oup of fibres extend from one ganglion to the other, embracing the eliac artery as they cross the aorta, and forming the cœliac plexus, iich receives fibres from the right vagus nerve, and contains numerous iall ganglia.

The **cœliac plexus** furnishes three secondary plexuses—superior stric, splenic, and hepatic. The superior gastric *plexus* accompanies e left gastric artery to the lesser curvature of the stomach, and supies branches to the adjacent portions of the anterior and posterior rfaces of that organ. The *splenic plexus* goes with the splenic artery, d receives branches from the right vagus nerve. It is distributed, th the branches of the artery, to the pancreas, cardiac extremity of e stomach, left half of its greater curvature and adjacent portions its surfaces, and the spleen. The *hepatic plexus* accompanies the tery of that name, and receives branches from the left vagus nerve. s distribution corresponds with that of the artery, and its offshoots e as follows: pyloric to the lesser curvature of the stomach; gastroıodenal, dividing into right gastro-epiploic to the greater curvature the stomach, and superior pancreatico-duodenal to the head of the ncreas, and the first and second parts of the duodenum; cystic to the ll-bladder; and hepatic to the liver.

The **diaphragmatic** or **phrenic plexus** receives its fibres from the per part of the cœliac ganglion, and it accompanies the phrenic artery the diaphragm, giving branches in its course to the suprarenal plexus.

The **suprarenal plexus** receives its fibres from the cœliac ganglion d cœliac plexus. It contains small ganglia, and is joined from ove by branches from the phrenic plexus, and below by branches m the renal plexus. It is distributed to the suprarenal gland.

The **renal plexus** derives its fibres from the aortico-renal ganglion, e cœliac and aortic plexuses, and the lowest splanchnic nerve when esent. (The lowest splanchnic nerve arises from the eleventh oracic ganglion, and enters the abdomen behind the medial arcuate ament, or through the crus of the diaphragm.) The fibres of the nal plexus, which contain ganglia here and there, are distributed th the renal artery to the kidney, branches being also given to the prarenal plexus, testicular plexus (ovarian in the female), and to the eter.

The **superior mesenteric plexus** is a continuation of the cœliac exus, and also receives fibres from the cœliac ganglia. It contains ganglion, called *superior mesenteric*, in contact with the origin of

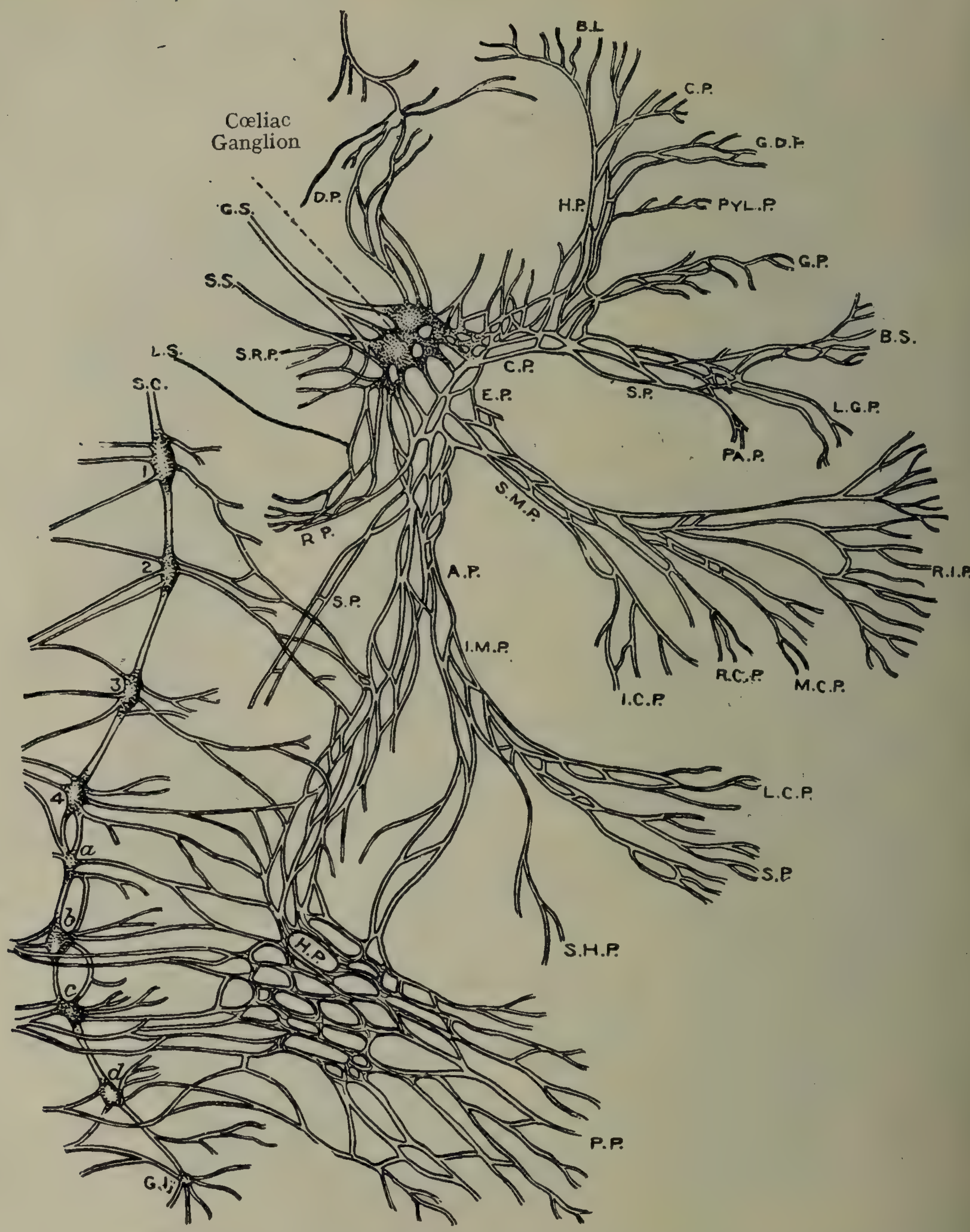


FIG. 471.—SCHEME OF THE SYMPATHETIC NERVE IN THE ABDOMEN AND PELVIS (FLOWER).

S.C. Sympathetic Trunk
1,2,3,4. Lumbar Ganglia
a,b,c,d, Pelvic Ganglia
G.I. Ganglion Impar
G.S. Greater Splanchnic
S.S. Lesser Splanchnic
L.S. Lowest Splanchnic
D.P. Phrenic Plexus
S.R.P. Suprarenal Plexus
R.P. Renal Plexus
S.P. Testicular Plexus
A.P. Aortic Plexus
I.M.P. Inferior Mesenteric Plexus
L.C.P. Upper Left Colic Plexus
S.P. Lower Left Colic Plexus
S.H.P. Superior Rectal Plexus
H.P. Hypogastric Plexus

P.P. Pelvic Plexus
E.P. Epigastric Plexus
C.P. Cœliac Plexus
S.P. Splenic Plexus
Pa.P. Pancreatic Plexus
L.G.P. Left Gastro-epiploic Plexus
B.S. Branches to Spleen
G.P. Superior Gastric Plexus
H.P. Hepatic Plexus
Pyl.P. Pyloric Plexus
G.D.P. Gastro-duodenal Plexus
C.P. Cystic Plexus
B.L. Branches to Liver
S.M.P. Superior Mesenteric Plexus
I.C.P. Ileo-colic Plexus
R.C.P. Right Colic Plexus
M.C.P. Middle Colic Plexus

R.I.P. Jejunal and Ileal Plexuses

ne artery of that name, and it accompanies that vessel and its branches o be distributed to the intestinal canal from the middle of the duo-enum to the commencement of the descending colon. Its secondary lexuses are as follows: jejunal and ileal, ileo-colic, right colic, middle olic, and inferior pancreatico-duodenal.

The **abdominal aortic plexus** derives its fibres from the cœliac ganglia nd the cœliac plexus. It extends along the aorta, beyond the origin f the superior mesenteric artery, in the form of two lateral strands hich communicate freely with one another over the vessel by many nterlacing fibres. It is reinforced laterally by branches from the umbar portion of the gangliated sympathetic trunk. The two lateral trands of the plexus ultimately cross the common iliac arteries, and nite in front of the body of the fifth lumbar vertebra to form the ypogastric plexus. The aortic plexus furnishes, on either side, ranches to the renal and testicular (or ovarian) plexuses, and supplies ne coats of the aorta. The right strand gives branches to the inferior ena cava, and the left furnishes the chief fibres of the inferior mesenteric lexus.

The **testicular (spermatic) plexus** derives its fibres from the renal nd aortic plexuses, and accompanies the testicular artery to the testis. n the female it is called the **ovarian plexus,** which goes with the artery f that name to the ovary.

The **inferior mesenteric plexus** is derived chiefly from the left strand f the aortic plexus, and contains a ganglion, called *inferior mesenteric,* hich lies below the root of the inferior mesenteric artery. The plexus ccompanies the inferior mesenteric artery, and furnishes upper left olic, lower left colic, and superior rectal plexuses, which supply the escending colon, pelvic colon, and rectum.

The **hypogastric plexus** is formed by the fusion of the two halves of ne aortic plexus after these have crossed the common iliac arteries. It reinforced by branches from the lumbar ganglia, and is situated in ont of the body of the fifth lumbar vertebra between the common ac vessels. It is a large flat plexus, measuring about $1\frac{1}{2}$ inches in readth, and it ends in two divisions, which become the right and left elvic plexuses.

Cœliac Artery (Cœliac Axis).—The cœliac artery is a short thick trunk hich arises from the front of the aorta between the crura of the aphragm just below the aortic opening. Its direction is forwards nd slightly downwards over the superior border of the body of the ancreas, and after a course of about $\frac{1}{2}$ inch it divides into three radiat-g branches—left gastric, splenic, and hepatic. Of these the splenic the largest, except during fœtal life, when it is exceeded by the epatic. The branches of the cœliac artery supply the stomach, uodenum, pancreas, spleen, liver, and gall-bladder.

Relations.—The caudate lobe of the liver *above,* the superior border the body of the pancreas and splenic vein *below,* the lesser omentum *front,* and a cœliac ganglion *on either side.* The artery is closely urrounded by the cœliac sympathetic plexus.

The **left gastric artery** (**coronary artery**) is directed upwards and the left as far as the lesser curvature of the stomach on the right s of the œsophagus. It then, on reaching the bare area at the back the stomach, bends sharply forwards and downwards, and passi between the two layers of the lesser omentum descends in two divisio from left to right along the lesser curvature towards the pylorus, wh it anastomoses with the two divisions of the right gastric branch of t hepatic. The artery is surrounded by the superior gastric sympathe plexus.

Branches.—These are œsophageal, cardiac, and gastric. The *œsoph geal branches* arise when the artery reaches the lesser curvature, a they ascend through the œsophageal opening of the diaphragm anastomose on the gullet with the lower œsophageal branches of t thoracic aorta. The *cardiac branches* are distributed to the card end of the stomach, where they anastomose with the short gast branches of the splenic. The *gastric branches* arise from the t divisions of the artery on the lesser curvature, and pass to the fro and back of the stomach, where they anastomose with branches of t gastro-epiploic arteries.

The **left gastric vein** ascends from right to left along the les curvature of the stomach as far as the œsophagus, where it recei a few œsophageal tributaries, after which it turns to the right a opens into the portal vein.

The **splenic artery** takes a tortuous course to the left along t superior border of the body of the pancreas behind the lesser sa On reaching the front of the left kidney it enters the lieno-renal lig ment, and breaks up into several splenic branches which enter t spleen through the hilum. The artery is invested by the splenic sy pathetic plexus; the splenic vein lies below it, and behind the pancre

Branches.—These are pancreatic, left gastro-epiploic, short gastr and splenic. The *pancreatic branches* arise at intervals along t superior border of the pancreas, which they enter. One of the known as the *arteria pancreatica magna*, enters the organ towa its left end, and passes from left to right, lying a little above the pa creatic duct. The *left gastro-epiploic artery* arises near the spleen, a passes within the gastro-splenic ligament to the greater curvature of t stomach, along which it descends from left to right between the t layers of the greater omentum as far as the centre, where it anastomos with the right gastro-epiploic. It furnishes *gastric branches* to the fro and back of the stomach, which anastomose with branches of the l gastric artery, and *epiploic branches*, which descend into the grea omentum, these latter being long and slender. The *short gast branches* arise from the terminal part of the splenic and from its splen branches. They are about five in number, and having passed with the gastro-splenic ligament to the cardiac extremity of the stomac they anastomose with branches of the left gastro-epiploic and le gastric arteries. The *splenic branches* are about five in number, a pass to the spleen within the lieno-renal ligament.

The **splenic vein** is formed by the union of about five veins which nerge from the spleen. It is of large size, and passes from left to ght behind the pancreas near its superior border, where it lies below ne splenic artery. Having crossed the aorta, it joins the superior nesenteric vein to form the portal vein behind the neck of the pan- reas. The vein receives the following tributaries: the short gastric, ne left gastro-epiploic, many pancreatic veins, and the inferior mesen- eric (as a rule).

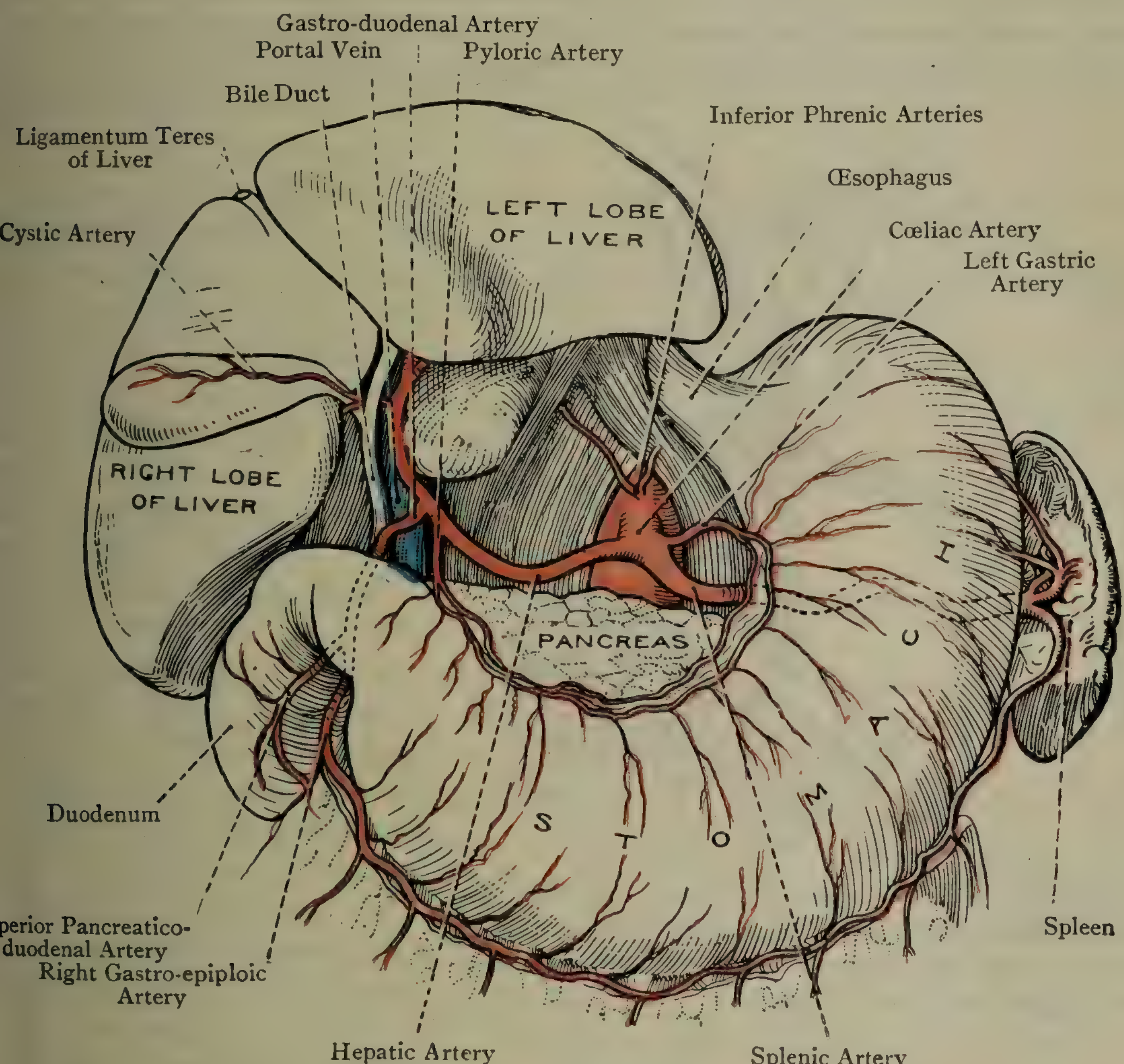


FIG. 472.—THE ARTERIES OF THE STOMACH, LIVER, AND SPLEEN (AFTER MERKEL).

The **hepatic artery** passes at first to the right along the superior order of the pancreas for a short distance, where it lies behind the sser sac. It then turns forwards *below* the opening into lesser sac the upper border of the first part of the duodenum near the pylorus, nd it subsequently ascends between the two layers of the lesser mentum *in front of* the opening into lesser sac towards the porta epatis of the liver, on approaching which it divides into a right and ft hepatic branch. The vessel is accompanied by the hepatic sym- athetic plexus. As it ascends between the two layers of the lesser

omentum it has the bile-duct on its right side, the portal vein bei behind both.

Branches.—These are right gastric, gastro-duodenal, and right a left hepatic. The *right gastric artery* (*pyloric artery*), of small siz arises near the pylorus, and passes to the lesser curvature of t stomach, where it divides into two branches. These lie between t two layers of the lesser omentum, and supply offsets to the front a back of the stomach. They anastomose with the two divisions of t left gastric artery. The *gastro-duodenal artery* also arises near t pylorus, and descends behind the first part of the duodenum, havi the bile-duct on its right and the portal vein behind it. Havi reached the lower bord of the first part of t duodenum, it occupies groove on the right of t neck of the pancreas, ar here divides into its tw terminal branches—rig gastro-epiploic and s perior pancreatico-duod nal. The *right gastr epiploic artery* passes fro right to left along t greater curvature of t stomach as far as i centre between the tw layers of the great omentum, and its distr bution and anastomos are similar to those of t left gastro-epiploic arter The *superior pancreatic duodenal artery*, havin divided into anterior an posterior branches, d scends between the hea of the pancreas and t second part of the duodenum, towards the lower end of which latter anastomoses with the inferior pancreatico-duodenal branches of th superior mesenteric. It supplies the first and second parts of the duc denum, and furnishes branches to the adjacent portion of the pancrea The *hepatic branches* are the terminal divisions of the trunk. The *righ* which is the larger, enters the porta hepatis at its right end, whilst th *left*, small in size, enters that porta at its left end, having previousl furnished a branch to the caudate lobe. The right branch gives o the *cystic artery*, and this divides into two branches, superior an inferior, which ramify on the upper and under surfaces of the gall bladder.

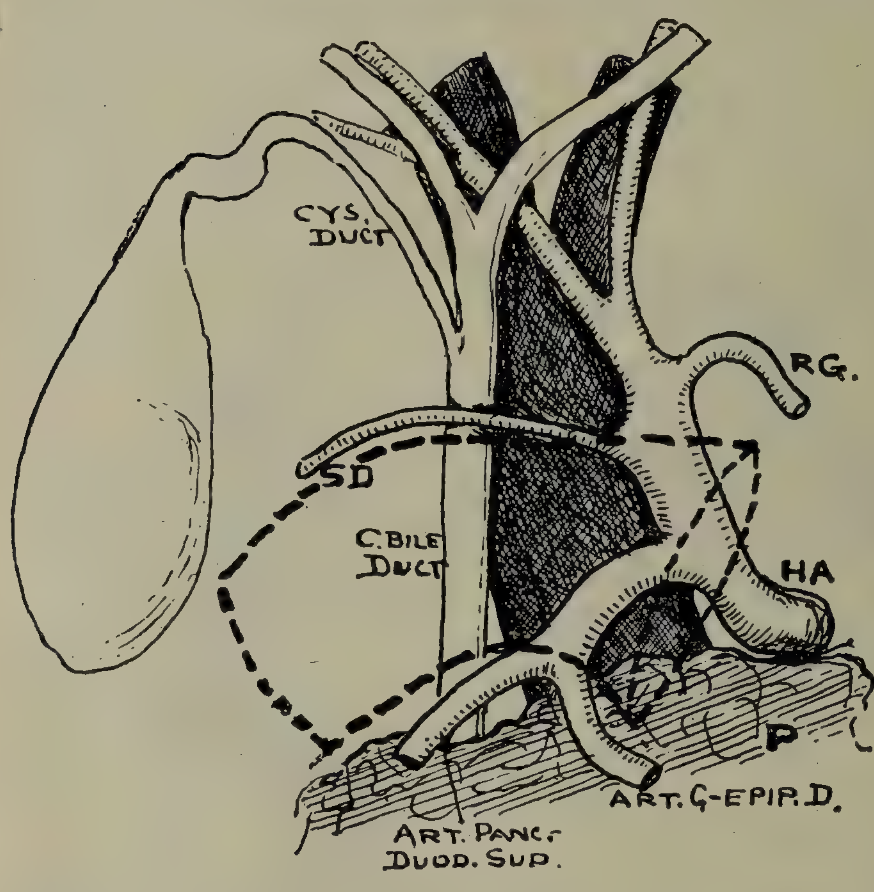


FIG. 473.—PLAN OF THE RELATIONS OF PORTAL VEIN, HEPATIC ARTERY (HA), AND BILE-DUCTS BEHIND THE DUODENUM (INTERRUPTED LINE), AND IN LESSER OMENTUM.

RG, right gastric; and SD, supra-duodenal arteries.

Variations of the Hepatic Artery.—A knowledge of the variations of the right nch of the hepatic artery is of considerable importance, owing to the fre-ncy with which operations are performed on the gall-bladder and the biliary sages. The right hepatic artery arises in about 20 per cent. of cases from superior mesenteric artery, while in about 4 per cent. of cases there are sent two right hepatic arteries, one arising from the main hepatic trunk, the er usually from the superior mesenteric artery. While the right hepatic ery usually passes behind the common hepatic duct, it passes in about 12 per t. of cases in front of it. The cystic artery most usually arises from the it hepatic, the most frequent site of origin being immediately after the artery made its appearance to the right of the duct. Accessory cystic arteries are infrequent. The left hepatic artery may arise from the left gastric artery. s important to remember that the cystic artery, when it arises from an sual place—which is not very uncommon—always lies anterior to the duct nt).

The *pre-pyloric vein* passes from left to right, and opens into the tal vein near the pylorus.

The *right gastro-epiploic vein* passes from left to right, and opens the superior mesenteric vein near its termination.

The *superior pancreatico-duodenal vein* takes up blood from the right l of the pancreas and from the duodenum, and opens into the superior senteric vein near its termination. Very constantly a small vein m the pancreatico-duodenal area passes upwards in the greater entum, lying anteriorly near its free margin, and opens into the tal vein.

The *cystic vein* usually ends in the right division of the portal n.

All the veins which return the blood from the stomach, duodenum, icreas, and spleen are destitute of valves, so that the blood can urgitate in cases of portal obstruction.

Cœliac Glands.—The glands of this group are numerous. They round the cœliac axis, and extend over the aorta as low as the gin of the superior mesenteric artery. They receive their afferent sels from the gastric, pancreatic, splenic, and hepatic glands, and ir efferent vessels either join the intestinal lymphatic trunk (or nks) of the superior mesenteric glands, or open independently into cisterna chyli.

Gastric Lymphatic Glands.—These are arranged in two groups, erior and inferior, the former lying along the lesser curvature of stomach, and being almost entirely confined to the left part of this vature, and the latter below and behind the pyloric canal, forming subpyloric and retro-pyloric groups. It is noteworthy that there no glands in the neighbourhood of the fundus or along the greater vature until the pylorus is reached. They receive their afferent sels from the stomach, and their efferent vessels pass to the cœliac nds.

Pancreatic Glands.—These lie along the superior border of the icreas. They receive their afferent vessels from that organ, and their erent vessels pass to the cœliac glands.

Splenic Glands.—These are numerous, and are situated near the

hilum of the spleen in contact with the tail of the pancreas. Th receive their afferent vessels from the spleen, and their efferent vess having been joined by some of those from the left half of the grea curvature of the stomach, pass to the cœliac glands.

Hepatic Glands.—These are situated between the two layers of t lesser omentum near the porta hepatis. They receive as affer vessels those of the deep lymphatics of the liver, which accompany t branches of the portal vein, and also some of the superficial lymphat of the inferior surface of the liver, and their efferent vessels pass to t cœliac glands.

All these glands are closely interconnected through anastomoses betwe their respective afferent and efferent vessels, and so infection of one group liable to be followed by infection of other groups.

Portal Vein.—This vein is formed by the union of the super mesenteric and splenic veins, and is about 3 inches in length. commences on a level with the body of the *first* lumbar verteb a little to the right of the middle line, where it lies behind the ne of the pancreas. It ascends behind the first part of the duodenu and then between the two layers of the lesser omentum in front the opening into lesser sac, where it has anterior to it the hepa artery and bile-duct, the artery being on the left of the duct. Wh the vessel arrives at the right extremity of the porta hepatis of the liv it presents a slight enlargement, called the *portal sinus*, and then divid into two branches, right and left, the former being the larger a shorter of the two. The *right branch*, having received the cystic ve enters the right lobe of the liver. The *left branch*, having traversed t porta hepatis from right to left, and furnished branches to the quadra and caudate lobes, crosses the fissure for ligamentum teres and ent the left lobe. As it crosses this fissure it is joined in front by t ligamentum teres of the liver, which is the remains of the umbilic vein of fœtal life. Posteriorly, and slightly to the right of this poi it is connected with the fibrous cord which represents the fœtal duct venosus. The portal vein near the pylorus receives the prepyloric a left gastric veins. The distinctive character of the vessel is that behaves like an artery, its blood ultimately entering the intralobu plexuses of the liver.

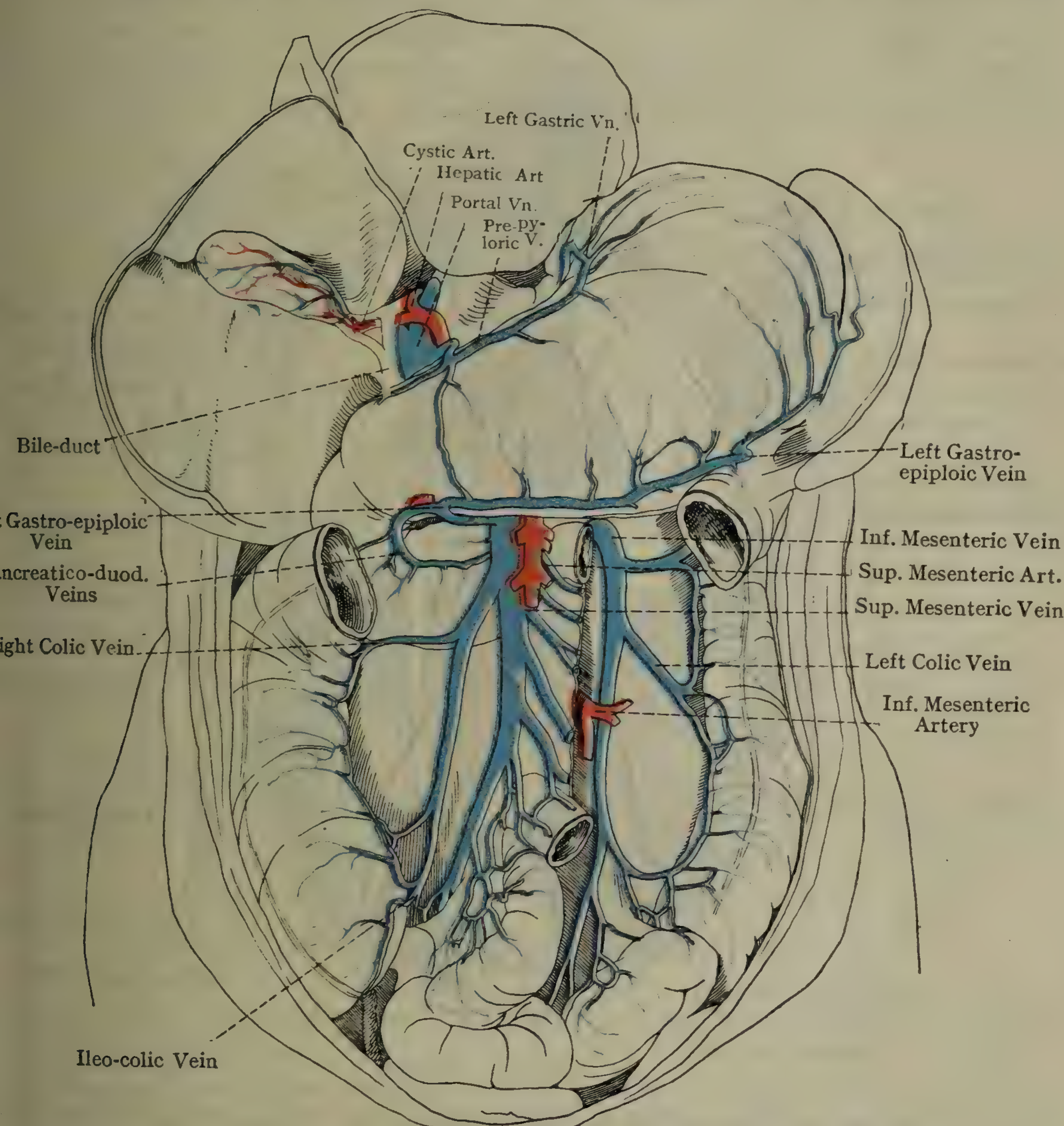
The sources from which the vein receives its blood are as follow (1) the stomach, (2) the small and large intestine, except a porti of the anal canal, (3) the pancreas, (4) the spleen, and (5) the ga bladder.

Summary of the Tributaries of the Portal Vein.—(1) The superior mesente vein, which takes up (*a*) the right gastro-epiploic, (*b*) the pancreatico-duoder veins, (*c*) the jejunal and ileal veins, (*d*) the ileo-colic, (*e*) the right colic, a (*f*) the middle colic. (2) The splenic vein, which takes up (*a*) the short gast veins, (*b*) the left gastro-epiploic, (*c*) many pancreatic veins, and (*d*) the infer mesenteric (as a rule), which in turn takes up the superior rectal, lower left col and upper left colic veins. (3) The prepyloric vein. (4) The left gastric ve (5) The cystic vein.

The portal vein and its tributaries are destitute of valves, so that blood can regurgitate in cases of portal obstruction.

Development of the Portal Vein.—The *lower portion* of the vein results from union of the two vitelline veins. The *upper portion* is developed from the half of the lower venous ring and the right half of the upper venous ring, ned by the vitelline veins around the primitive duodenum.

For a description of the **bile-duct,** see p. 779.



IG. 474.—THE PORTAL VEIN AND ITS TRIBUTARIES (AFTER SPALTEHOLZ).

Kidneys.—The kidneys are two in number, right and left, and are ated deeply at the posterior part of the abdomen, where they lie ind the peritoneum. They chiefly occupy portions of the epigastric hypochondriac regions, but also extend slightly into the umbilical lumbar regions. Relatively to the vertebral column they extend n the level of the upper border of the last thoracic vertebra to about centre of the body of the third lumbar, the right kidney being

usually somewhat lower than the left. The long axis of each o
is directed downwards and slightly outwards, so that their upper
are rather nearer the middle line than the lower. The superior l
of the right kidney is usually the lower border of the eleventh rib, w
that of the left is usually the upper border of the eleventh rib.
feriorly the organs approach the iliac crests, from which they are dis
about 1 to 2 inches, the right being the nearer of the two. Each kid

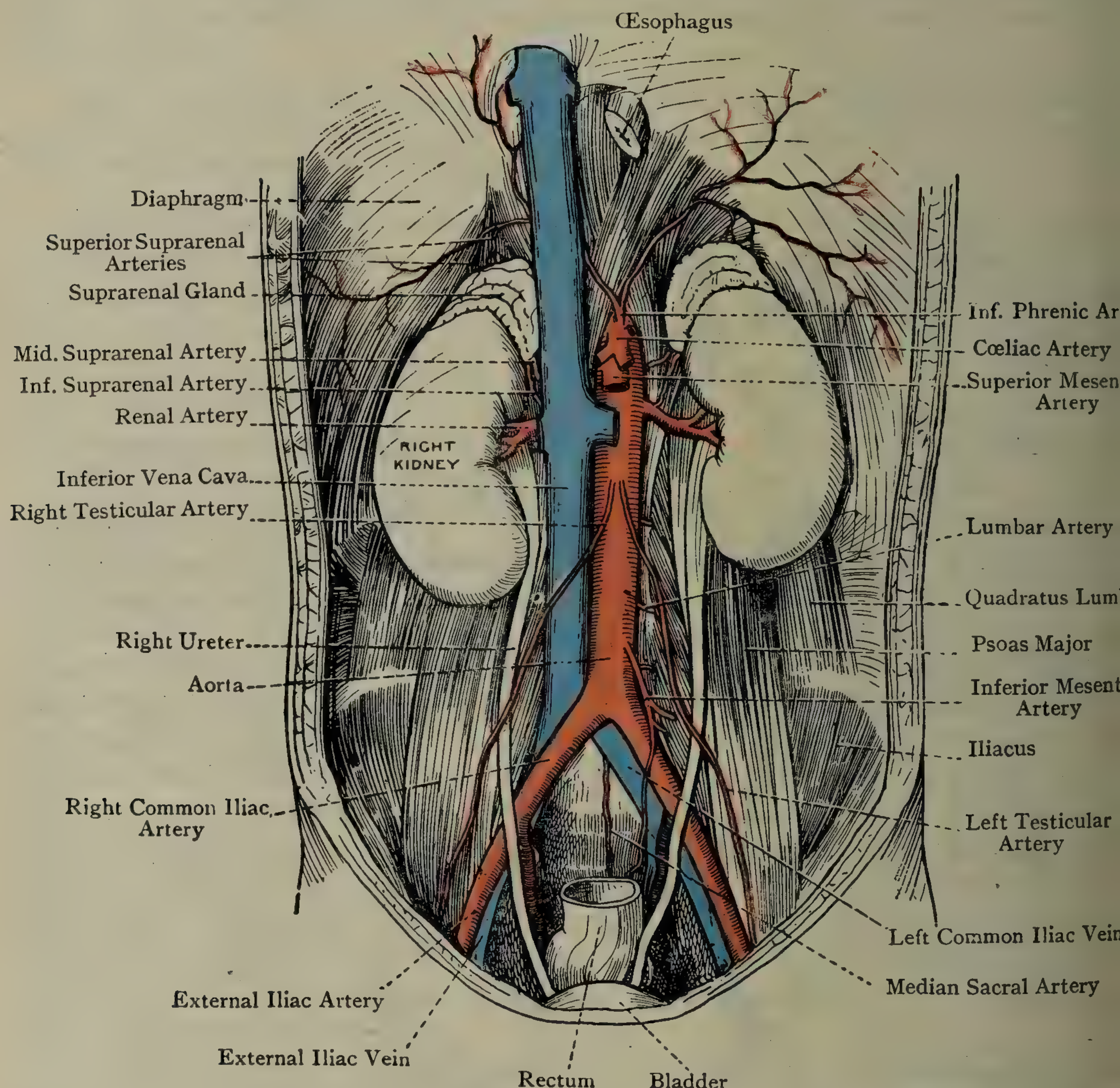


FIG. 475.—DISSECTION OF THE POSTERIOR ABDOMINAL WALL.

is surrounded by a quantity of areolar and adipose tissues, constitut
the paranephric fat, which is in turn enclosed by a fibrous tissue co
ing known as the perirenal capsule (Gerota), and which, along with
adjacent viscera, anchors the organ. The capsule is thicker beh
than in front, and encloses the suprarenal gland as well as the kidn
The suprarenal gland is attached to the under surface of the diaphra
by a strand of fibrous tissue forming a suspensory ligament. Ther
no communication or connection between the glands of either s

ie length of a kidney is about 4 inches, the breadth about $2\frac{1}{2}$ inches, d the thickness about $1\frac{1}{4}$ inches. The right kidney is usually shorter d broader than the left. The weight of the organ is about $5\frac{1}{4}$ ounces. form the kidney is bean-shaped. It presents two smooth surfaces, o extremities, and two borders. The anterior surface looks out- irds as well as forwards, and presents important visceral impressions, iilst the posterior surface looks inwards as well as backwards, and esents muscular impressions. The extremities are enlarged and ınd, the superior more so than the inferior, the latter often assuming omewhat pointed appearance. The lateral border has an inclination ckwards, and is convex and free. The medial border has an inclina-

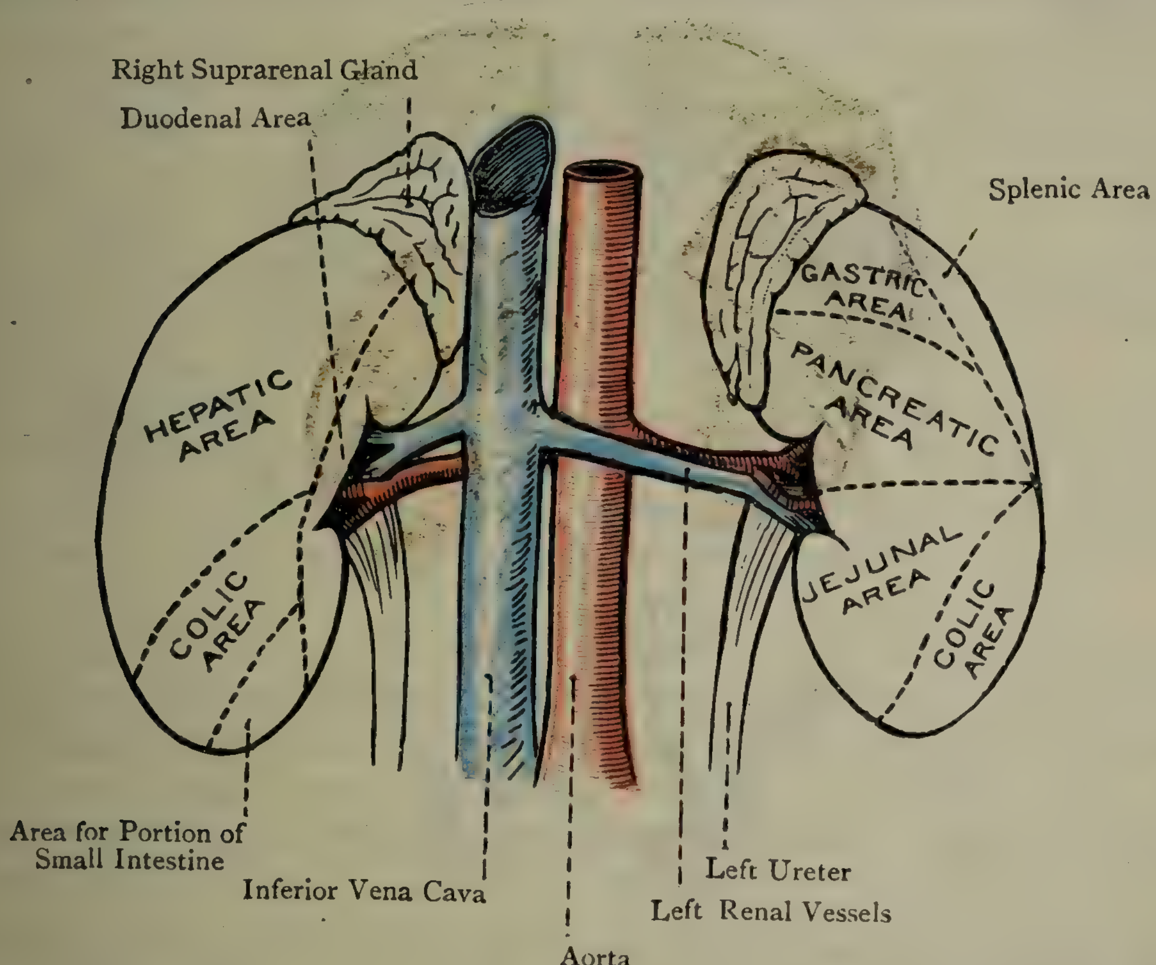


FIG. 476.—THE VISCERAL AREAS OF THE KIDNEYS.
In this case the right renal vein was higher than usual.

n forwards, is concave, and is connected with the renal vessels and pelvis of the kidney.

Relations—*Anterior Surface of the Right Kidney.*—This surface is erlapped by the right suprarenal gland for a very short distance at upper and inner part. It presents three visceral areas—hepatic, odenal, and colic. The *hepatic area* lies somewhat obliquely, and cupies about the upper two-thirds, being in contact with the renal pression on the under surface of the right lobe of the liver. It is vered by peritoneum. The *duodenal area* corresponds with an elongated rrow strip lying close to the hilum, and reaching a little above and low it. It is in contact with the posterior wall of the second part of duodenum, both being destitute of peritoneum. The *colic area* s below the hepatic, and, like it, is oblique. It is in contact with the

upper end of the ascending colon and the right colic flexure witho the intervention of peritoneum. Between the lower part of the du denal and the colic impressions—that is, at the lower and inner pa of the anterior surface—there is often a small area covered by pe toneum which is in contact with a portion of the small intestine.

Anterior Surface of the Left Kidney.—This surface is overlapp by the left suprarenal gland for a somewhat greater distance at its up and inner part than obtains on the right side. It presents five visce areas—splenic, gastric, pancreatic, colic, and jejunal. The *sple area* is situated at the upper and outer part close to the lateral bord

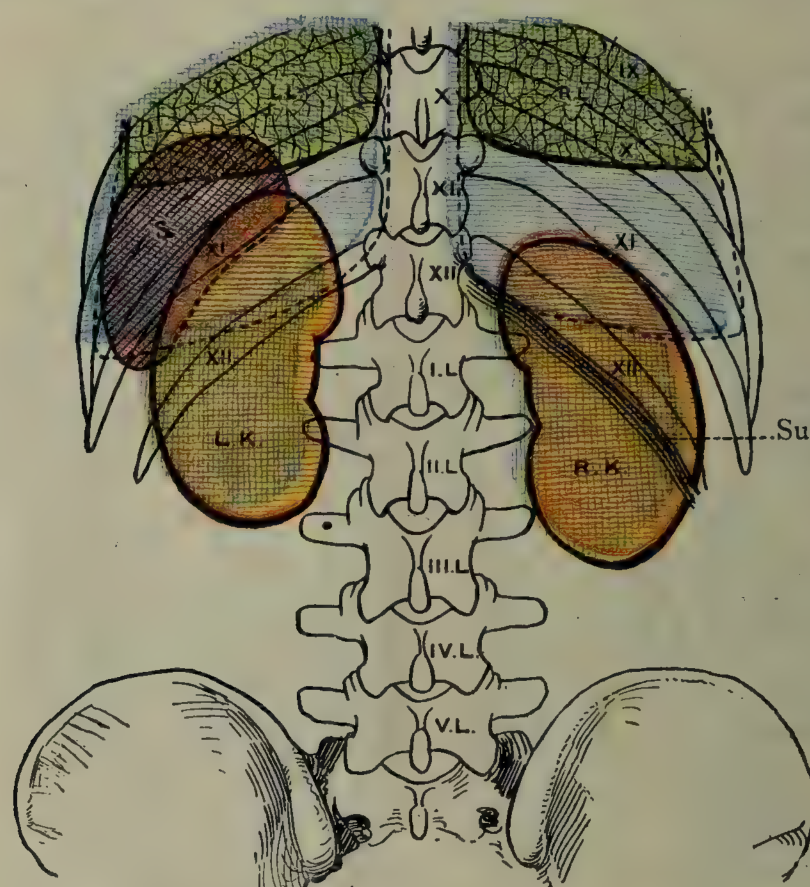


FIG. 477.—DIAGRAM SHOWING THE RELATIONS OF THE KIDNEYS FROM BEHIN

R.L. Right Lung	XI. Eleventh Rib
L L. Left Lung	XII. Twelfth Rib
S. Spleen	I.L. First Lumbar Vertebra
R.K. Right Kidney	II.L. Second Lumbar Vertebra
L.K. Left Kidney	III.L. Third Lumbar Vertebra
IX. Ninth Rib	IV.L. Fourth Lumbar Vertebra
X. Tenth Rib	V.L. Fifth Lumbar Vertebra

and is in contact with the renal surface of the spleen, the peritoneu of the greater sac intervening. The *gastric area*, somewhat triangul lies at the upper end between the splenic and suprarenal areas, and abo the pancreatic area. It is in contact with the postero-inferior surface the stomach, with the intervention of the peritoneum of the small sa The *pancreatic area* lies transversely below the gastric area, and exten as low as about the centre of the hilum. It is in relation with t posterior surface of the body of the pancreas and the splenic vesse without peritoneum. The *colic area* is situated at the lower and ou part, and is in contact with the left colic flexure and the commencem of the descending colon, without peritoneum. At the lower and inn

rt there is a small area covered by peritoneum, which is related to a rt of the *jejunum*.

Posterior Surface.—This surface is readily recognized by observing at the pelvis of the kidney is posterior at the hilum. The inner rtion of it rests upon (*a*) the psoas major and its sheath, and (*b*) the ıs of the diaphragm. The outer portion rests, from above down- ırds, upon (*a*) the twelfth rib (in the case of the left kidney the venth rib also), (*b*) the diaphragm, and (*c*) the quadratus lumborum, vered by the anterior layer of the lumbar fascia. An important rgical relation of the upper part of this division of the posterior rface is that the pleura, in descending between the diaphragm and e twelfth rib, lies behind the kidney. Three nerves pass downwards d outwards behind the organ—namely, the subcostal, ilio-hypogastric, d ilio-inguinal. Kidneys hardened *in situ* usually show impressions oduced by the last rib and the transverse processes of the upper nbar vertebræ.

The *superior extremity* is capped by the suprarenal gland, which also tends for a little over the anterior surface and adjacent portion of e medial border.

The *lateral border*, which is convex, rests on the posterior aponeurosis the transversus abdominis. The lateral border of the right kidney, er about its upper two-thirds, is in contact with the liver, whilst the eral border of the left kidney at its upper end is in contact with the leen.

Near this border a small collection of fat is often found which cupies the interval between the kidney and spleen on the left side, d between the kidney and liver on the right side; this fat lies outside e fibrous capsule, and has been named the paranephric body to tinguish it from the paranephric fat which lies within the capsule.

The *medial border* of the right kidney lies very near the inferior na cava, whilst that of the left is situated fully 1 inch from the rta. This border is concave, and presents a longitudinal fissure, lled the *hilum*, which extends over about its middle third. It esents two somewhat thick lips, anterior and posterior, and it leads a cavity within the organ, called the *renal sinus*. It transmits e following structures in order from before backwards: the branches the renal vein, the branches of the renal artery, with branches of the ıal sympathetic plexus and lymphatics, and the pelvis of the kidney.

The side to which a kidney belongs may be ascertained if the uctures at the hilum are *in situ* by noting that the hilum looks wards, that the ureter is posterior and inclines downwards. If, on e other hand, the structures at the hilum have been removed, the le to which a kidney belongs can usually be easily determined by ting that the anterior lip of the hilum shows two indentations rresponding to the two prepelvic branches of the renal artery, ıereas the posterior lip only shows one indentation, which, more- er, points downwards, corresponding to the single retro-pelvic anch of the artery.

Varieties—Form.—The kidneys may be much elongated, or somewhat rou or triangular. The lobulated condition (Fig. 478), which is characteristic the kidney in early life, may persist in the adult.

Size.—One kidney may be diminished in size, in which case there may b proportionate increase in the other organ.

Position.—It is very rare to find the kidneys higher than usual, but one both not infrequently extend into the iliac fossa, or over the pelvic brim.

Number—*Diminution.*—One kidney (usually the left) may be entirely s pressed, in which case the solitary kidney usually occupies its normal posit and may, or may not, be of large s

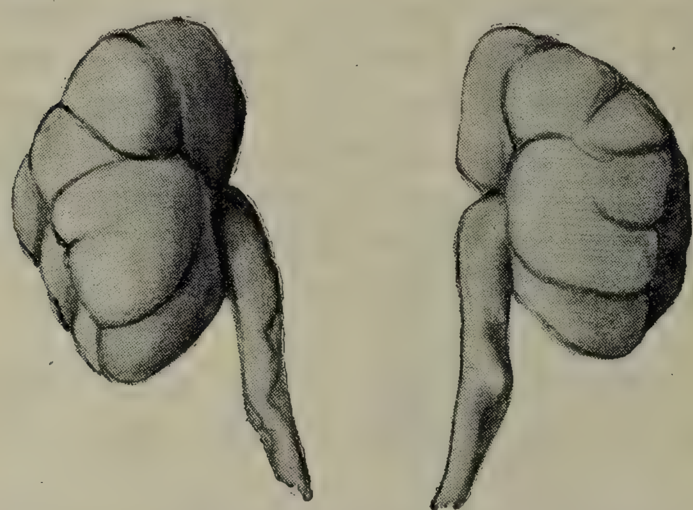


FIG. 478.—KIDNEY OF A CHILD SHORTLY BEFORE BIRTH.

Increase.—The number may be creased to three, the additional or being lateral or median in position.

Horseshoe Kidney.—This condit is brought about by the fusion of lower parts of the organ, the c necting band of renal substance tending across the vertebral colum

Preternatural Mobility.—The kid is usually anchored in its normal p tion by its capsule and the adjac viscera, but it is sometimes mova which may be due to one of causes: (1) the capsule may be v loose, giving rise to the condit known as **movable kidney;** or (2) organ may be attached to the poste abdominal wall by a peritoneal fold, called the *meso-nephron*, in which case condition known as **floating kidney** occurs, this being said to be more frequ on the right side.

Movable kidney is more frequent in the female than in the male, a peculiar which has been attributed to the fact that in the female the renal fossæ cylindrical, whereas in the male they are pear-shaped, with the narrow end bel (Southam).

For the structure and development of the kidney, see pp. 900 a 910.

Ureter.—The ureter is the excretory duct of the kidney, and conve the urine to the bladder. It is a cylindrical, thick-walled tube, li a goose-quill, its average length being about 12 inches, and its diame about $\frac{1}{5}$ inch. The ureter commences towards the lower end of t kidney, where it is the continuation of the pelvis, and terminates in t bladder. The pelvis is funnel-shaped, and flattened from before bac wards. It lies partly in the renal sinus, where it receives the calic and partly outside the hilum, where it lies behind the other transmitt structures. Its direction is downwards and inwards, and, havi become narrow, it passes into the ureter towards the lower end of t kidney.

The ureter passes downwards and inwards behind the peritoneu in contact with the posterior abdominal wall. It rests at first up the psoas major and its sheath, being here crossed superficially by t testicular (or ovarian) vessels, which are taking a course downwar and outwards, and deeply by the genito-femoral nerve, which is taki a similar course. In this part of its course the right duct has the inferi vena cava near it on its inner side, whilst the left duct has the aor

its inner side, but at some little distance. On the right side the ɔer end of the ureter lies behind the second part of the duodenum; the left side the ureter is crossed by the upper and lower left colic sels. The ureter next crosses the terminal part of the common iliac ery (or the commencement of the external iliac), after which it ers the pelvic cavity, the right ureter being crossed by the lower t of the root of the mesentery proper, and the left by a portion of pelvic meso-colon, its position here corresponding with that of the ersigmoid recess. In the pelvis the ureter first passes downwards, kwards, and slightly outwards, lying in front of the internal iliac sels and the sacro-iliac joint, following the curvature of the pelvic ll in this region. It then turns forwards, downwards, and inwards, ıg beneath the peritoneum, and crossing medially the obturator sels and nerve, and the umbilical artery. It subsequently passes ards to the bladder, being crossed medially by the vas deferens. ving arrived at the postero-lateral or ureteric angle of the bladder, it nmences to pierce the vesical wall anterior to the upper free end of the ninal vesicle, being here about 2 inches distant from its fellow, and ɔut $1\frac{1}{2}$ inches from the base of the prostate gland. It now pursues an ique course through the wall of the bladder, lying in it for about nch, and finally opens into the interior by a very small slit-like erture placed obliquely at one angle of the base of the trigonum icæ, where it is distant from its fellow and from the urethral orifice ɔut $1\frac{1}{4}$ inches. In the female the ureter, in its pelvic course, passes ng the side of the cervix uteri and upper part of the vagina, being tant $\frac{3}{8}$ inch from the cervix, and being here crossed antero-laterally the uterine artery.

Varieties.—(1) The pelvis may be absent, its place being taken by two, very rarely three, tubes. (2) **Double Ureter.**—The foregoing tubes may ıain separate for some distance beyond the hilum, or even as low as the bladder, s giving rise to a double or a triple ureter. (3) **Dilated Ureter.**—This con- on is liable to result in consequence of urethral stricture, enlarged prostate, l vesical calculus.

For the structure and development of the ureter, see pp. 907 l 910.

Suprarenal Glands (Suprarenal Capsules).—The suprarenal glands lrenals) are two in number, right and left, and are situated in the gastric region. Each is compressed from before backwards, broad m side to side, and set upon the superior extremity of the corre- ɔnding kidney, to which it is bound by connective tissue. Each ɔsule encroaches upon the adjacent parts of the anterior surface d medial border of the kidney, the left being mainly situated upon the dial border. The dimensions of the organ are so variable that they ı only be stated approximately as follows: the length is about $1\frac{1}{4}$ hes, and the breadth rather less than 2 inches. The weight, on an erage, is about 4 grammes, and they are almost as large at birth as later years.

The **right suprarenal gland** is rather smaller than the left, and is

quadrangular. It is pressed between the diaphragm and the poste surface of the right lobe of the liver, and its surfaces are anterior posterior, the former having an inclination outwards and the la inwards. The *anterior surface*, close to the inner border, is in con with the inferior vena cava, and elsewhere it is related to the poste surface of the right lobe of the liver. At its upper and inner part t is a small fissure, called the *hilum*, through which the single right su

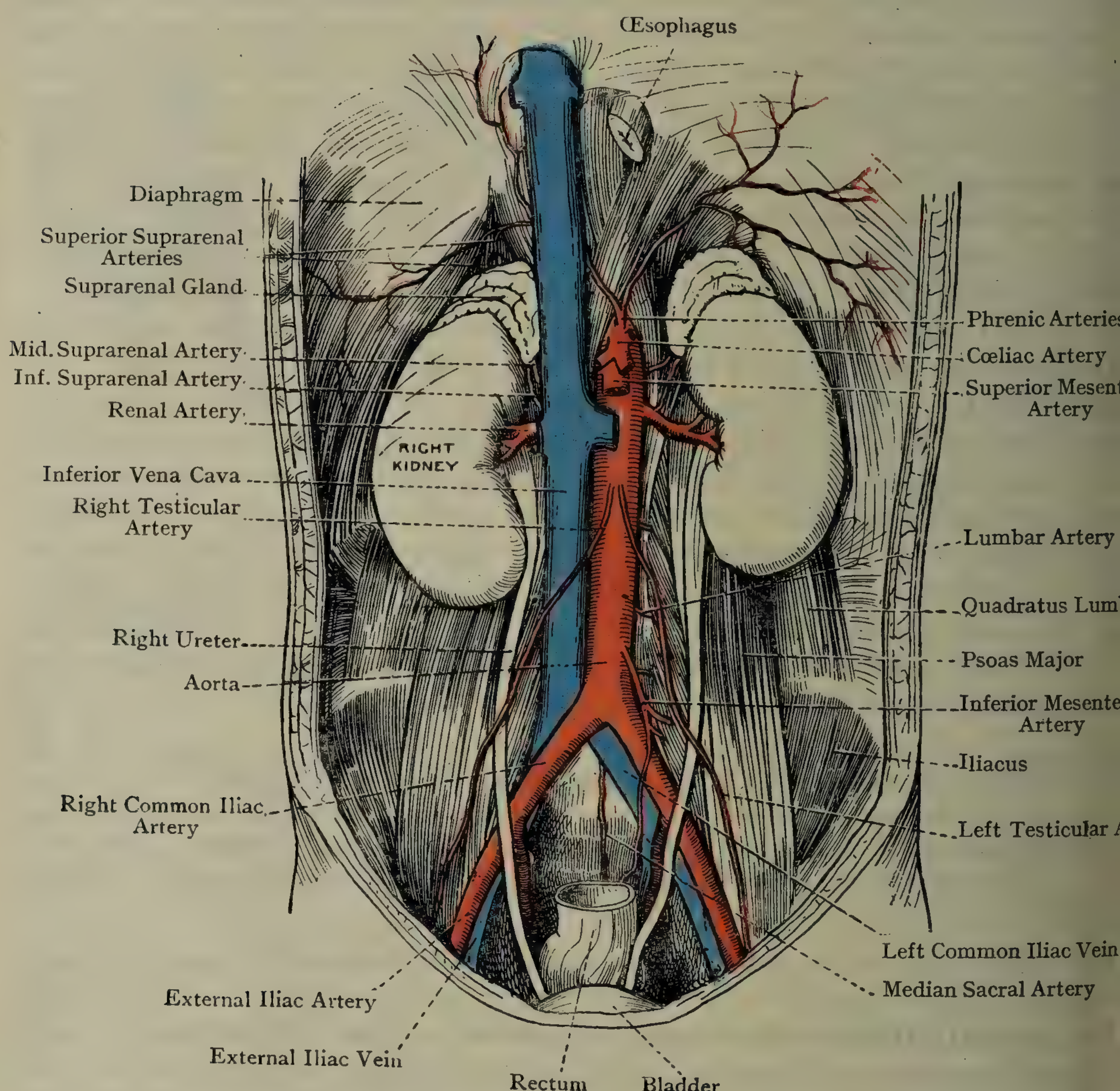


FIG. 479.—DISSECTION OF THE POSTERIOR ABDOMINAL WALL.

renal vein emerges. The peritoneum gives a partial covering to t surface at its lower and outer part. The *posterior surface* is in conta with the diaphragm and the upper part of the anterior surface of t right kidney. The right cœliac ganglion lies on the inner side of t right gland.

The **left suprarenal gland** is somewhat semilunar. The *anter surface* is related above to the postero-inferior surface of the stoma with the intervention of the lesser sac, which furnishes it with a pe

oneal covering. Below this it is related to the posterior surface of the ody of the pancreas and the splenic vessels, without peritoneum. he hilum, through which the left suprarenal vein emerges, is situated t the lower and inner part of this surface. The *posterior surface* at its pper part is in contact with the left crus of the diaphragm, and below rests upon the upper and inner part of the front of the left kidney, s well as upon its medial border. Its upper lateral angle is usually in ontact with the apex of the spleen.

For the structure and development of the suprarenal gland, see . 897.

Abdominal Aorta.—The abdominal aorta commences at the aortic pening of the diaphragm on a level with the lower border of the body of he twelfth thoracic vertebra, where it lies in the middle line, and it sually terminates opposite the centre of the body of the fourth lumbar ertebra, a finger's breadth to the left of the middle line, by dividing into he right and left common iliac arteries. The position of the bifurcation ay be indicated in one of two ways as follows: (1) by taking a point inch below and to the left of the umbilicus; or (2) by taking a point the line which connects the highest parts of the iliac crests a finger's readth to the left of where it intersects the linea alba. The bifurcaion may take place a little lower down or higher up than the normal evel. The length of the vessel is about 5 inches. It occupies the pigastric and umbilical regions, where it lies very deeply behind the eritoneum, and its direction is downwards with a slight inclination to he left.

Relations—*Anterior.*—The direct anterior relations, from above ownwards, are as follows: the origins of the phrenic arteries, the celiac artery, cœliac glands, and cœliac plexus, the ascending layer f the transverse meso-colon, the pancreas and splenic vein, the root f the superior mesenteric artery, the third part of the duodenum nd left renal vein, the origins of the testicular (or ovarian) arteries, he aortic plexus, the pre-aortic group of lumbar glands, the peritoneum f the greater sac, and the origin of the inferior mesenteric artery. he more remote anterior relations are the lesser omentum, stomach, ransverse colon with its meso-colon, coils of the small intestine, root f the mesentery proper, and greater omentum. *Posterior.*—The disc etween the twelfth thoracic and first lumbar vertebræ, the bodies and iscs of the upper four lumbar vertebræ, and the anterior longitudinal igament, the left lumbar veins, and the origins of the lumbar and nedial sacral arteries. *Right.*—The right crus of the diaphragm, vith the cisterna chyli and vena azygos lying deeply between the vessel nd the right crus, the cisterna chyli being nearest the aorta, and lightly covered by it; and the inferior vena cava. *Left.*—The left rus of the diaphragm, the left cœliac ganglion, the terminal portion f the third part of the duodenum, and the left sympathetic gangliated runk.

Branches.—These are nine in number, and are arranged in two roups, *visceral* and *parietal*, four of them being single and five arranged

in pairs. The four single branches are the cœliac artery, super mesenteric, inferior mesenteric, and median sacral. The five pa are the inferior phrenic, middle, suprarenal, renal, testicular (ovari

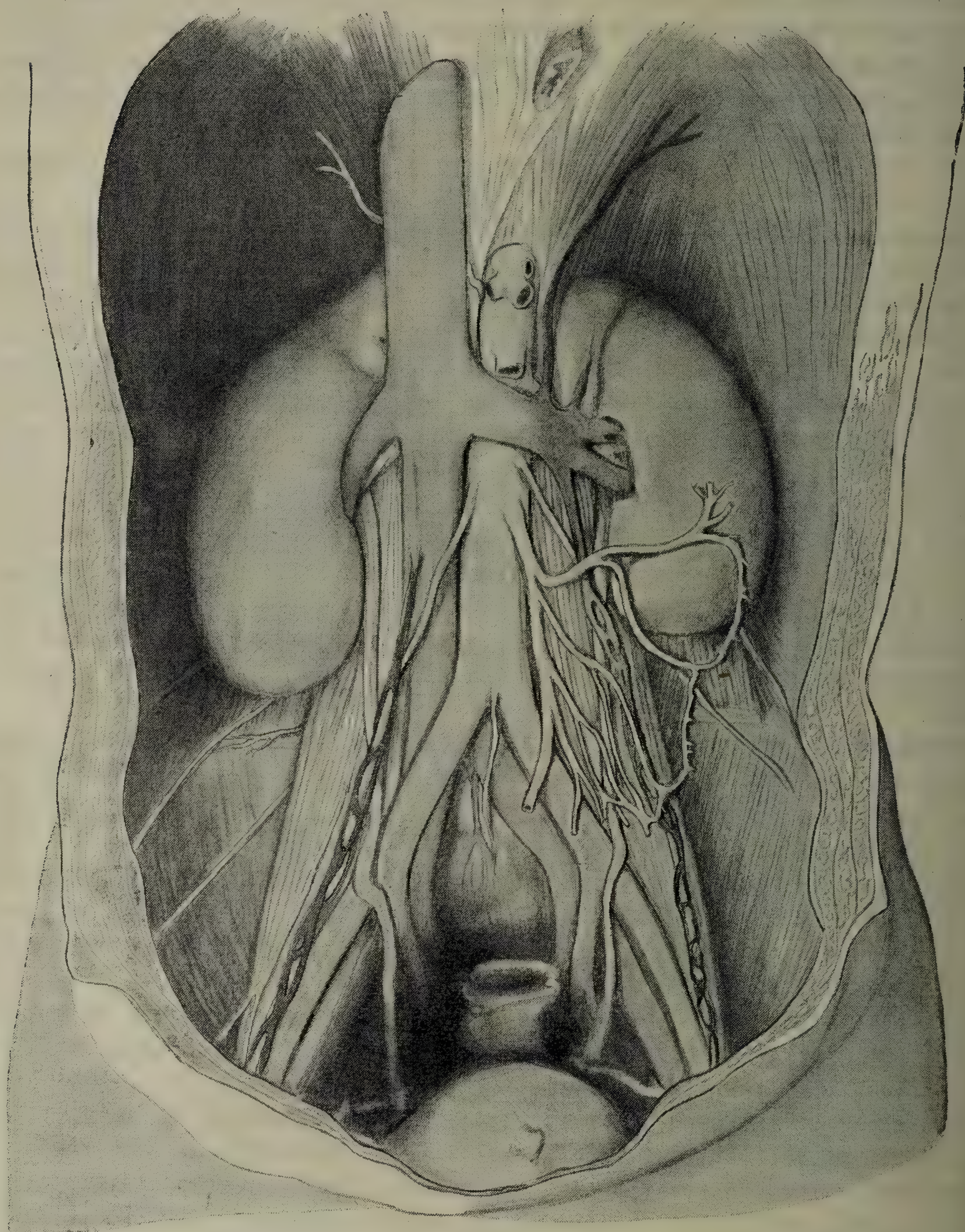


FIG. 480.—DISSECTION OF STRUCTURES ON POSTERIOR WALL.
Inferior mesenteric artery is laid down (with some of its branches) in positio

in the female), and the lumbar. Excluding the lumbar arteries, th order of origin of the branches is as follows: (1) phrenic, (2) cœlia artery, (3) superior mesenteric and (4) middle suprarenal, both o the same level, (5) renal, (6) testicular (or ovarian), (7) inferior meser

c, and (8) median sacral. In what follows, the letter P after an ery signifies parietal, and V visceral.

The **phrenic arteries** (P) are two in number, right and left. They se, either separately or by a common trunk, from the front of the ta, as soon as the vessel has passed through the aortic opening of diaphragm. They at once diverge, each passing outwards and vards over the crus of the diaphragm, the right vessel lying behind inferior vena cava, and the left behind the œsophagus. Each ends dividing into two branches, medial and lateral. The *medial branch* sses forwards and inwards in a curved manner in front of the central don, and anastomoses with its fellow of the opposite side, and the sculo-phrenic of the internal mammary. The *lateral branch* passes wards, and anastomoses with the musculo-phrenic and the lower ercostal arteries. Each phrenic artery furnishes a *superior supra-al branch* (or branches) to the suprarenal gland, the right vessel o giving off a few branches to the inferior vena cava, whilst the supplies a few branches to the œsophagus.

The *right* **phrenic vein** opens into the inferior vena cava, and the terminates in the left suprarenal vein, left renal vein, or inferior na cava.

The **cœliac artery** (V) and **superior mesenteric artery** (V) will be ind described on pp. 811 and 796.

The **middle suprarenal arteries** (V) are of small size, and are two in mber, right and left, each arising from the side of the aorta on a el with the origin of the superior mesenteric artery. The vessel sses outwards and upwards over the crus of the diaphragm to the prarenal gland, in which it anastomoses with the superior suprarenal the phrenic and the inferior suprarenal of the renal.

The *right* **suprarenal vein** opens into the inferior vena cava, and the *t* into the left renal vein.

The suprarenal veins originally open mainly into the subcardinal system. e right suprarenal vein thus opens into the upper segment of the inferior na cava (above the right renal vein). The left suprarenal vein, as the remnant the left subcardinal vein, joins the left renal vein.

The **renal arteries** (V) are remarkable for their large size, and are o in number, right and left. They arise from the side of the aorta out $\frac{1}{2}$ inch below the superior mesenteric on a level with the body the first lumbar vertebra, the right artery being usually a little ver than the left. They form right angles with the aorta, and cross e crura of the diaphragm on their way to the hila of the kidneys, e right vessel passing behind the inferior vena cava, second part of e duodenum, and head of the pancreas, whilst the left passes behind e body of the pancreas. Each vessel has its own vein in front of it, d the aortico-renal ganglion lies over its root. On approaching the nal hilum each vessel divides into three or four branches, one of which, iown as the retro-pelvic branch, usually passes behind the pelvis of e kidney, whilst the others lie between the renal vein in front and the

pelvis behind. For the subsequent distribution of the branches the kidney, see p. 904.

Before breaking up into its proper renal branches the vessel gi off an *inferior suprarenal artery* to the suprarenal gland, *paraneph branches* to the capsule, and *ureteric* to the upper part of the ureter

Varieties.—(1) Very often there is an *accessory renal artery* present, ari close to the main vessel, and usually above it. (2) The renal artery may di into its renal branches close to its origin. (3) There may be an *aberrant r artery*, which may arise from the phrenic, testicular (or ovarian), inferior me

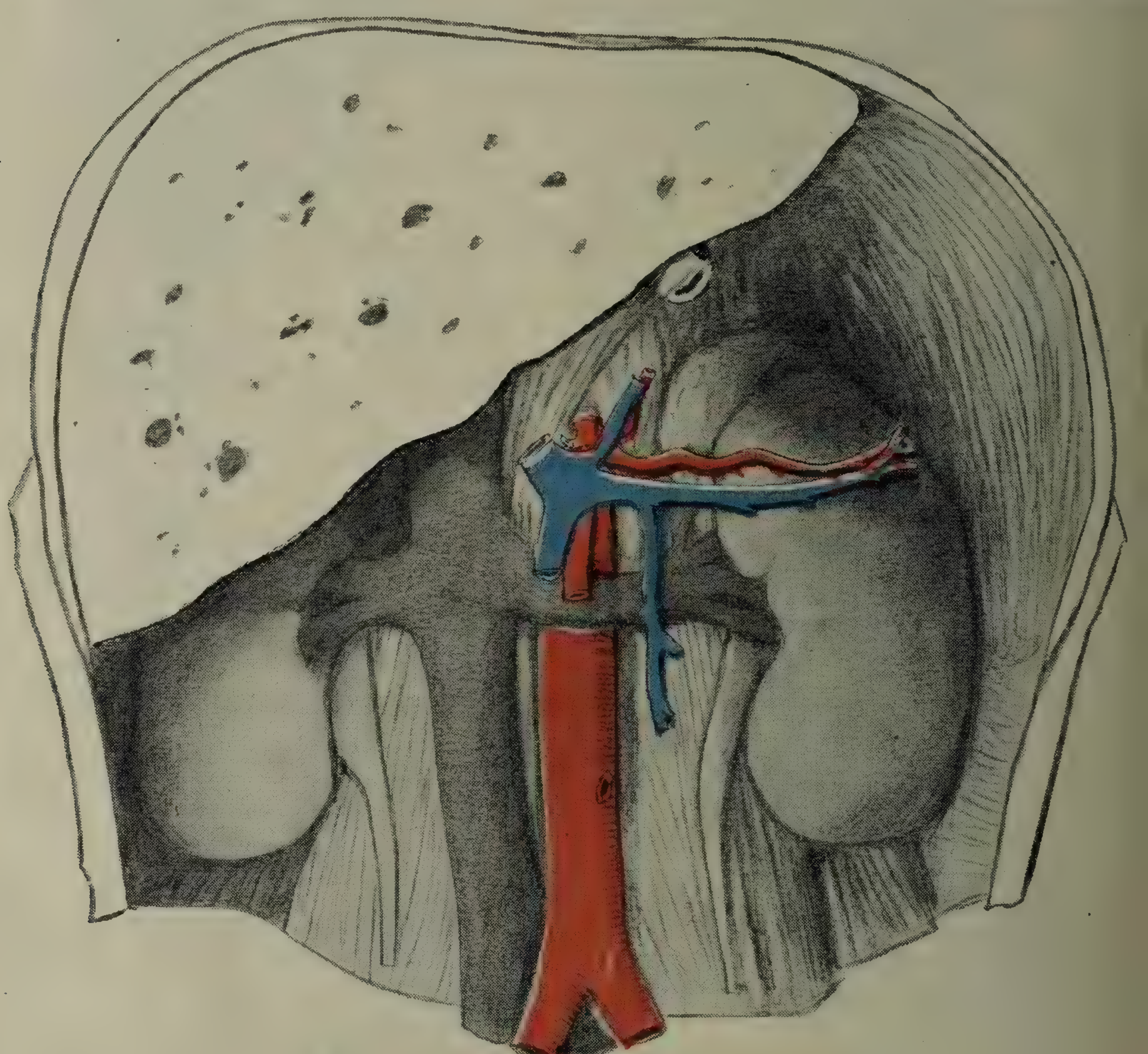


FIG. 481.—TO SHOW THE ARRANGEMENT OF VEINS JOINING TO FORM THE PORT VEIN, AND THEIR RELATIONS TO THE AORTA.

teric, common or external iliac, or median sacral. An aberrant renal arte when present, is usually confined to one side, more frequently the right; artery more often passes behind the ureter than in front (Hutchinson). (4) cases of variations, or even in the normal condition, one or more of the re branches may fail to enter the hilum, and may pierce the kidney on its anter surface, or near the upper or lower end.

The **renal veins,** like the arteries, are of large size. Each lies front of its artery, and receives tributaries from the paranephric f and the upper part of the ureter. The vessels are tributaries of t inferior vena cava, which they join almost at a right angle, the le

ittle higher than the right. The left vein crosses in front of the ta, taking up in its course the left suprarenal and left testicular ovarian) veins. In some cases there is a single semilunar valve at lower part of the opening of each renal vein into the inferior vena 'a.

The renal veins originally join the periganglionic veins. Subsequently the it renal vein opens into the junction of the upper and lower segments of the rior vena cava. When the left cardinal vein becomes obliterated, in great t the left renal vein becomes continuous with the primitive inferior vena cava. mesial portion of the left renal vein is developed from the pre-aortic venous xus. For details see Chapter XIII.

The **testicular arteries (spermatic arteries)** (V) are two in number, ht and left, and they arise from the front of the aorta about 1 inch ow the renal arteries. If they arise separately they are close to each ier, but they sometimes spring by a common trunk. They are long, nder, somewhat tortuous vessels, which at once diverge, each passing iquely downwards and outwards behind the peritoneum. In this irse the vessel rests upon the aorta for a short distance, and then on the psoas major and its sheath, where it crosses the ureter. e right artery passes in front of the inferior vena cava and behind terminal part of the ileum, whilst the left passes behind the left ic vessels and the iliac part of descending colon. Subsequently the ery, on its way to the deep inguinal ring, lies upon the terminal part the external iliac. At the deep ring it approaches the vas deferens form, with other structures, the spermatic cord. The vessel then sses through the deep inguinal ring, along the inguinal canal, and ough the superficial inguinal ring into the scrotum, where it divides o glandular and epididymal branches. In the abdomen the testicular ery furnishes ureteric branches to the ureter, and in the scrotum gives off cremasteric branches to the coverings of the spermatic cord, ich anastomose with the cremasteric branch of the inferior epigastric. ıring fœtal life the vessel is very short, and takes a transverse course the testis, which is then lying near the kidney. As the testis, how- er, descends into the scrotum the vessel gradually becomes much ngated.

Varieties.—(1) One or both testicular arteries may be absent, in which cases testis is supplied chiefly by the artery to the vas deferens. (2) A testicular ery may arise from a renal artery.

The **testicular veins (spermatic veins)** spring from the pampiniform exus of the spermatic cord at the deep inguinal ring, and are at first o in number on each side, which lie one on either side of the corre- onding artery. They subsequently unite to form a single vessel, iich on the *right* side opens at an acute angle into the inferior vena va, and on the *left* at a right angle into the left renal vein. There is ually a valve at the point of termination of each vein, though this ay be absent. In the left testicular vein, where it joins the left renal in, the valve directs the current of blood entering by the testicular in in the direction of the inferior vena cava. It also prevents the

blood in the left renal vein from entering the testicular vein by direc the current over the mouth of the latter vessel. The *left* testic vein is rather longer than the right.

The **testicular** (or **ovarian**) **veins** drain the embryonic gonad into the cardinal venous system. Part of the abdominal vena cava (Chapter XII) is veloped from the subcardinal vein, so that the *right* testicular vein opens into On the left side the subcardinal system drains by pre-aortic anastomosis the right subcardinal (inferior vena cava), the anastomosis forming part of left renal vein; hence the *left* testicular vein or ovarian vein opens into the renal vein.

The **ovarian arteries** (V) in the female take the place of the testic arteries in the male, and their course and relations in the abdor correspond with those of the testiculars. The ovarian arteries however, shorter than the testiculars, and they do not pass out thro the inguinal canal, but enter the pelvis by crossing the commencem of the external iliac artery. In the pelvis each vessel becomes v tortuous, and passes between the two layers of the broad ligamen the uterus to be distributed to the ovary. In the abdomen the art supplies branches to the ureter, and in the pelvis it furnishes the foll ing offsets: *tubal* to the uterine tube; a *uterine branch* to the side of uterus; and a *ligamentous branch* to the ligamentum teres of the ute which it accompanies as far as the inguinal canal. The ovarian arter like the testicular, are very short and transverse in direction dur fœtal life, when the ovary occupies a position similar to that of testis. They, however, gradually become elongated as the ov descends to its future abode in the pelvis.

The **ovarian veins** spring from the ovarian or pampiniform ple between the two layers of the broad ligament close to the ovary. A emerging therefrom their subsequent course and mode of terminat resemble those of the testicular veins.

For the **inferior mesenteric artery** (V) and **vein,** see p. 801; the **median sacral artery** (P) and **vein,** see p. 946; and for the **lum arteries** (P) and **veins,** see p. 847.

Inferior Vena Cava.—The inferior vena cava commences oppos the upper border of the body of the fifth lumbar vertebra a little the right of the middle line, where it is formed by the union of right and left common iliac veins, and it terminates at the poste inferior angle of the right atrium of the heart. It ascends along right side of the aorta, resting upon the anterior and right aspects the lumbar vertebræ as high as the level of the second. Beyond t point it diverges from the aorta, and is supported by the right c of the diaphragm. It then occupies the fossa for vena cava on posterior surface of the right lobe of the liver. On leaving this foss passes through the caval opening in the central tendon of the diaphrag and almost immediately afterwards opens into the postero-infer angle of the right atrium of the heart. As the vein passes through caval opening, its walls are connected with the margins of that openi and so the patency of the vessel is maintained.

Relations—*Anterior.*—From below upwards, the right common c artery, lower part of the root of the mesentery proper, right ticular (or ovarian) vessels, third part of the duodenum, head of pancreas, origin of the portal vein, first part of the duodenum, ening into lesser sac, and posterior surface of the liver. *Posterior.*—e bodies, discs, and anterior longitudinal ligament of the lower three nbar vertebræ, the corresponding right lumbar vessels, inner border

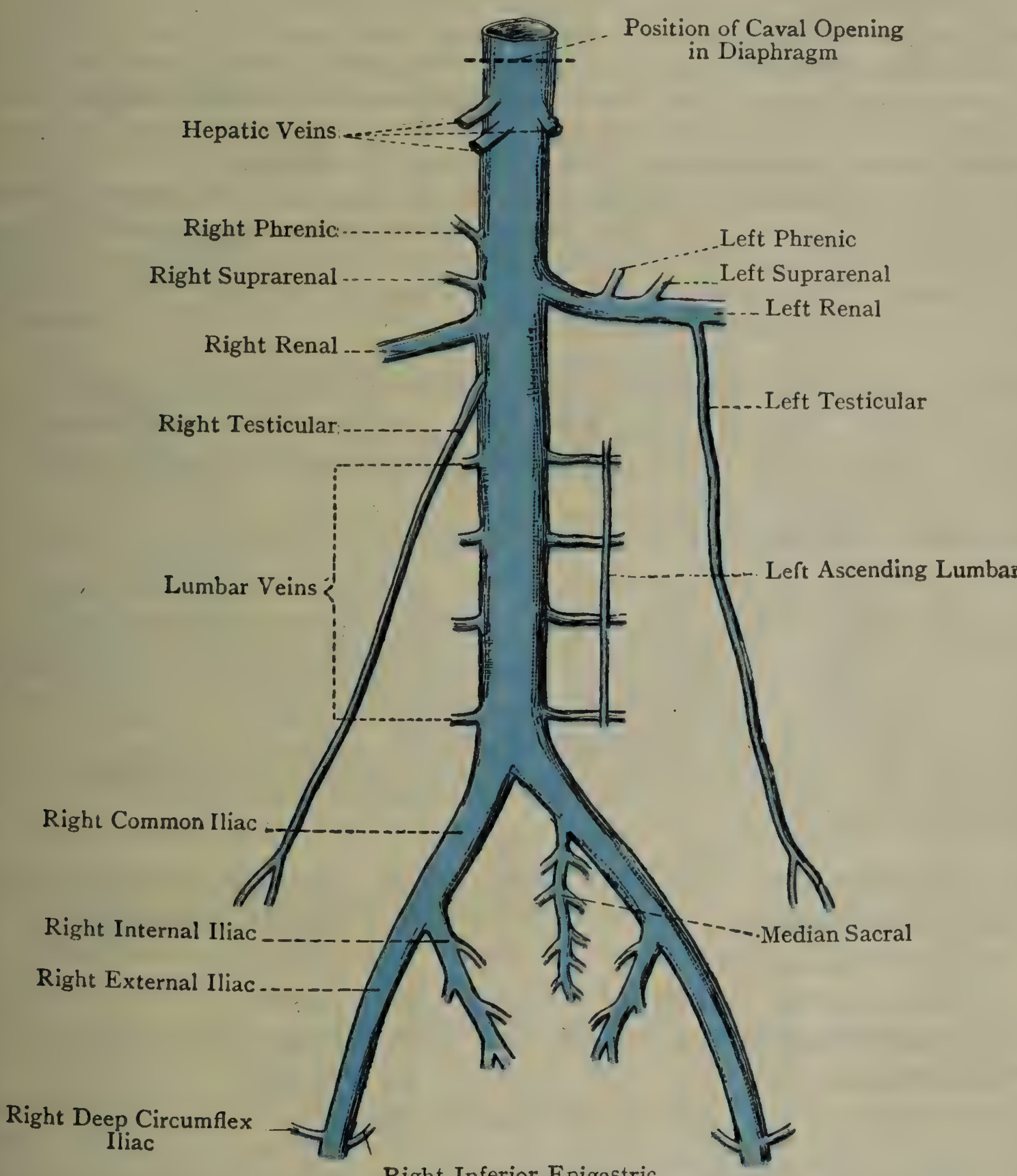


FIG. 482.—SCHEME OF THE INFERIOR VENA CAVA AND ITS TRIBUTARIES.

the right psoas major and its sheath, right sympathetic gangliated ınk, right renal artery, right cœliac ganglion, right crus of the dia-ragm, right suprarenal gland, and right phrenic artery. *Right.*—om below upwards, the right ureter and the medial border of the ht kidney. *Left.*—From below upwards, the aorta and the right ıs of the diaphragm.

Tributaries.—These are as follows: the right and left common c veins, right and left lumbar veins, the right testicular (or ovarian)

vein, the right and left renal veins, the right suprarenal vein, the rig phrenic vein (and sometimes the left), and the hepatic veins at t fossa for vena cava of the liver.

Chief Varieties.—(1) The vessel may be found on the left side of the ao in its lower part, in which cases it subsequently crosses that vessel to take its usual position on its right side. This may be due to a transposition of visce or to a permanent patency of the lower part of the left cardinal vein of fœtal li (2) The two common iliac veins, instead of uniting at the level of the fifth lumb vertebra, may run up on either side of the aorta until they have received th renal tributaries, after which the left crosses the aorta to join the right, a form the inferior vena cava about the level of the first lumbar vertebra. (3) T inferior vena cava in very rare cases may terminate in a large azygos vein, a through means of that in the superior vena cava. Under these circumstan the hepatic veins open into the right auricle of the heart.

Development.—The *postrenal segment* of the inferior vena cava is develop from the lower portion of the right supracardinal or periganglionic veins. T *prerenal segment* is developed from (1) the upper portion of the right subcardi vein; (2) the hepatic sinusoids; and (3) the common hepatic vein (Lewis). S development of vessels, in Chapter XIII.

Aortic Lymphatic Glands.—These glands are very numerous, a are arranged in *four groups*, which lie around the abdominal aort The groups are spoken of as pre-aortic, juxta-aortic, right and left, a retro-aortic, respectively.

Pre-aortic Glands.—These are usually disposed in *three sets*- namely, (1) cœliac glands, which constitute a very distinct set arou the origin of the cœliac artery; (2) superior mesenteric glands, in t region of the origin of the superior mesenteric artery, and along t trunk of the vessel; and (3) inferior mesenteric glands, in the region the origin of the inferior mesenteric artery.

The *afferent* vessels of the pre-aortic glands are derived from t following sources:

1. Rectum.
2. Pelvic colon.
3. Descending colon.
4. Transverse colon.
5. Ascending colon.
6. Cæcum.
7. Vermiform appendix.
8. Small intestine.
9. Stomach.
10. Liver.
11. Pancreas.
12. Spleen.
13. Juxta-aortic glands.

The cœliac glands more particularly receive their chief *affere* vessels from the following glands:

1. Gastric glands.
2. Retro-pyloric glands.
3. Hepatic glands.
4. Splenic glands.
5. Pancreatic glands.

The *efferent* vessels of the pre-aortic glands usually unite to for one trunk, called the *intestinal lymphatic trunk*, which with the lumba lymphatic trunks from the juxta-aortic glands forms the cisterna chyl A few of them pass to the retro-aortic glands.

Juxta-aortic Glands (Lateral Lumbar Glands).—These are disposed wo groups—right and left. The *right* glands lie both in front of, behind, the inferior vena cava, whilst the glands of the *left* side n a single chain on the left side of the abdominal aorta.

The juxta-aortic glands of either side receive their *afferent* vessels n the following sources:

1. Common iliac glands.
2. Testis.
3. Ovary, uterine tube, and adjacent half of body of uterus.
4. Suprarenal gland.
5. Kidney.
6. Abdominal wall.

Their *efferent* vessels for the most part unite on either side to form *mbar lymphatic trunk*, right and left, which opens into or forms the erna chyli. Some pass to the pre-aortic glands, and others to the o-aortic glands.

Retro-aortic Glands.—These glands are about four in number, and lie behind the abdominal aorta in front of the bodies of the third fourth lumbar vertebræ. Their *afferent* vessels are derived from pre-aortic and lateral aortic glands, as well as from the vertebral ies and ligaments to which they are related. Their *efferent* vessels e to form a single trunk, called the *intestinal lymphatic trunk*, which is into the cisterna chyli.

Diaphragm—*Origin.*—**Sternal Portion.**—By two fleshy slips from back of the xiphoid process close to its lower end. **Costal Portion.**— six fleshy slips at either side from the inner surfaces of the lower costal cartilages, which interdigitate with slips of the transversus ominis. **Lumbar Portion.**—From the lateral and medial arcuate nents, and from the anterior surfaces of the bodies of lumbar ebræ, as well as the intervertebral discs and anterior longitudinal nent, by two crura, the right crus reaching usually as low as the between the third and fourth lumbar bodies, and the left as low as disc between the second and third.

Insertion.—The central tendon on all sides.

Nerve-supply.—The right and left phrenic nerves, each of which ngs chiefly from the anterior primary division of the fourth cervical e, and usually receives a branch from the fifth, and sometimes from third. Each phrenic nerve, on approaching the diaphragm, des into a dorsal and two ventral branches, the dorsal branch being ributed to the lumbar portion, the two ventral branches accomying the two branches of the phrenic artery. On the right side, re a communication takes place between the right phrenic nerve and right phrenic sympathetic plexus, a small ganglion, called the *glion diaphragmaticum*, is situated at the place of communication. milar connection is established on the left side, but no ganglion is ent.

Arterial Supply.—(1) The phrenic branches of the abdominal a; (2) the pericardiaco-phrenic and musculo-phrenic, both branches he internal mammary of each side; (3) the phrenic branch of the

superior epigastric of the internal mammary of each side; and (4) branc
from the lower intercostal arteries.

Lymphatics.—These are arranged in two groups, one on the thor
aspect, the other on the abdominal aspect; there is a free communica
between the two groups on each side of the middle line, but not so
between the groups of the two sides. The free communication refe
to is promoted by the movements of respiration, for during inspirat
when the pressure in the thorax is reduced, and that in the abdo
is increased, the lymph flows from the abdominal to the thor
surface of the diaphragm, while during expiration the movemen
reversed. The lymph is drained from the diaphragm superiorly by

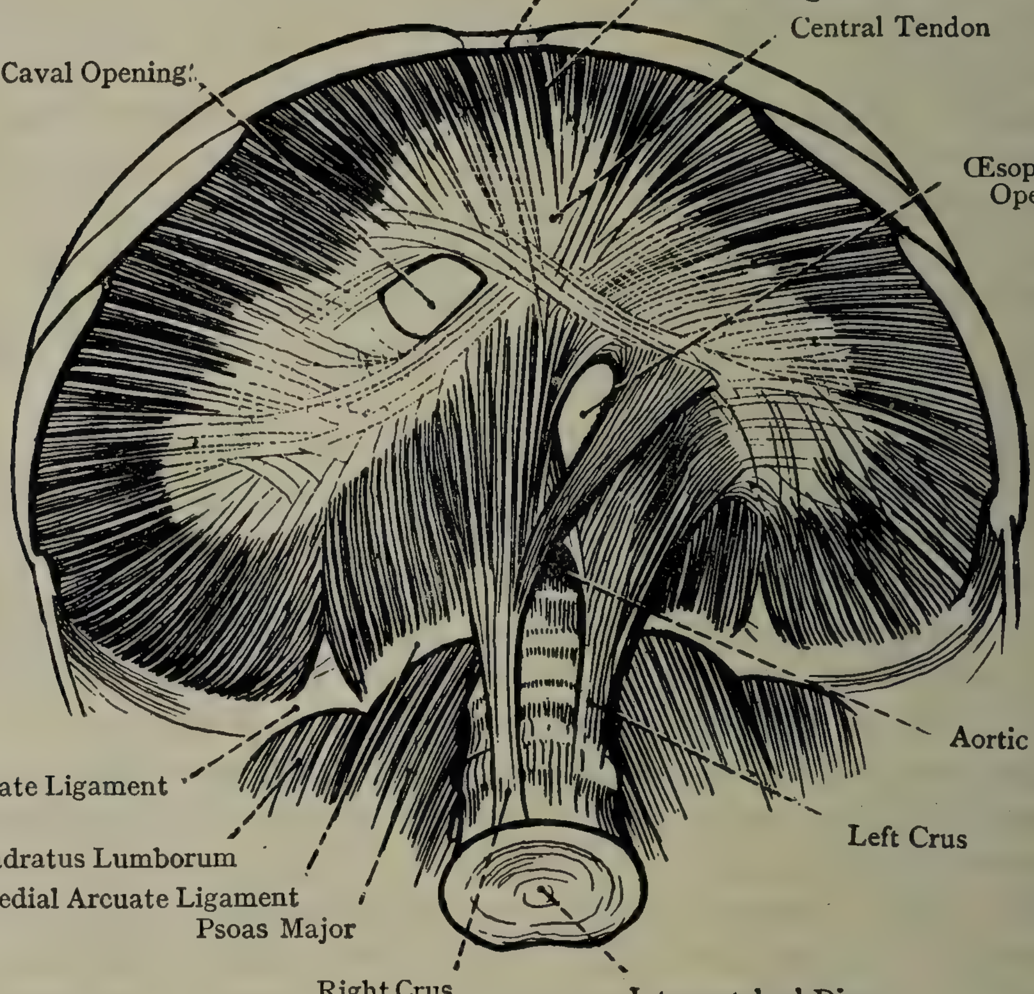


Fig. 483.—The Diaphragm (Inferior View).

supradiaphragmatic glands, which send their efferents to the inte
mammary, posterior mediastinal, and intercostal glands, and from
diaphragm inferiorly by the upper juxta-aortic glands of either s
the pre-aortic and œsophageal glands. The lymphatics of the vari
viscera in relation with the diaphragm are separate from those of
diaphragm except in the case of the liver.

Action.—The diaphragm by its contraction increases the vert
diameter of each half of the thorax, and is therefore a muscle of
spiration. The middle portion of the central tendon is fixed by rea
of the fibrous portion of the pericardium, which is implanted into
being connected above with the deep cervical fascia. The fle

rtion, however, becomes flattened, and descends towards the abdomen, placing the viscera, and so increasing the vertical diameter of each lf of the thorax. The diaphragm also elevates the lower ribs, except e last, which is fixed by the quadratus lumborum muscle.

The muscular fibres pass in an arched manner upwards and inwards to the tral tendon, upon which they converge from all points. The sternal portion separated on either side from the costal portion by a small interval occupied areolar tissue, through which the superior epigastric vessels and some of the erficial lymphatics of the upper surface of the liver pass. Above and below s interval are the pleura and peritoneum respectively. In this situation a phragmatic hernia may take place, involving one or other of the abdominal cera. Between the lowest costal fibres of the corresponding lateral arcuate ment there is sometimes another areolar interval of small size. The **crura** strong, thick, musculo-tendinous bundles disposed vertically, the left being smaller, shorter, and more posterior of the two. Each crus is fleshy laterally, l strongly tendinous medially, the lower extremity of each being entirely dinous. On a level with the lower border of the body of the twelfth thoracic tebra the inner tendinous fibres of the crura are connected by a fibrous band, led the median arcuate ligament, which lies in front of the aorta. The muscular res of the crura pass upwards in a diverging manner to be inserted into the sterior border of the central tendon. The innermost muscular fibres on either e, reinforced by fibres springing from the median arcuate ligament, decussate ore reaching the central tendon, and enclose between them the œsophageal ening. In the decussation the bundle derived from the right crus passes in nt of that from the left, which latter is of small size.

The **central tendon** is also called the *cordiform* or *trefoil* tendon. is much elongated from side to side, convex in front, and conve behind. It is divided into three lobes or alæ—right, median, d left, of which the right is the largest, and the left the smallest d narrowest.

The diaphragm presents three foramina—namely, aortic, vena val, and œsophageal.

The **aortic opening** is situated in the middle line between the upper rtions of the crura, and in front of the disc between the bodies of e twelfth thoracic and first lumbar vertebræ. It is bounded on her side by a crus, in front by the median arcuate ligament, and hind by the anterior longitudinal ligament of the vertebral column. is therefore not really an opening in the diaphragm, but is situated hind it. It transmits the aorta, thoracic duct, and azygos vein, in is order from left to right.

The **vena caval opening** is situated in the central tendon close to its sterior border and at the junction of the right and median lobes. is somewhat four-sided, with rounded angles, and transmits the ferior vena cava, twigs from the right phrenic nerve, and some of e deep lymphatics of the liver.

The **œsophageal opening** is situated in the fleshy part of the muscle. is elliptical, and lies in front, and a little to the left, of the aortic ening, being separated from it behind by the inner decussating res of the crura. It transmits the œsophagus, the right and left gus nerves, and the œsophageal branches of the left gastric tery.

In addition to the foregoing foramina, the diaphragm presents certain sr fissures as follows: each crus is pierced by the greater and lesser splancl nerves, and sometimes by the lowest. The left crus is also pierced by the infe vena hemiazygos vein. The musculo-phrenic artery pierces the costal port and the branches of the phrenic nerve are also transmitted through the mus A small vein pierces the central aponeurosis on the left side at a point co sponding to that of the vena caval opening on the right side; it is believed represent the left vitelline vein of the embryo.

The **arcuate ligaments** are five in number, as follows: lateral, ri and left; medial, right and left; and median. The **lateral arcu ligament** is a thickening of the upper part of the anterior wall of sheath of the quadratus lumborum, and extends from the last to the tip of the transverse process of the first lumbar vertebra. T subcostal artery and anterior primary division of the last thora

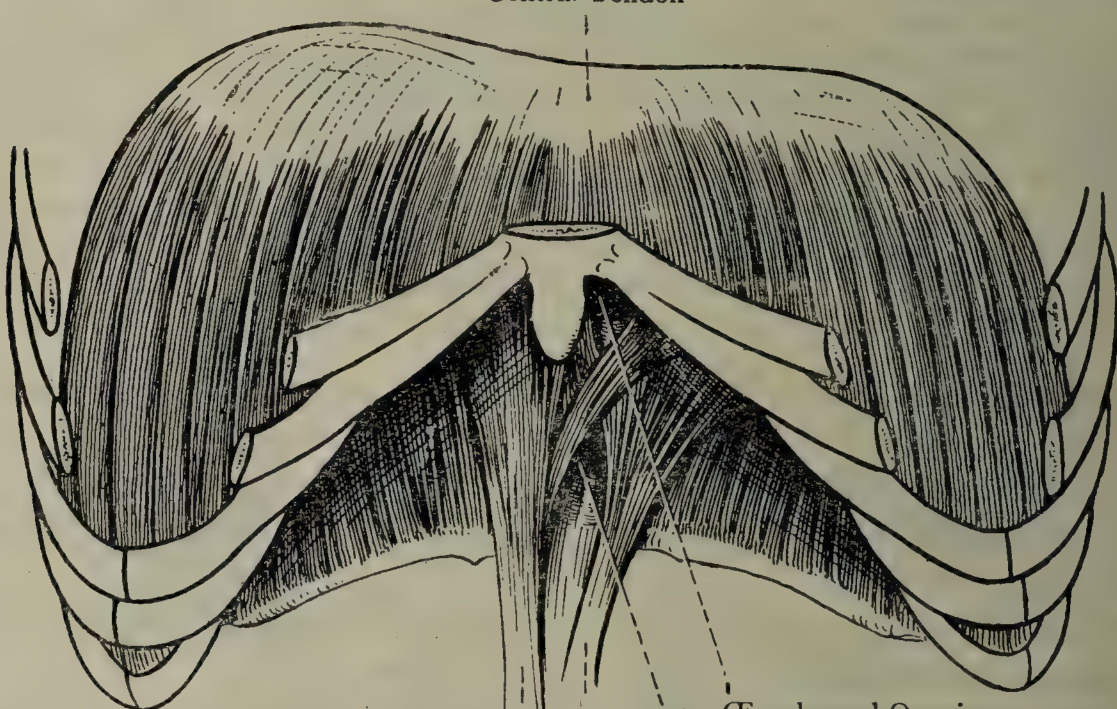


FIG. 484.—THE DIAPHRAGM (SUPERIOR VIEW) (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

nerve pass downwards and outwards behind it. The **medial arcu ligament** is a thickening of the upper part of the sheath of the pso major, and extends from the tip of the transverse process of the fi lumbar vertebra to the side of its body, and sometimes to that of t second vertebra. The gangliated trunk of the sympathetic pas into the abdomen behind it, and sometimes the lowest splanchnic ner The **median arcuate ligament** is a fibrous band which connects t innermost tendinous fibres of the crura on a level with the lower bord of the body of the twelfth thoracic vertebra, and arches over the aort

Relations of the Diaphragm—*Superior.*—The right and left pleuræ with lungs, and the pericardium with the heart. *Inferior.*—The peritoneum, exc opposite the bare area of the posterior surface of the liver; the liver with falciform, coronary, and right and left triangular ligaments; the stomach; sple pancreas; kidneys; and suprarenal glands.

Development.—The diaphragm is developed in four parts—ventral and dorsal l lateral (R. and L.).

The *ventral part*, central, is the first to appear, and is developed from the **tum transversum.** It lies between the pericardial and peritoneal cavities, l has the primitive *œsophagus* passing on its dorsal aspect in the mid-line, with *ericardio-peritoneal passage on each side of this*; these are the primitive pleural

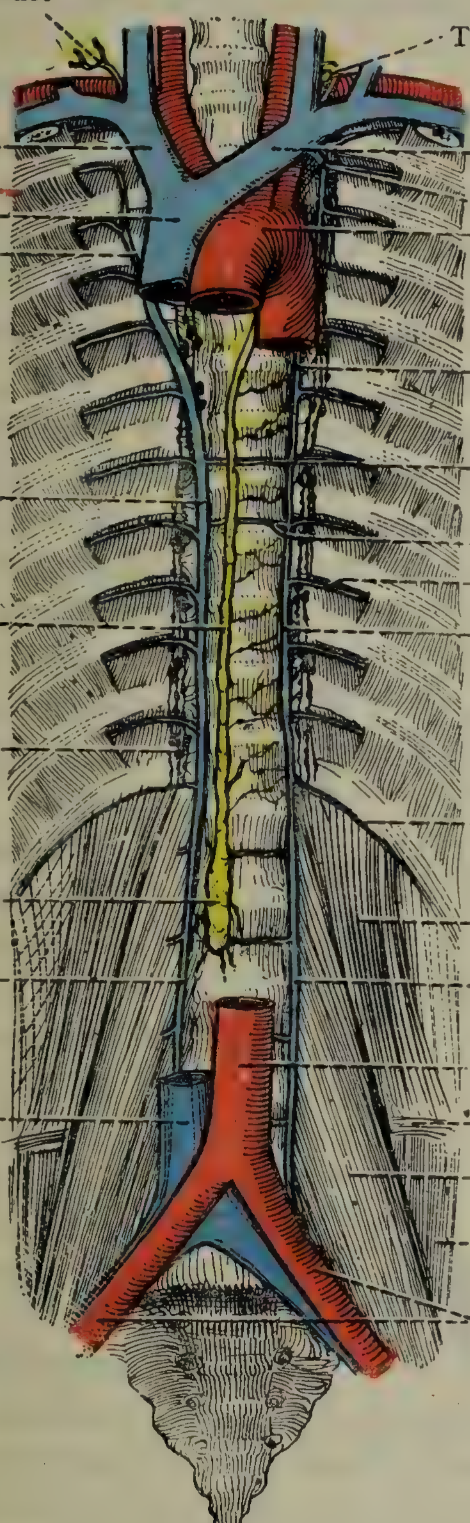


FIG. 485.—THE THORACIC DUCT, AZYGOS VEINS, AND POSTERIOR INTERCOSTAL GLANDS.

ties, from which the secondary pleuræ will start their extension into the y-wall.

Each of the *lateral parts* is brought into existence as the result of extension of eural sac. This, enlarging in the body-wall, splits this into inner and outer rs. The extension of the cavity caudally brings the inner layer into evidence he **pleuro-peritoneal membrane,** separating the growing pleura from the ominal cavity. Extension of muscle cells from the central part into these

lateral membranes makes them into the lateral portions of the diaphragm. fusion between these pleuro-peritoneal membranes and the ventral part o diaphragm may be incomplete on one or other side, in which cases a commu tion is left between the thoracic and abdominal cavities, through which a *phragmatic hernia* may occur. The persistent opening is just lateral to the su renal gland.

The central dorsal part of the diaphragm is formed from the common d mesentery, or meso-œsophagus (see p. 61), into which muscular fibres ex to form the crura.

Gangliated Trunk of the Sympathetic.—This cord enters the al men behind the inner portion of the medial arcuate ligament. It descends along the inner border of the psoas major, where it lie *front of* the bodies of the lumbar vertebræ, and having passed bel the common iliac artery, it enters the pelvis. The right lumbar tr is under cover of the inferior vena cava, whilst the left lies a little to left of the aorta, and the lumbar vessels of each side pass beneath corresponding cord. Each cord usually possesses four ganglia.

Branches.—These are arranged in two sets—namely, rami c municantes, and branches of distribution. The *rami communica* which are long, are of two kinds, white and grey, the latter b the more numerous. The *w* rami are composed of me lated nerve-fibres, and are more than three in num They are derived from anterior primary division the first two or possibly th lumbar nerves, and procee the ganglia. The *grey* r pass from all four ganglia join the anterior primary d sions of the five lumbar ner One or more rami may div and so pass to one or m ganglia. Both white and g rami pass together bene the fibrous arches of the ps major in company with lumbar vessels, and the co munications with the lum nerves are established cl to the intervertebral forami The *branches of distribu* proceed partly from the ganglia and partly from the connecting co and are distributed to the coats of the aorta, the bodies and ligame of the lumbar vertebræ, and the hypogastric plexus, the last branc crossing the common iliac artery.

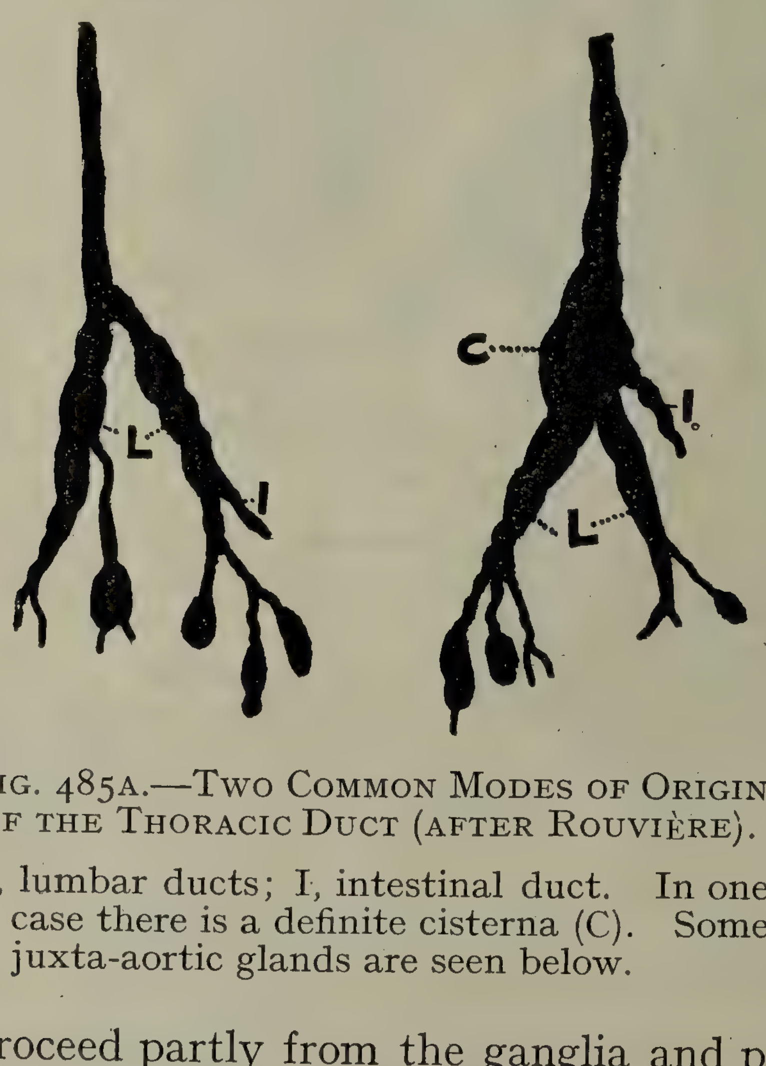


FIG. 485A.—TWO COMMON MODES OF ORIGIN OF THE THORACIC DUCT (AFTER ROUVIÈRE).

L, lumbar ducts; I, intestinal duct. In one case there is a definite cisterna (C). Some juxta-aortic glands are seen below.

Cisterna Chyli (Receptaculum Chyli).—This is the dilated commen ment of the thoracic duct. It is situated deeply at the upper part

posterior abdominal wall in front of the bodies of the first and second bar vertebræ, where it has the aorta on its left side and slightly in t, and the vena azygos on its right side. It is overlapped by the t crus of the diaphragm. It is somewhat elliptical, being about ch broad at its widest part, and about 2 inches in length. Superiorly ecomes narrow, and is continued into the thoracic duct, which rs the thorax through the aortic opening of the diaphragm. It ives the following efferent vessels from below upwards: the right left lumbar lymphatic trunks from the juxta-aortic glands, which its lower narrow end; the efferent vessels from the retro-aortic ds; and the intestinal lymphatic trunk (or trunks) from the pre-ic glands.

zygos Veins.—These are three in number—namely, the vena gos, the inferior vena hemiazygos, and the superior vena hemi-gos.

The **vena azygos** usually commences in the *right ascending lumbar* , which is formed by longitudinal anastomosing branches passing veen the lumbar veins in front of the lumbar transverse processes, so disposed as to form one vein which communicates with the rior vena cava, and with one or other of the following veins of the t side: the common iliac, the internal iliac, the ilio-lumbar, or the ral sacral. Sometimes, however, the azygos vein springs from the terior aspect of the inferior vena cava close to the right renal vein, rom that renal vein itself, or from the first right lumbar vein. It nds upon the body of the first lumbar vertebra, where it lies on the t side of the cisterna chyli under cover of the right crus of the phragm, and it enters the thorax through the aortic opening of t muscle. For its subsequent course in the thorax, where it ninates in the superior vena cava, see the section of the thorax.

The **inferior vena hemiazygos** commences in the *left ascending bar vein*, through which it has communications similar to those he azygos vein. It may, moreover, spring from the left renal vein, he first left lumbar vein. It enters the thorax through the left crus he diaphragm, and subsequently terminates in the azygos vein.

The azygos and inferior hemiazygos veins are persistent portions of right and left cardinal veins of fœtal life.

The azygos and inferior hemiazygos veins, through their connections h the ascending lumbar veins, establish communications with the rior vena cava, and with the common iliac veins or some of their utaries. They therefore form important channels by which a siderable quantity of blood is returned from the lower limbs and lominal wall in cases of obstruction of the inferior vena cava.

The superior vena hemiazygos will be found described in connection h the thorax.

Fasciæ of the Posterior Abdominal Wall—Iliac Fascia.—This fascia ers the iliacus and psoas major muscles. Above the level of the c crest it is related only to the psoas major, and the part covering t muscle is spoken of as the *psoas sheath*. *Superiorly* it forms the

medial arcuate ligament, which extends between the tip of the lumbar transverse process and the side of the body of that verte *Medially* it is attached to (*a*) the intervertebral discs and contigu margins of the bodies of the lumbar vertebræ, and (*b*) the fibrous ar over the lumbar vessels opposite the centre of each lumbar b *Laterally*, near the tips of the lumbar transverse processes, it bl with the anterior layer of the lumbar fascia which covers the quadr lumborum. Below the level of the iliac crest the iliac fascia covers iliacus as well as the psoas major. This part of it is known as *fascia iliaca*, and it passes uninterruptedly from the iliacus on to psoas major. *Laterally* it is attached to the anterior two-thirds of iliac crest immediately within its inner lip, and *medially* to the al the sacrum and the iliac portion of the pectineal line. *Inferiorl* is disposed in the following manner: along the outer half of the ingu ligament on its deep aspect the fascia is firmly attached to that l ment, and joins the fascia transversalis, the two constructing a c which contains the first part of the deep circumflex iliac artery. posite the external iliac vessels the fascia passes downwards beh them and the inguinal ligament to form the posterior wall of the fem sheath. Medial to the external iliac vessels it is continuous with pubic lamina of the fascia lata, as that covers the upper part of pectineus. From the point of junction between the iliac fascia and pubic fascia lata an intermuscular septum (ilio-pectineal) passes ba wards between the pectineus and the psoas major to be attached to ilio-pubic eminence and the front of the capsular ligament of the joint.

The importance of the iliac fascia has reference to the course taken by in cases of lumbar (psoas) abscess. The pus cannot pass outwards over quadratus lumborum without bursting through the psoas sheath, because psoas sheath is bound down to the anterior wall of the fascia covering quadratus lumborum at the outer border of the psoas muscle. It cannot across the vertebral column on account of the attachments of the psoas sh in that situation. The usual course, therefore, taken by the pus is to dif itself downwards within the psoas sheath. On reaching the iliac fossa it diffuse outwards beneath the iliac fascia as that covers the iliacus muscle, b cannot enter the pelvic cavity on account of the attachment of the iliac fa to the pelvic brim, unless it bursts through the psoas sheath. Consequen the pus usually treks along the psoas major within its sheath, and, pas behind the inguinal ligament and the femoral sheath containing the fem vessels, it may point in the region of the saphenous opening on a level with lesser trochanter, simulating a femoral hernia, or it may accompany one or o of the large vessels in this region, more particularly perhaps the medial fem circumflex artery, which may conduct it to the back and inner side of the th

Lumbar Fascia (Aponeurosis).—This is situated between the rib and the iliac crest, and is often regarded as the posterior aponeur of the transversus abdominis muscle. Strictly speaking, only middle layer is the posterior aponeurosis of this muscle. When follo backwards it divides into three layers—anterior, middle, and poster The **anterior layer,** which is thin, covers the quadratus lumbor and is attached medially to a vertical ridge on the anterior surface

e transverse processes of the lumbar vertebræ some distance medial their tips. In this situation it is interposed between the quadratus mborum and psoas major, and receives the iliac fascia which forms e psoas sheath. At the outer border of the quadratus lumborum it ins the middle layer, and is here also continuous with the fascia transrsalis. Superiorly it forms the lateral arcuate ligament, which tends between the last rib and the tip of the first lumbar transverse ocess. Inferiorly it is attached to the ilio-lumbar ligament and the ntiguous part of the inner lip of the iliac crest. The **middle layer,** hich is of considerable strength, is attached medially to the tips of e lumbar transverse processes, and laterally, at the outer border of e quadratus lumborum, it is joined by the anterior lamina, whilst the outer border of the sacro-spinalis it receives the posterior layer.

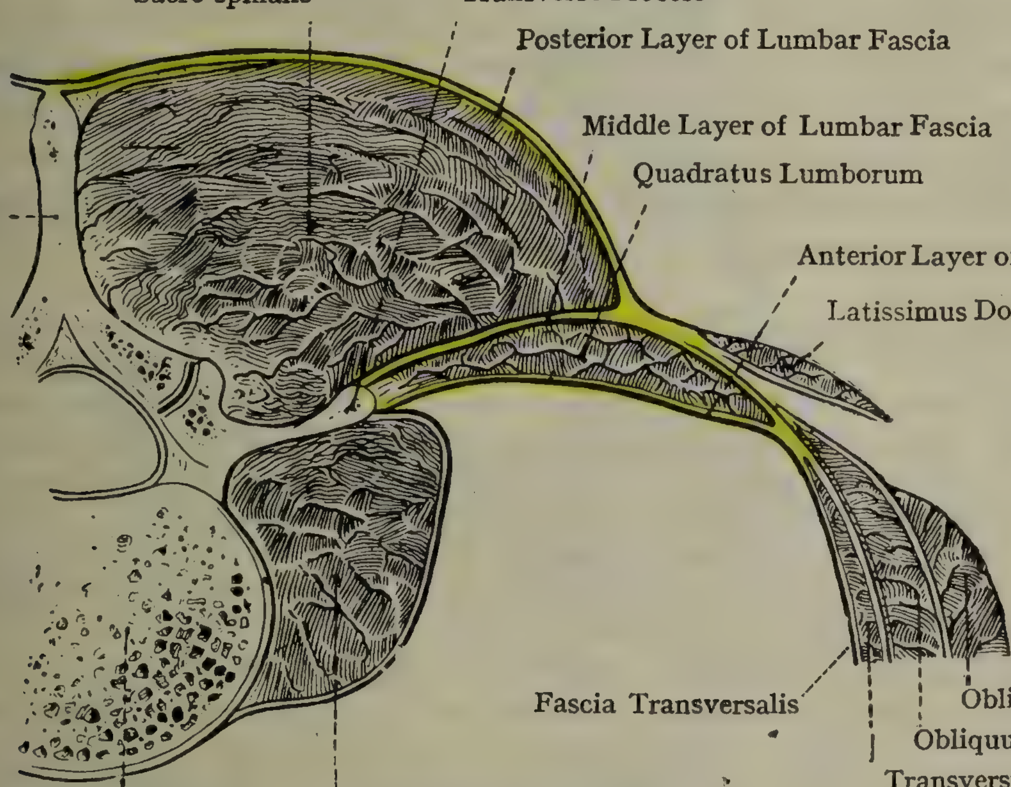


FIG. 486.—DIAGRAM OF THE LUMBAR FASCIA.

ıperiorly it is attached to the lower border of the last rib, and inriorly to the back part of the summit of the iliac crest. The middle yer lies between the quadratus lumborum and the sacro-spinalis. ıe **posterior layer,** which is also very strong, is attached to the spinous ocesses of the lumbar and sacral vertebræ, and the posterior fourth the outer lip of the iliac crest. It lies behind the sacro-spinalis, at the ıter border of which it blends with the middle layer, and so the uscle is enclosed in a sheath. The posterior layer is joined by the scia covering the latissimus dorsi, and affords attachment to the tter muscle and serratus posterior inferior.

Muscles of the Posterior Abdominal Wall—Psoas Major (Magnus)— *igin.*—(1) The inner part of the anterior surface of the transverse ocesses of the lumbar vertebræ; (2) the lateral aspects of the inter-

vertebral discs, and of the adjacent borders of the twelfth thorac and all the lumbar vertebræ; and (3) a series of fibrous arches whi cross the lumbar vessels at the centres of the bodies of the lumb vertebræ.

Insertion.—The lesser trochanter of the femur, by a tendon whi receives on its outer side the greater part of the iliacus.

Nerve-supply.—The lumbar plexus. The branches come mo particularly from the anterior primary divisions of the second a third lumbar nerves.

Action.—Acting from its origin, the muscle is a powerful flexor the thigh upon the pelvis, coming into play in walking, or ascendi a stair; it is a weak medial rotator of the hip. Acting from its i sertion, it is a flexor of the lumbar portion of the vertebral colur upon the pelvis, and of the pelvis upon the thigh, as in the act of stoo ing. The muscle of one side, acting from its insertion, is capable producing lateral flexion of the lumbar portion of the vertebral colum

As the muscle descends close to the pelvic brim the fibres of t iliacus begin to join the outer side of its tendon, and they contin to do so as far as the insertion, thus giving rise to a conjoined mus known as the **ilio-psoas.**

Psoas Minor (Parvus).—This muscle is present in man on one or both sic in about 45 per cent. of bodies. It *arises* from the lateral aspect of the int vertebral disc between the twelfth thoracic and first lumbar vertebræ, and fr the contiguous borders of their bodies, by means of a small fleshy belly, which usually about 2 inches long. It is then replaced by a long, narrow, flat tend which expands as it is about to take *insertion* into the middle of the pectin line and the ilio-pubic eminence, in which latter situation it blends with the il pectineal intermuscular septum. It also gives an aponeurotic expansion to t whole length of the inguinal ligament.

The *nerve-supply* is the anterior primary division of the first lumbar ner Acting from its origin, the muscle tends to flex the pelvis upon the verteb column, and is a tensor of the psoas sheath. Acting from its insertion, it ten to flex the lumbar portion and lower part of the thoracic portion of the verteb column upon the pelvis. Its characteristic action is seen in the position assum by saltatory animals preparatory to the act of leaping, that position consisti in a drawing forwards of the pelvis and vertebral column.

The psoas minor lies along the anterior aspect of the psoas major close to inner border, except at the pelvic brim, where its expanded tendon turns to t inner side of that muscle.

Iliacus—*Origin.*—(1) The lateral part of the upper surface of the a of the sacrum; (2) the anterior sacro-iliac, ilio-lumbar, and lumb sacral ligaments; and (3) the upper half of the iliac fossa, reachi anteriorly as low as the anterior inferior iliac spine.

Insertion.—(1) The outer aspect of the tendon of the psoas majo (2) the triangular surface which is situated below, and in front c the lesser trochanter of the femur (between it and the spiral line and (3) the ilio-femoral ligament. The fibres inserted into the ili femoral ligament are those which arise in the region of the anterior i ferior iliac spine. They are sometimes separated from the rest of t muscle, and are then known as the *ilio-capsularis.*

Nerve-supply.—The femoral nerve.

Action.—Acting from its origin, the muscle is a flexor of the thigh pon the pelvis. Acting from its insertion, it is a flexor of the pelvis pon the thigh.

Quadratus Lumborum—*Origin.*—(1) The ilio-lumbar ligament;) the inner lip of the crest of the ilium for about 2 inches behind nd outside the ilio-lumbar ligament; and (3) the tips of the transverse rocesses of the lower three or four lumbar vertebræ.

Insertion.—(1) The lower border of the last rib along its inner half, nd (2) the tips of the transverse processes of the upper three or four

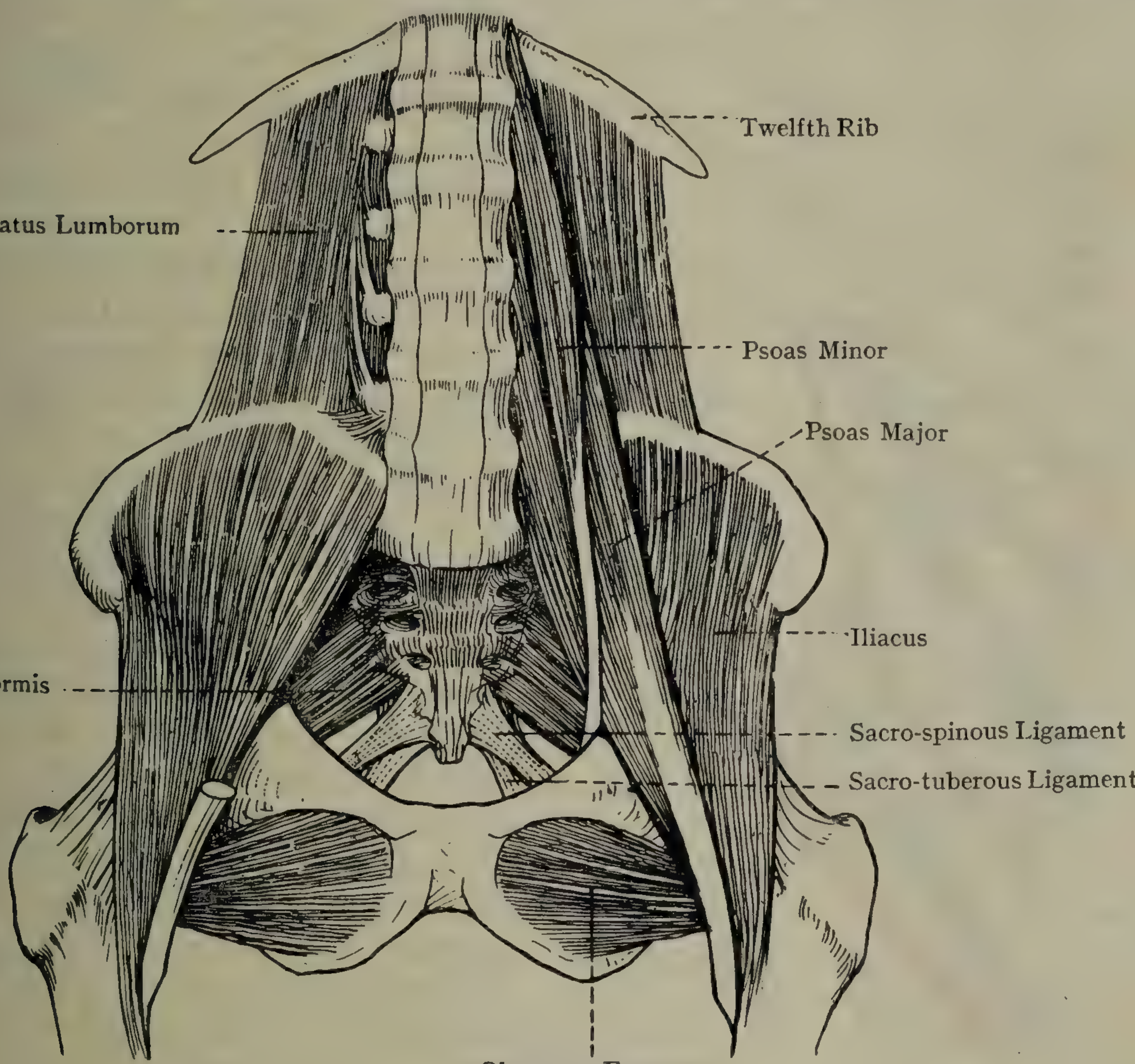


FIG. 487.—THE PSOAS, ILIACUS, AND QUADRATUS LUMBORUM MUSCLES.

ımbar vertebræ, by tendinous slips which lie behind the slips of origin. he fibres of the muscle are so arranged as to form deep and supercial layers; the deep layer consists of ilio-transverse fibres, the supercial layer of transverso-costal fibres medianly and of ilio-costal fibres ıterally.

Nerve-supply.—The subcostal nerve and the anterior primary ivisions of the first two lumbar nerves.

Action.—Acting from its origin, the muscle depresses and fixes ıe last rib, and is therefore a muscle of inspiration, inasmuch as is auxiliary to the diaphragm. In depressing the last rib the

muscle is also capable of producing lateral flexion of the vertebr column. Acting from the last rib, it will produce lateral flexion the pelvis.

The muscle is encased in a sheath, the anterior wall of which formed by the anterior layer of the lumbar fascia, and the posteri wall by the middle layer.

Lumbar Plexus.—The lumbar plexus is situated deeply in front the transverse processes of the first three lumbar vertebræ in the su stance of the psoas major. It is formed by the anterior prima divisions of the first three lumbar nerves and the greater part of th of the fourth. In addition, t anterior primary division of the fir lumbar is usually reinforced by small communicating branch fro the subcostal nerve, called the *dors lumbar nerve*. The nerves concern in the lumbar plexus first furnish t following branches: (1) the first giv twigs to the psoas minor when pre ent; (2) the first and second supp branches to the quadratus lur borum; (3) the second and thi give branches to the psoas majo and (4) the upper two or three fu nish white rami communicantes the lumbar sympathetic gangliate trunk. The mode of formation ar branches of the plexus are as follow the first lumbar, having been, as rule, reinforced by the dorso-lumba from the subcostal, furnishes, fro above downwards, the ilio-hyp gastric and ilio-inguinal, and the it descends to join a branch from th second. The second, third, and tha part of the fourth which enters int the plexus break up into a sma anterior or ventral, and a large po terior or dorsal division. The descending branch from the first join a branch from the ventral division of the second to form th genito-femoral nerve, which arises next in order to the ilio-inguina The lateral cutaneous nerve of thigh arises by two roots from th dorsal divisions of the second and third. The femoral nerve arise by three roots from the dorsal divisions of the second, third, an fourth, the root from the third being the largest. The obturator nerv arises usually by three roots from the ventral divisions of the secon third, and fourth, but the root from the second may be absent. Th accessory obturator nerve, when present, arises by two roots from th

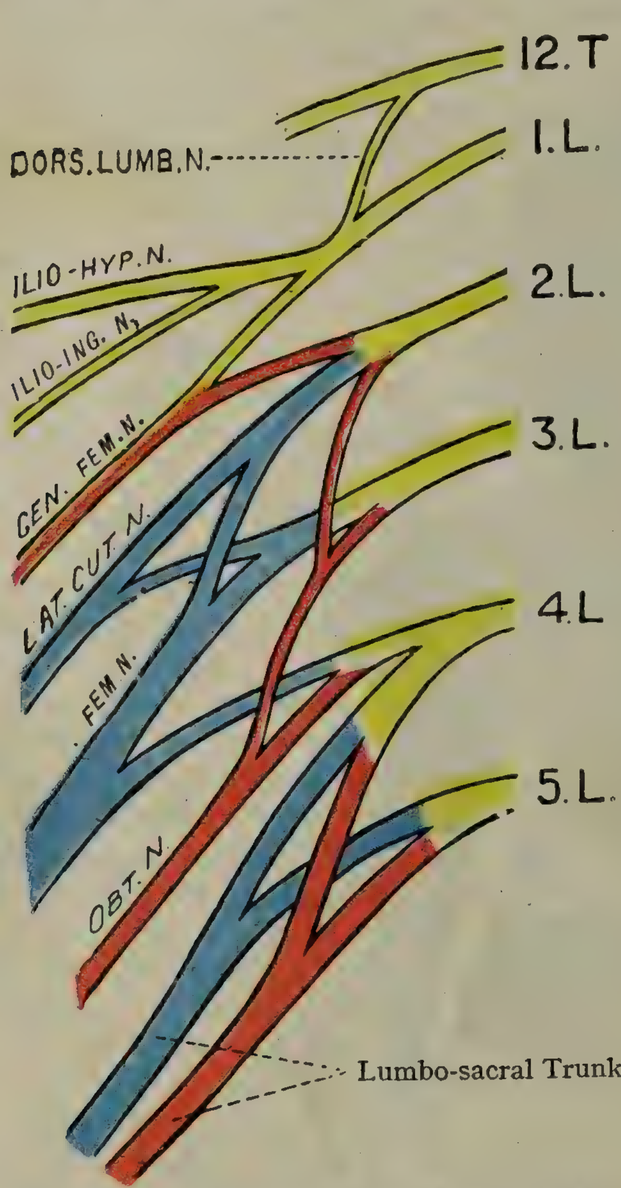


FIG. 488.—DIAGRAM OF THE RIGHT LUMBAR PLEXUS.

ird and fourth, which are interposed between the roots of the femoral ıd main obturator nerves.

The branches of the lumbar plexus are accordingly as follows:

1. Muscular to psoas minor (when present), from first lumbar.
2. Muscular to quadratus lumborum, from first and second lumbar.
3. Muscular to psoas major, from second and third lumbar.
4. Two or three white rami communicantes, to the lumbar sympa- etic gangliated trunk, from the upper two or three lumbar.
5. Ilio-hypogastric and ilio-inguinal, from first lumbar.
6. Genito-femoral, from first and *ventral* division of second lumbar.
7. Lateral cutaneous nerve of thigh, from *dorsal* divisions of second ıd third lumbar.
8. Femoral, from *dorsal* divisions of second, third, and fourth mbar.
9. Obturator, from *ventral* divisions of second, third, and fourth mbar.
10. Accessory obturator (when present), from third and fourth mbar, between the roots of the femoral and main obturator.

The **ilio-hypogastric nerve,** having pierced the outer border of the oas major near its upper part, passes outwards and downwards over e quadratus lumborum, lying below the subcostal nerve and behind e kidney. It then pierces the posterior part of the transversus odominis a little above the iliac crest, and furnishes its *lateral cutaneous anch,* which, perforating the internal and external oblique, crosses e iliac crest at the junction of its middle and anterior thirds to be stributed to the integument of the adjacent part of the gluteal region. ıe nerve continues its course forwards between the internal oblique ıd transversus abdominis, supplying branches to these muscles and mmunicating with the ilio-inguinal nerve. About 1 inch in front of e anterior superior iliac spine it pierces the internal oblique, and then ns forwards between the fibres of that muscle which arise from the guinal ligament and the external oblique aponeurosis. Finally, it erces that aponeurosis 1 inch above the superficial inguinal ring, and distributed to the integument of the suprapubic region, where it is series with the anterior cutaneous nerves. The ilio-hypogastric erve is serially continuous with the intercostal nerves; like these it ves off a lateral cutaneous branch, and then ends as an anterior ıtaneous nerve.

The **ilio-inguinal nerve,** having pierced the outer border of the psoas ajor lower down than, but close to, the ilio-hypogastric, passes bliquely outwards and downwards over the quadratus lumborum, here it may lie below the lower end of the kidney or behind it. It en passes forwards immediately above the inner lip of the iliac crest neath the transversus abdominis. In this part of its course it may st upon the iliac fascia and iliacus muscle. Near the anterior part the iliac crest it pierces the transversus, and here communicates with e anterior cutaneous branch of the ilio-hypogastric. It subsequently rforates the internal oblique, after which it descends through the

lower two-thirds of the inguinal canal, and emerges through the sup ficial inguinal ring, where it lies lateral to the spermatic cord. Fina having pierced the external spermatic fascia, it is distributed to integument of the inner side of the thigh in its upper third, and integument of the scrotum or labium majus, according to the s The ilio-inguinal nerve in its course supplies branches to the inter oblique and transversus abdominis muscles. It differs from the i hypogastric and intercostal nerves in the following two respects: it d not give off any lateral cutaneous branch, and it is not distribu to the skin of the abdominal wall. The ilio-hypogastric and ilio-ingui nerves often arise by a common trunk, and their fibres for a considera part of their course are often contained in the same sheath.

The **genito-femoral nerve** (**genito-crural nerve**) passes forwa through the psoas major, and appears on its superficial surface ab the level of the body of the third lumbar vertebræ, where it lies close the inner border of the muscle. It sometimes pierces the muscle two parts, due to an early division of the nerve into its genital a femoral branches. It then descends upon the psoas sheath, passi slightly outwards, and crossing behind the ureter. At a variable d tance above the inguinal ligament (sometimes in the psoas major) nerve divides into two branches, genital and femoral. The *gen branch* lies upon the external iliac artery close above the inguinal li ment, and enters the inguinal canal through the deep inguinal r to be distributed to the cremaster muscle. The *femoral branch* desce on the outer side of the external iliac artery, and passes out behi the inguinal ligament, having just prior to this crossed the deep circu flex iliac artery. On entering the thigh it lies for about $\frac{1}{2}$ inch wit the femoral sheath, and subsequently, piercing the outer wall of t sheath, is distributed to the skin over the femoral triangle.

The **lateral cutaneous nerve of thigh** pierces the outer border of psoas major near its centre, and takes a direction downwards and o wards over the back part of the iliac crest into the iliac fossa. It t crosses the iliacus under cover of the fascia iliaca towards the anter superior iliac spine, where it enters the thigh behind the outer end the inguinal ligament. For the distribution of the nerve in the thi see p. 564.

The **femoral nerve** (**anterior crural nerve**) pierces the outer bor of the psoas major about the level of the back part of the pelvic bri It then passes forwards, lying deeply between the psoas major a iliacus, and appears in the thigh behind the inguinal ligament. Wh in the abdominal cavity it gives branches to the iliacus muscle. T course and distribution of the nerve in the thigh will be found p. 575.

The **obturator nerve** pierces the inner border of the psoas ma at the back part of the pelvic brim, and lies upon the ala of the sacru having the lumbo-sacral trunk deep to it on its inner side. Passi deeply behind the common iliac artery it enters the pelvic cavity, a passes along the outer wall a little below the pelvic brim, where it l

ove the obturator artery. It then enters the thigh through the turator canal. For the course and distribution of the nerve in the igh, see p. 579.

The accessory obturator nerve (when present) pierces the inner border of the ɔas major close to the main obturator nerve, but, unlike it, does not enter the vic cavity. Its course is forwards along the inner border of the psoas major derneath the external iliac vessels, and it emerges on to the thigh by passing er the superior pubic ramus beneath the pectineus muscle. Under cover of ıt muscle it divides into the following three branches: *articular* to the hip-nt; *muscular* to the deep surface of the pectineus; and a *reinforcing branch* join the superficial or anterior division of the main obturator nerve. It is netimes very small and only represented by articular branches. At its origin s more closely associated with the femoral nerve than with the main obturator. is present in about 30 per cent. of cases.

Varieties of the Lumbar Plexus.—These assume the form of two types, high prefixed, and low or postfixed. In the *prefixed type* the anterior primary vision of the third lumbar is a nervus furcalis, and takes part in the sacral exus; whilst in the *postfixed type* the anterior primary division of the fifth nbar is a nervus furcalis, and takes part in the lumbar plexus.

Lumbo-sacral Trunk.—This is formed by the union of the ventral ıd dorsal divisions of the descending branch of the fourth lumbar rve with the ventral and dorsal divisions of the anterior primary vision of the fifth lumbar. It is a large double trunk, which rests ɔon the ala of the sacrum, being at first under cover of the psoas ajor, and subsequently lying on its inner side, where it has the turator nerve lateral and superficial to it. In its course it passes hind the common and internal iliac vessels, and in the pelvis, its two visions having joined those of the anterior primary division of the st sacral nerve, it takes part in the sacral plexus, entering more rticularly the upper or outer band of that plexus which is continued to the sciatic nerve.

The anterior primary division of the fourth lumbar nerve is known a *nervus furcalis* from the fact that it is distributed partly to the mbar and partly to the sacral plexus.

Lumbar Arteries.—These are branches of the abdominal aorta, ing parietal in their distribution, and serially continuous with the sterior intercostal and subcostal arteries. They are eight in number, ur right and four left, and they arise in pairs, separately or conjointly, ɔm the posterior aspect of the parent trunk. They occupy the grooves the centres of the bodies of the first four lumbar vertebræ. As each tery winds round a vertebral body it passes beneath one of the fibrous ches of the psoas major and the lumbar sympathetic gangliated ınk. It then passes behind the psoas major and lumbar plexus, and reaching the interval between two adjacent lumbar transverse pro-sses it gives off a posterior branch. The upper two arteries pass neath the corresponding crus of the diaphragm, and those of the ght side also pass beneath the cisterna chyli and the azygos vein. l four arteries on the right side pass beneath the inferior vena cava. ıe trunk of each lumbar artery gives off a few vertebral branches to e body and ligaments of the adjacent vertebral and muscular branches

to the psoas major. The *posterior branch* passes backwards betv the adjacent transverse processes in company with the poste primary division of a spinal nerve, and divides into a medial and lat branch. The medial branch supplies the multifidus, and the lat branch supplies the sacro-spinalis, giving also cutaneous branches w accompany the cutaneous nerves to the skin. Opposite an ir vertebral foramen the dorsal branch furnishes a *spinal branch,* w enters the vertebral canal through the foramen, to be distribute the spinal cord and its coverings, as well as to the wall of the cana

The continuations of the arteries then usually pass behind quadratus lumborum, with the exception, as a rule, of that of the fou At the outer border of that muscle they pierce the aponeurosis of transversus abdominis, and pass forwards between that muscle and internal oblique as far as the lower part of the rectus abdominis, wl they enter. They furnish the following offsets: muscular to the qu ratus lumborum; extraperitoneal to the extraperitoneal are tissue, which anastomoses with branches of the ilio-lumbar, the phre and the hepatic colic, and renal arteries, thus forming the ex peritoneal arterial plexus of Turner; muscular to the abdom muscles, which anastomose above with the lower two intercostal subcostal arteries, below with the ascending branch of the deep circ flex iliac and ilio-lumbar, and in front with the inferior epigast Sometimes there are five lumbar arteries on each side, the fifth coming usually from the median sacral artery. Each of these pa beneath the corresponding common iliac vessels, and having furnis a lumbar branch, usually to the gluteus maximus, is distributed o the lateral mass of the sacrum, and ends in the iliacus, where it an tomoses with the deep circumflex iliac artery.

The **lumbar veins** open into the inferior vena cava, those of left side passing behind the abdominal aorta. The vessels of e side are connected by a series of longitudinal anastomosing veins front of the lumbar transverse processes, and the longitudinal ve thus formed is called the *ascending lumbar vein.*

Subcostal Artery.—This vessel is the last parietal branch of thoracic aorta. It lies below the last rib, and is in series with posterior intercostals above and the lumbar arteries below. It wi round the side of the body of the twelfth thoracic vertebra, and cou along the lower border of the twelfth rib with the subcostal ne passing behind the lateral arcuate ligament of the diaphragm and front of the quadratus lumborum. This part of the vessel is beh the kidney and the ascending or descending colon according to the si Its subsequent course corresponds with that of the lumbar arteries. anastomoses with the lower two intercostal arteries, the termi branches of the lumbar arteries, the ascending branch of the d circumflex iliac, and the inferior epigastric artery. This vessel has be borne in mind in such operations as nephrotomy, nephrorrhap and nephrectomy.

The **subcostal vein** of each side enters the thorax behind the late

uate ligament of the diaphragm, the right opening into the azygos n, and the left into the inferior vena hemiazygos.

Subcostal Nerve.—This is the anterior primary division of the elfth thoracic nerve, and is in series with the eleventh or last inter-stal. It accompanies the subcostal artery, and ultimately enters sheath of the rectus abdominis, which muscle it pierces from behind wards to become an anterior cutaneous nerve. In its course it gives an undivided *lateral cutaneous branch*, which pierces the internal l external oblique muscles, and descends er the iliac crest to be distributed to the n of the anterior part of the gluteal ion; this branch may be small or absent. sides this branch it furnishes the follow-offsets: (1) *dorso-lumbar* to the anterior mary division of the first lumbar nerve; l (2) branches to the quadratus lumborum, nsversus abdominis, internal oblique, and ramidalis.

FIG. 488A.—SCHEME ILLUSTRATING THE 'GROUPS' OF AORTIC GLANDS (MODIFIED FROM ROUVIÈRE).

Glands in front of aorta are pre-aortic, PA; those beside aorta are right and left lateral aortic, RL, LL; the right lateral group is composed of sub-groups: A-V, between aorta and vena cava inferior; PV, prevenous; RV, retro-venous; and LV, latero-venous. Glands behind the aorta are not shown, being made up of derivatives from one or both lateral groups.

Lumbar Glands.—These are very numer-s, and are divided into four groups—-aortic, retro-aortic, and juxta-aortic, ht and left. They lie behind the parietal itoneum, in front of, behind, and along sides of the aorta and inferior vena cava. e lower glands are continuous with the per members of the group of the **common c glands.** The lumbar glands receive ir afferent vessels from the following rces: (1) the alimentary canal down to anal orifice; (2) the liver and gall-bladder; the pancreas; (4) the spleen; (5) the testes the male; the ovaries, uterine tubes, and per end of the uterus in the female; the kidneys; (7) the suprarenal glands; the vertebral part of the diaphragm; the common iliac glands; and (10) the lominal wall. Their efferent vessels unite form the lymphatic intestinal and the nphatic lumbar trunks, which in turn n to form the cisterna chyli at the level of the body of the second nbar vertebra.

Common Iliac Arteries.—These vessels are the terminal branches of abdominal aorta. They arise from that vessel opposite the centre the body of the fourth lumbar vertebra, a finger's breadth to the t of the middle line, and they at once diverge from each other. Their irse is obliquely downwards and outwards over the lower portion the body of the fourth and the whole of that of the fifth lumbar tebra, as well as the disc between the two. Each artery, on arriving

opposite the lumbo-sacral articulation, ends by dividing into exter and internal iliac arteries. The length of the right common iliac about 2 inches, and that of the left about $1\frac{3}{4}$ inches. The left ves is less oblique in direction than the right, and the course of each may indicated in the following manner: draw a line from a point $\frac{3}{4}$ in below the umbilicus, a finger's breadth to the left of the middle li to a point at the groin midway between the anterior superior iliac sp and the symphysis pubis, and let this line be slightly curved with t convexity directed outwards. About the upper 2 inches of this l indicate the course of the common iliac artery, and the remainder th of the external iliac vessel.

FIG. 489.—LYMPHATICS OF THE ABDOMEN (AFTER MASCAGNI).

Relations—*Anterior.*—The peritoneum, coils of the small intestin one half of the aortic sympathetic plexus, and the ureter, which latte crosses the artery close to its termination, though it may be transferre to the commencement of the external iliac vessel. An additional supe ficial relation of the left common iliac artery is that it is crossed by th superior rectal vessels.

Posterior.—Each artery rests upon the lower half of the body o the fourth and the whole of that of the fifth lumbar vertebra, as we as the disc above and below the latter, and the gangliated sympatheti trunk. The **right** vessel is separated from the foregoing structures b the commencement of the inferior vena cava, the terminal part of th left common iliac vein, and the right common iliac vein, whilst the **lef**

vessel is free from posterior venous relations. Lying deeply behind each artery there are the obturator nerve, lumbo-sacral trunk, and between them the ilio-lumbar artery.

External.—On the outer side of the **right** vessel there are, from above downwards, the inferior vena cava, right common iliac vein, and psoas major. On the outer side of the **left** vessel is the psoas major.

Internal.—On the inner side of the **right** vessel, from below upwards, there are the right common iliac vein, the left common iliac vein, and the hypogastric sympathetic plexus. On the inner side of the **left** vessel there are the left common iliac vein and the hypogastric plexus.

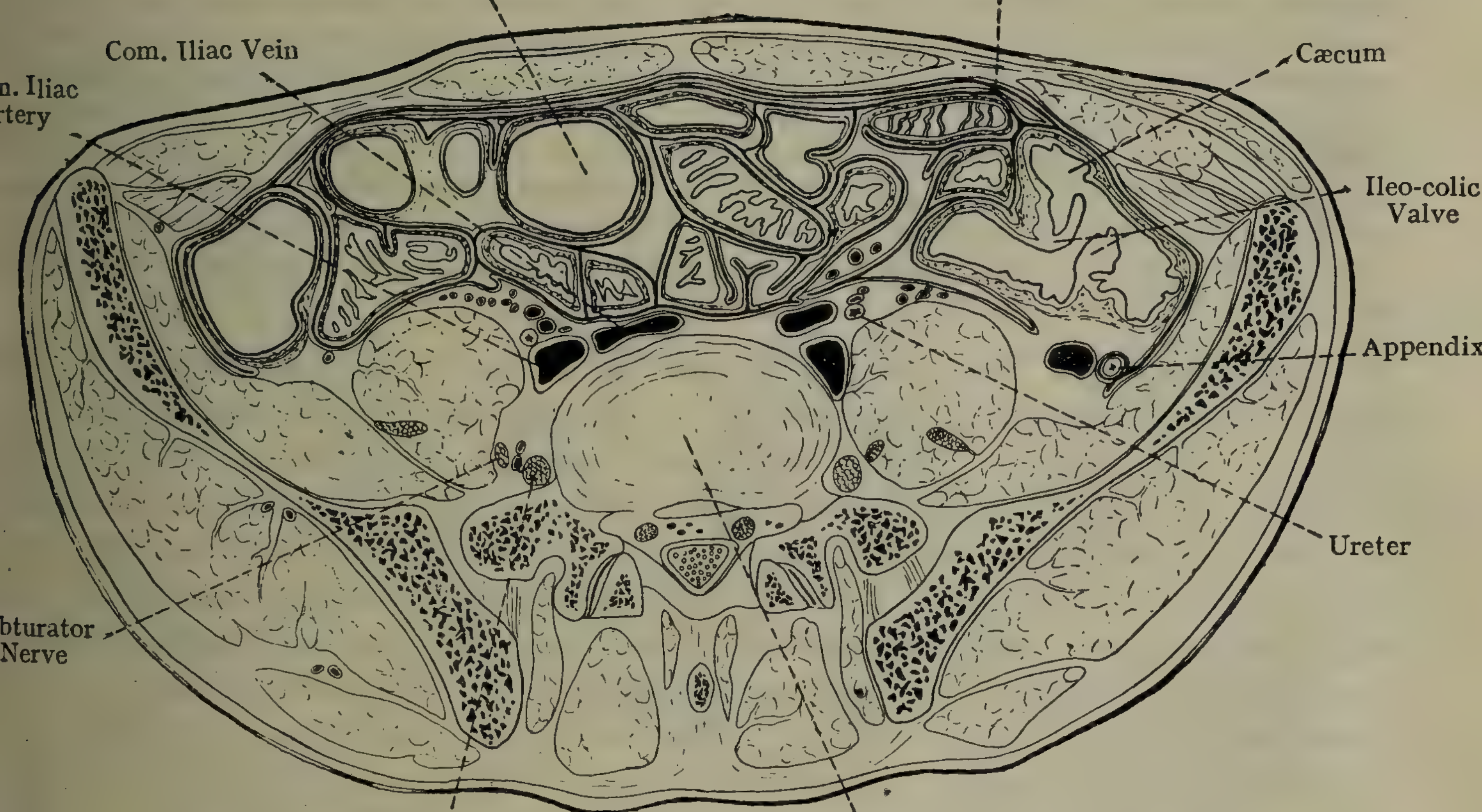


FIG. 490.—TRANSVERSE SECTION AT THE LEVEL OF THE DISC BETWEEN THE BODY OF THE FIFTH LUMBAR VERTEBRA AND THE SACRUM (AFTER SYMINGTON).

It is to be noted that the left artery is related only to its own vein, which lies on its inner side. The right artery, on the other hand, is related to three veins as follows: the inferior vena cava, which lies partly behind its upper end and partly on its outer side; the terminal part of the left common iliac vein, which lies partly on its inner side and partly behind it; and the right common iliac vein, which, from below upwards, lies first on its inner side, then behind it, and finally on its outer side.

The inner, outer, and middle chains of common iliac glands lie on the inner, outer, and posterior aspects respectively of the common iliac vessels.

Branches.—These are as follows: peritoneal to the peritoneum and extraperitoneal areolar tissue; muscular to the psoas major;

ureteric to the ureter (all of small size and unimportant); exter iliac; and internal iliac. In some cases the common iliac gives one or other of the following vessels: ilio-lumbar, median sacral, late sacral, lumbar, or an aberrant renal artery.

Varieties.—The chief variety affects the length of the vessel. It may very short, which is due either to a low bifurcation of the aorta or a high bifu tion of the artery itself; or it may be very long, which is due to exactly oppo causes. When abnormally long, the vessel is usually more or less tortuous.

Collateral Circulation.—After ligature of a common iliac artery, the cl channels by which the circulation is carried on are as follows: (1) the supe epigastric of the internal mammary from the first part of the subclavian ana moses with the inferior epigastric of the external iliac; (2) the lumbar branc of the aorta anastomose with (*a*) the ascending branch of the deep circum iliac from the external iliac, and (*b*) the ilio-lumbar of the internal iliac; (3) superior rectal of the inferior mesenteric from the aorta anastomoses with (*a*) middle rectal of the internal iliac, and (*b*) the inferior rectal of the inter pudendal from the internal iliac; (4) the median sacral from the aorta anastomo with the lateral sacral branches of the internal iliac; and (5) the pubic branc of the obturator from the internal iliac and of the inferior epigastric from external iliac, both of one side, anastomose across the middle line with the co sponding branches of the opposite side. The vesical and middle and inferior rec arteries of one side anastomose in a similar manner with those of the oppo side.

Common Iliac Veins.—Each vein is formed by the union of t external and internal iliac veins opposite the corresponding sac iliac articulation on a level with the brim of the pelvis. They un to form the inferior vena cava opposite the upper border of the bo of the fifth lumbar vertebra a little to the right of the middle li behind and on the right side of the right common iliac artery. T right vein is necessarily shorter than the left, and it ascends alm vertically, lying at first medial to, then behind, and finally on t outer side of its own artery. The left vein ascends very oblique from left to right, lying medial to its own artery, and then behind th of th right side. It crosses the median sacral artery, and is cross by the superior rectal vessels and the left half of the aortic plex The common iliac veins are usually destitute of valves.

Tributaries.—These are chiefly the external iliac, internal ilia and ilio-lumbar. In addition, the left vein receives the median sac vein.

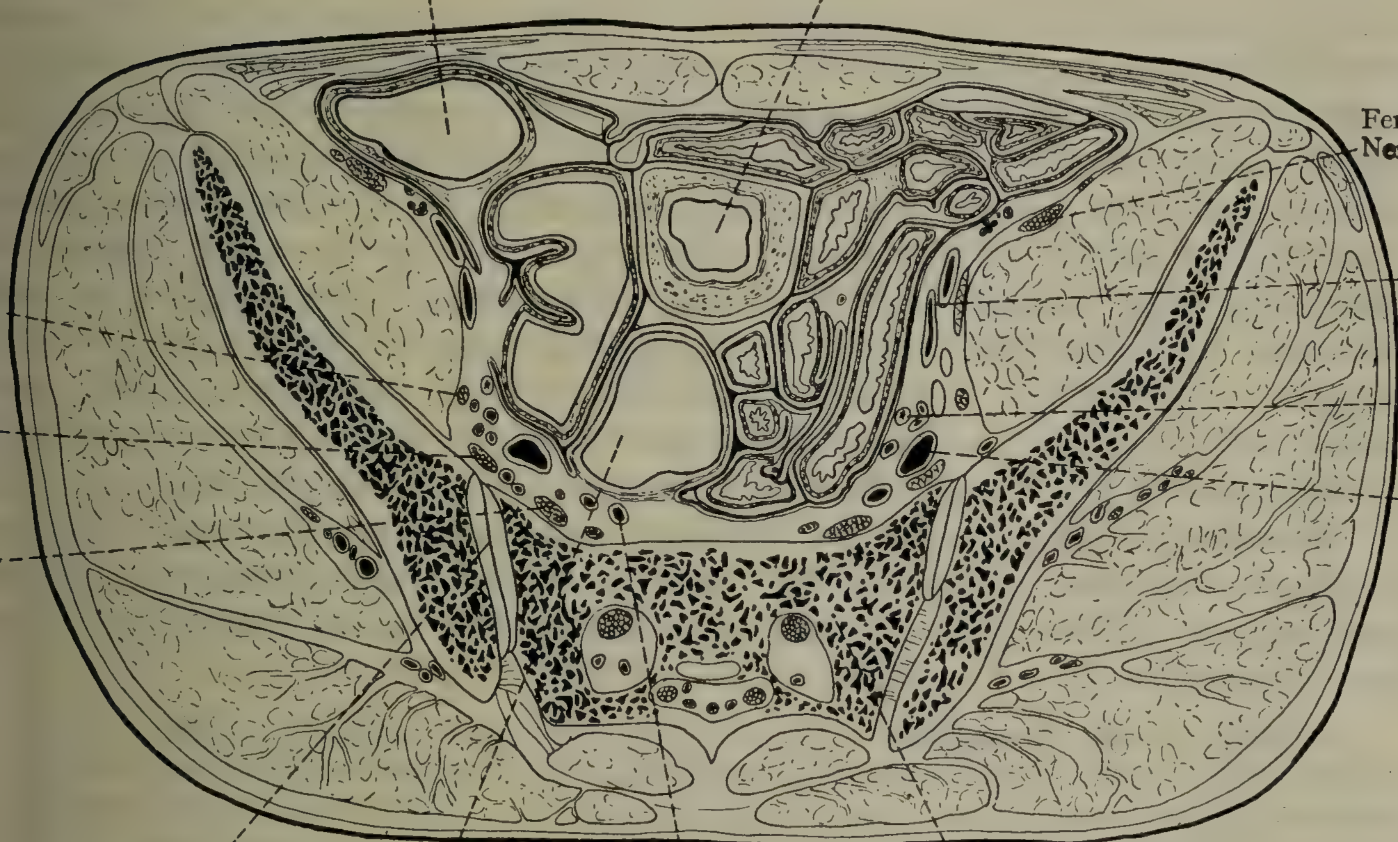
The *left* common iliac vein is mainly the persistent and enlarged *transve branch* (transverse iliac) which connects the right and left supracardinal periganglionic veins of the embryo above the back part of the pelvic brim. I commencement, however, is developed from the left veins. The *right* comm iliac vein is developed from the part of the right cardinal vein which interven between the termination of the right external iliac vein and the right extremi of the transverse iliac vein.

Common Iliac Lymphatic Glands.—These glands are about *ni* in number, and are arranged in *three groups*—lateral, intermediate, a medial—which lie along the common iliac artery. The *afferent* vess of the *lateral* and *intermediate groups* are derived from the external a internal iliac glands; the *afferent* vessels of the *medial group* procee

n the other hand, directly from the viscera, from (1) the prostate and, (2) the base of the bladder, (3) the lower part of the vagina, and) the cervix uteri.

The *efferent* vessels of all the common iliac glands of one side pass the juxta-aortic glands of the same side.

External Iliac Artery.—This vessel is the larger of the two terminal visions of the common iliac in the adult. It extends from the lumbo-cral articulation to the lower margin of the inguinal ligament, where is continued into the femoral artery. Its course is along the pelvic im, and at the groin it passes through the vascular lacuna at a point idway between the anterior superior iliac spine and the symphysis



G. 491.—TRANSVERSE SECTION AT THE LEVEL OF THE SECOND SACRAL VERTEBRA (AFTER SYMINGTON).

ibis. The *course* of the vessel may be indicated in the following anner: draw a line from a point $\frac{3}{4}$ inch below the umbilicus; a finger's eadth to the left of the middle line, to a point at the groin midway tween the anterior superior iliac spine and the symphysis pubis, and t this line be slightly curved with the convexity directed outwards. bout the upper 2 inches of this line indicate the course of the common ac artery, and the remainder that of the external iliac vessel. The ne indicating the course of the vessel corresponds to the lower part of at which has been given as indicating the course of the common iliac. he vessel is from $3\frac{1}{2}$ to 4 inches long, and its direction is downwards, itwards, and forwards.

Relations—*Anterior.*—The artery is covered by the parietal p toneum and extraperitoneal areolar tissue, the portion of the la which is related to it being known as **Abernethy's fascia.** The ri vessel at its commencement is crossed by the terminal part of ileum, and sometimes by the vermiform appendix, whilst the left its commencement is crossed by the pelvic colon, and each may crossed by the ureter. In the female both arteries are crossed superic by the ovarian vessels. Near the inguinal ligament each vesse crossed by the deep circumflex iliac vein, and the genital branch of genito-femoral nerve lies upon it. The testicular vessels in the m also lie for a short distance upon it in this situation, and the vas defer (or ligamentum teres of the uterus) arches over it from without inwa The external iliac glands lie along the artery. *Posterior.*—The art rests upon the iliac fascia at the pelvic brim, except for a little ab the inguinal ligament, where it lies upon the psoas muscle with intervention of the fascia which forms its sheath. The right art at its commencement has its own vein behind it for a short distance, each vessel may have the accessory obturator nerve as a deep poste relation. *Lateral.*—The psoas major covered by the iliac fascia, genito-femoral nerve, and its femoral branch. *Internal.*—The p toneum, the extraperitoneal areolar tissue (Abernethy's fascia), wh binds the artery with its vein to the iliac fascia, the external iliac v (except for a short distance above on the right side, where the vei behind the artery), and the vas deferens near the inguinal ligamen

Branches.—These are as follows: muscular to the psoas maj glandular to the external iliac glands (both unimportant); infe epigastric; and deep circumflex iliac. For the latter two, see pp. and 732.

Varieties of the Branches.—(1) The origin of the inferior epigastric may transferred to the femoral, or to the arteria profunda femoris, and the de circumflex iliac may be transferred to the femoral. (2) The medial circumfl obturator, or arteria profunda femoris may arise from the external iliac, in wh latter case two large arteries would emerge on to the thigh beneath the ingui ligament.

The **external iliac vein** is the continuation of the femoral vein. extends from the lower border of the inguinal ligament to the sac iliac articulation on a level with the brim of the pelvis, where it jo the internal iliac, and so forms the common iliac vein. The *right* v lies at first medial to its artery, and then behind it. The *left* vein l medial to its artery throughout. Its chief tributaries are the infer epigastric and deep circumflex iliac veins.

The external iliac vein of adult life is preceded in function by the infer gluteal vein of the embryo, which is the primitive vein of the lower limb. In t process of development the upper part of the femoral and the whole of t external iliac vein of the adult are continued upwards from the long sapheno vein to the cardinal portion of each common iliac vein, and the inferior glut vein is now a tributary of the internal iliac.

Collateral Circulation.—When the external iliac artery is ligatured, t collateral circulation is carried on through the following channels: (1) t

ıperior epigastric of the internal mammary from the first part of the subclavian ıastomoses with the inferior epigastric of the external iliac; (2) the pubic ranch of the obturator from the internal iliac anastomoses with the pubic ranch of the inferior epigastric; (3) the ilio-lumbar and superior gluteal, both om the internal iliac, and the abdominal branches of the lumbar arteries from ıe aorta anastomose with the deep circumflex iliac of the external iliac; (4) the ɔturator from the internal iliac anastomoses with the medial circumflex of the teria profunda femoris; (5) the inferior gluteal from the internal iliac anas-ɔmoses with the medial and lateral circumflex, and the first perforating of the teria profunda femoris; (6) the gluteal anastomoses with the external circum-ex and the ascending branch of the medial circumflex from the arteria pro-nda femoris; (7) the companion artery of sciatic nerve of the inferior gluteal ıastomoses with the perforating branches of the arteria profunda femoris; and) the superficial perineal and dorsal artery of penis of the internal pudendal from ıe internal iliac anastomose with the superficial and deep external pudendal of ıe femoral.

External Iliac Lymphatic Glands.—These glands are related to the xternal iliac vessels, and are about *twelve* in number. They are usually rranged in *three chains*—lateral, intermediate, and medial—there eing about *four* glands in each chain. The *lateral chain* lies on the *uter* side of the external iliac artery, between it and the psoas major ıuscle, except the lowest gland, which lies upon that muscle. The *ıtermediate chain* lies in front of the interval between the external iac artery and vein. The *medial chain* lies below the level of the ex-ɛrnal iliac vein, upon the upper part of the lateral wall of the pelvis, bove the obturator nerve. One of the glands of this chain may lie ithin the pelvic entrance to the obturator canal, and is spoken of s the *obturator gland*, but it is not constant. The lowest gland of ach chain lies close to the deep aspect of the inguinal ligament, and ıese are known as the *retro-femoral glands*—lateral, intermediate, and ıedial respectively.

The *afferent* vessels of the external iliac glands convey lymph from ıe following sources:

1. The deep inguinal glands.
2. Some of the superficial inguinal glands.
3. The deep structures of the antero-lateral abdominal wall *below* ıe umbilicus.
4. To a certain extent the glans penis or glans clitoridis, these ymphatics passing along the inguinal canal.
5. The adductor muscles.
6. The prostate gland and prostatic urethra in part.
7. The bladder.
8. Part of the *membranous* and the *bulbar* portions of the urethra.
9. The upper part of the vagina.
10. The body and cervix of the uterus.

The *efferent* vessels of all the external iliac glands pass to the ommon iliac glands.

Lacunar Region.—The lacunar region is situated between the ıguinal ligament and the anterior margin of the hip bone, and is ivided into two compartments—muscular and vascular.

The **muscular lacuna** is subdivided into two portions, lateral iliac, and medial or pectineal, by the *ilio-pectineal septum*, wh separates the psoas magnus from the pectineus. This septum pa between the ilio-pubic eminence and the fascia iliaca at its poin junction with the upper part of the pubic portion of the fascia l The *lateral compartment*, which is of large size, is bounded in front the outer part of the inguinal ligament and the iliac fascia, behind the anterior margin of the ilium, and medially by the ilio-pectin septum. It transmits (1) the ilio-psoas muscle, (2) the lateral cutane nerve of thigh, and (3) the femoral nerve. The *medial compartmen* situated between the superior pubic ramus behind and the upper p of the pubic lamina of the fascia lata in front, the ilio-pectineal sept being lateral to it. It contains the origin of the pectineus muscle, is shut off from the abdominal cavity by the attachment of the pu lamina of the fascia lata to the medial portion of the pectineal line. connection with this portion of the fascia lata there is a bundle fibres, known as the *pectineal ligament* (*of Cooper*). This ligam extends between the ilio-pubic eminence and the pubic tubercle, tween which points it is attached to the medial portion of the pectin line in front of the pectineal part of inguinal ligament, being clos incorporated with the pubic lamina of the fascia lata.

The **vascular lacuna** is situated anterior to the other two. It bounded posteriorly by the connection between the iliac fascia the pubic lamina of the fascia lata, whilst anteriorly it is bounded the central portion of the inguinal ligament and the downward p longation of the fascia transversalis to form the anterior wall of femoral sheath, that fascia being here strengthened by the deep femo arch. It gives passage to (1) the external iliac vessels, the vein be medial to the artery; and (2) the femoral branch of the genito-femo nerve, which lies close to the outer side of the artery. The part of t lacuna medial to the external iliac vein forms the femoral ring, wh is closed by the femoral septum.

STRUCTURE AND DEVELOPMENT OF THE ABDOMINAL VISCERA.

Structure of the Stomach.

The wall of the stomach is composed of four coats—serous, mu cular, submucous, and mucous.

The **serous coat** is formed by the peritoneum, which covers eve part of the organ except (1) along the lesser and greater curvatur and (2) the *uncovered trigone*, situated on the posterior surface, bel and a little to the left of the cardiac orifice.

The **muscular coat** (**muscularsi externa**) is composed of plain muscul tissue disposed in three layers—external or longitudinal, middle circular, and internal or oblique. The *external* or *longitudinal fib* are continuous with the longitudinal fibres of the œsophagus, and

pyloric end of the stomach they are continuous with the longitudinal
·es of the duodenum. They are most abundant along the lesser
vature, and partially separate off in that region a tubular portion
the cavity known as *the inter-*
gastric canal, which is thought
provide for the rapid trans-
ssion of fluids. The *middle* or
ular fibres completely surround
stomach from the fundus to
pyloric end. At first they are
ı and irregular in position,
over the pyloric canal they
thick. At the pylorus they
ome augmented, and are gath-
l together into a thick muscular
, called the **pyloric sphincter,**
ich lies within a circular fold
the mucous membrane. The
ermost fibres of this ring be-
ıe continuous with the circular
·es of the duodenum. Some of
circular fibres appear to be
tinuous with the superficial
ular fibres of the right side of the lower end of the œsophagus.
internal or *oblique fibres* are continuous with the circular fibres of the left side of the lower end of the œsophagus. They loop over the stomach immediately to the left of the cardiac orifice, and run very obliquely downwards and to the right for a considerable distance on both surfaces of the organ. They cannot be traced as far as the pylorus, but end by inclining downwards to the greater curvature, where they blend with the circular fibres.

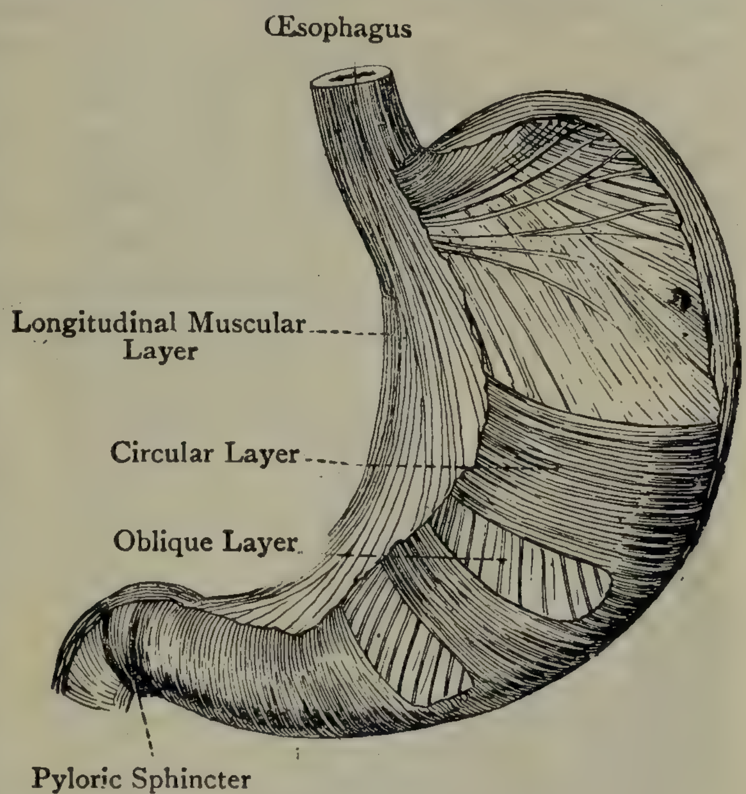


Fig. 492. — Dissection showing the Muscular Layers of the Stomach.

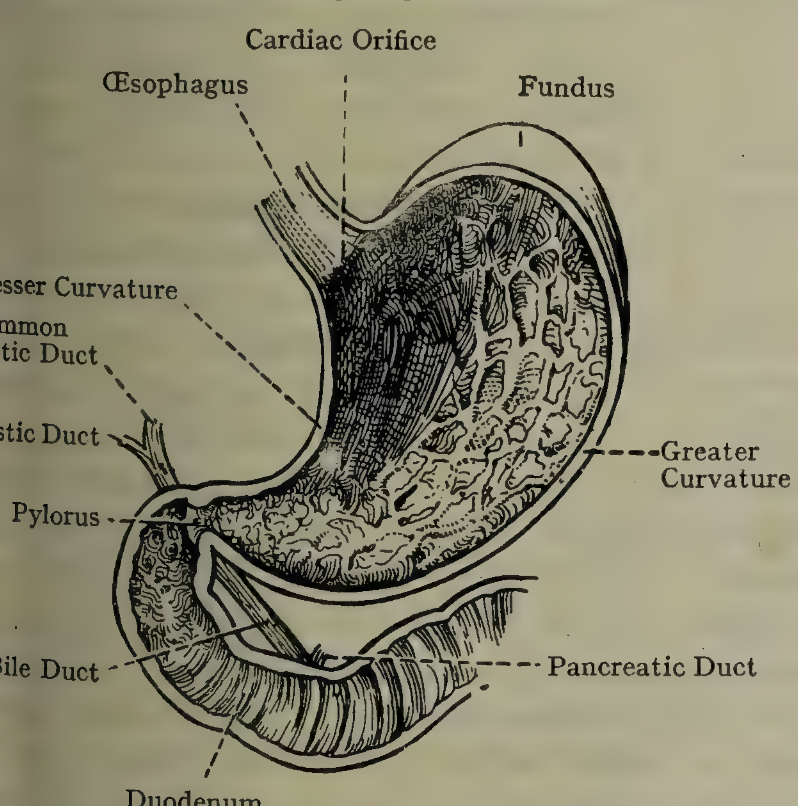


Fig. 493.—The Stomach and Duodenum opened.

The **submucous coat** is situated between the muscular and mucous coats. It is composed of
se areolar tissue, and serves partly as a connecting medium, and
tly as a bed in which the arteries subdivide before entering the
cous coat.

The **mucous coat** is covered by a single layer of columnar epithe It is soft and pulpy, and in the empty state of the viscus is th into folds, which are for the most part longitudinal, and are due t loose connection between the muscular and mucous coats. T however, are readily effaced when the stomach becomes diste It is thickest towards the pyloric end, and in healthy adults it l light crimson colour, while in early life this is heightened into a b rosy tint. After death, however, it presents a mottled appear being marked with grey-brown patches. When examined with a it presents a great number of polygonal depressions, varying in diar from $\frac{1}{100}$ to $\frac{1}{350}$ inch, the largest being near the pylorus. These in

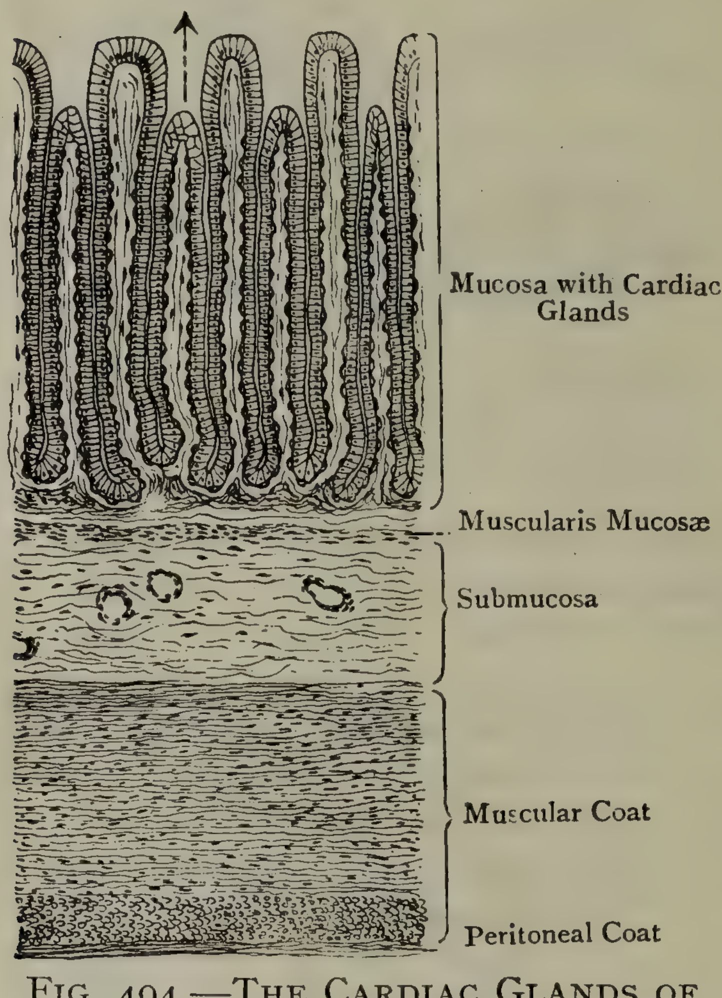


FIG. 494.—THE CARDIAC GLANDS OF THE STOMACH (HIGHLY MAGNIFIED).

to it a honeycomb appear The mucous membrane surro ing them is elevated into r by subjacent capillary netw and in the region of the py these ridges present proc called *plicæ villosæ*. The gonal depressions are beset minute pores, which are the fices of the **gastric glands.** T glands, which belong to the tu variety, are placed perpen larly in the mucous coat, are closely packed together upright stakes. They are of kinds, cardiac and pyloric, tween which there are ce differences.

The **cardiac glands** are situ in the cardiac two-thirds. **duct** of each forms about one- of the entire length of the g It is lined with a single lay columnar epithelium. The end of the duct is connected with two or three *gland-tubes*, v represent two-thirds of the entire gland. Each gland-tube is divi into a neck, body, and fundus. The *neck* is the part connected the duct, and it forms one-third of the length of the gland-tube is narrower than the body, and is lined with coarsely granular polyh cells, which almost completely fill it, thus leaving a very small lu These are called the **central** or **chief cells.** Between these and basement membrane there are interposed large oval or sphe granular cells, each having a clear nucleus. These, which are c the **parietal** or **oxyntic** (' acid-forming ') **cells,** do not form a contin layer, but are placed at intervals, and they give rise to small swel on the wall of the neck. The *body* is wider than the neck, and f two-thirds of the length of the gland-tube. It is lined by a prolonga

he central or chief cells of the neck, which almost completely fill it, which have now become somewhat columnar and transparent. ween these cells and the basement membrane there are a few ietal or oxyntic cells here and re. The parietal cells of the k and body impart the charac- stic beaded appearance to the id-tube. The *fundus* is the d deep end of the gland-tube.

The **pyloric glands** are situated he pyloric third. The duct of forms one-half of the entire th of the gland. It is lined a single layer of columnar helium. The deep end of the t is connected with two or e gland-tubes, which represent -half of the entire gland. The k of each tube is comparatively rt, and the body is branched ts deep extremity. The neck body are lined with cubical ular cells, representing the tral or chief cells of the cardiac ids, and they are not so vded as in the cardiac glands, hat there is a very distinct en. There is an entire absence of parietal or oxyntic cells, and body of each gland-tube has an undulating, convoluted outline. pyloric glands are serially continuous with Brunner's glands of small intestine.

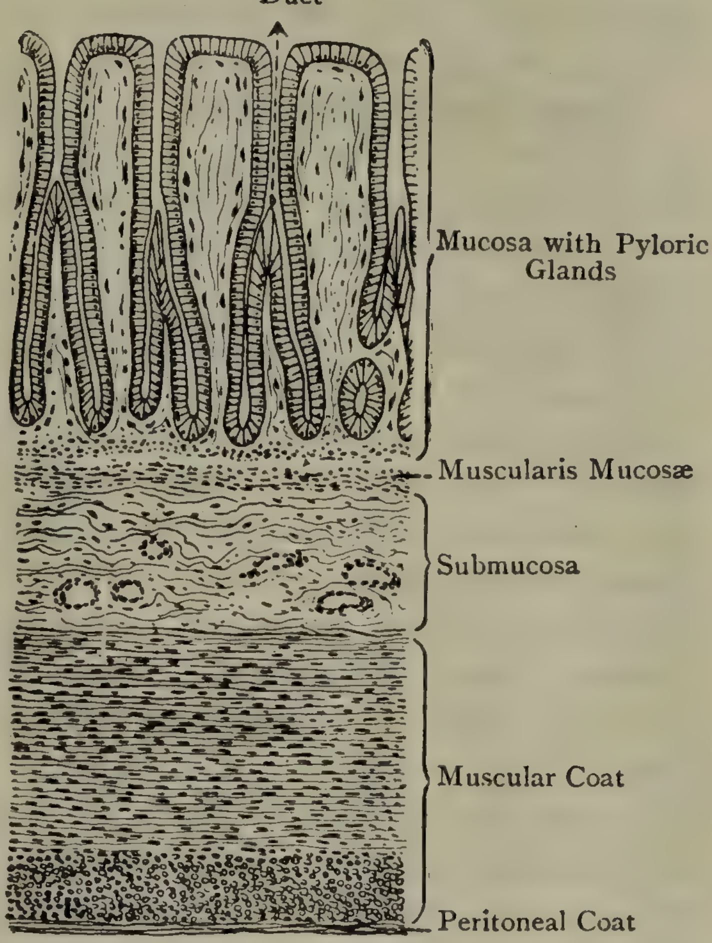


FIG. 495.—THE PYLORIC GLANDS OF THE STOMACH (HIGHLY MAGNIFIED).

Summary of the Cardiac and Pyloric Glands.

Cardiac Glands.	Pyloric Glands.
)ucts short.	1. Ducts long.
;land-tubes long.	2. Gland-tubes short.
;land-tubes almost filled with coarsely granular polyhedral cells, called central or chief cells.	3. Gland-tubes lined with cubical granular cells.
,umen very small.	4. Lumen distinct.
;land-tubes have parietal or oxyntic cells between the central cells and the basement membrane.	5. Gland-tubes destitute of parietal or oxyntic cells.

At the deepest part of the mucous coat, and forming a part of it, re is a stratum of plain muscular tissue, called the *muscularis mucosæ* (*scularis interna*), which is disposed in two layers—outer longitudinal l inner circular. The mucous membrane is also provided with phoid tissue in the interspaces between the deep ends of the gastric

glands. In the cardiac part of the stomach this lymphoid tissue occ in the form of isolated collections, called **lymph follicles,** which be resemblance to the solitary glands of the intestinal mucous membr In the neighbourhood of the pylorus these lymph follicles bec aggregated, and so resemble somewhat the aggregated lymph nodules of the small intestine.

Blood-supply—Arteries.—Along the lesser curvature there (1) the left gastric branch of the cœliac artery in two divisions, (2) the right gastric branch of the hepatic, also in two divisions. Al the greater curvature there are (1) the right gastro-epiploic of gastro-duodenal of the hepatic from the cœliac artery, and (2) the gastro-epiploic of the splenic from the cœliac artery. At the fur there are the short gastrics of the splenic artery.

The branches arising from all these arteries enter the muscular without piercing the peritoneum. They subsequently make t way inwards to the submucous coat, where they break up into branc which freely anastomose with one another. Fine branches then e the mucous coat, which run upwards between the closely-packed gas glands, round which they form by their anastomoses a delicate capil network with its meshes elongated in the direction of the gland-tu From their network somewhat larger vessels proceed upwards, wl by their anastomoses form a coarser and more superficial netw around the orifices of the ducts of the glands. The arteries along lesser curvature are smaller, longer, and not so tortuous as those al the greater curvature; further, they do not anastomose so fre features which are probably attributable to the fact that the le curvature, unlike the greater curvature, undergoes relatively li change in distension of the stomach.

Veins.—These arise from the superficial network of capilla round the orifices of the ducts of the glands. They take a downw course between the gland-tubes, and on reaching their deep ends t form a plexus. From this plexus branches proceed outwards to submucous coat, in which they form another plexus. The branc arising from this latter plexus, having passed through the muscu coat, terminate in the following veins: (1) the right gastro-epipl which opens into the superior mesenteric; (2) the left gastro-epiploic short gastrics, which open into the splenic; (3) the left gastric; (4) the prepyloric, the latter two opening directly into the portal v The veins of the stomach contain numerous valves, which are su ciently competent in early life to oppose the return of venous blc but in the adult they are incompetent.

Lymphatics.—These commence near the free surface of the muc membrane either in loups or in enlargements, and they take a do ward course between the gland-tubes, where they open into a r work of lacunar spaces. The branches which proceed from network, on reaching the deep ends of the glands, form a ple and the vessels issuing from this plexus, on entering the submuc coat, form another plexus, the lymphatics of which are furnished v

ves. The vessels which emerge from this latter plexus accompany bloodvessels, and pass to the lesser and greater curvatures, and vicinity of the hilum of the spleen. At the lesser curvature y are connected with the coronary glands, at the greater curvature 1 the subpyloric glands, lst those which accomy the short gastric ries pass through the nic glands, the efferent sels of all these glands mately passing to the iac glands. In addition the lymphatic vessels described there is a peritoneal lymphatic cus.

Fig. 495a.—Scheme (after Rouvière) of the Chains of Lymph Glands accompanying the Branches of the Cœliac Artery (CA).
G, left gastric; H, hepatic; S, splenic; Sp., spleen. Also shows the lymphatic territories of the stomach corresponding with the vascular supplies.

Nerves.—These are ded from (1) the two i nerves, and (2) symetic plexuses from the iac plexus. The **right** us nerve descends upon *posterior surface* of the nach, whilst the **left** ve descends upon the *rior surface*. The symetic plexuses closely mpany the arteries. The nerves form two gangliated plexuses posed of non-medullated nerve-fibres. One of these is situated veen the longitudinal and circular fibres of the external muscular , and corresponds to the plexus myentericus of Auerbach of the stine. The other plexus is situated in the submucous coat, and esponds to the plexus of Meissner of the intestine.

'he explanation of the right vagus nerve descending upon the posterior ice, and the left upon the anterior surface, of the stomach is found in the tion assumed by the stomach in the early embryo. Briefly stated, at that od of life the stomach is a straight tube, and its surfaces are right and left. two vagi nerves, therefore, right and left, naturally descend on the right left surfaces of the viscus. When, however, the stomach turns over on its owing to the enlargement of the omental bursa towards the left, the surface h was originally right becomes posterior, and the surface which was originally becomes anterior. Thus the right nerve eventually descends on the posterior inally the right) surface, and the left nerve descends on the anterior (originally eft) surface.

Pylorus.—The opening between the pyloric end of the stomach the duodenum is provided with a sphincter muscle, called the *ric sphincter*. This is formed by an aggregation of the *circular* cular fibres, which causes the mucous membrane to project in form of an annular fold, thus giving rise to the **pyloric valve.** The

pyloric sphincter is only relaxed when the contents of the sto
are being passed into the duodenum. At all other times it is
condition of firm contraction, and the pyloric orifice then take
form of a cleft.

The average length of the stomach is about 10 inches, and its average
at the widest part about 5 inches. Its capacity is very variable.

Development of the Stomach (for general relations, etc., of the early sto
see p. 79).—The cavity of the stomach begins to show a dilatation befo
5 mm. stage. The dilatation increases fairly rapidly, possibly in assoc
with the freedom ensured by the fact that the organ is carried on the
wall of the lesser sac; the area of the fundus is quite distinct before the e
the first month as an enlargement to the left of the line of the wall of the
which is only connected with the body and pyloric portion. The fundus
not begin to grow out to its proper size, however, before the end of the s
month.

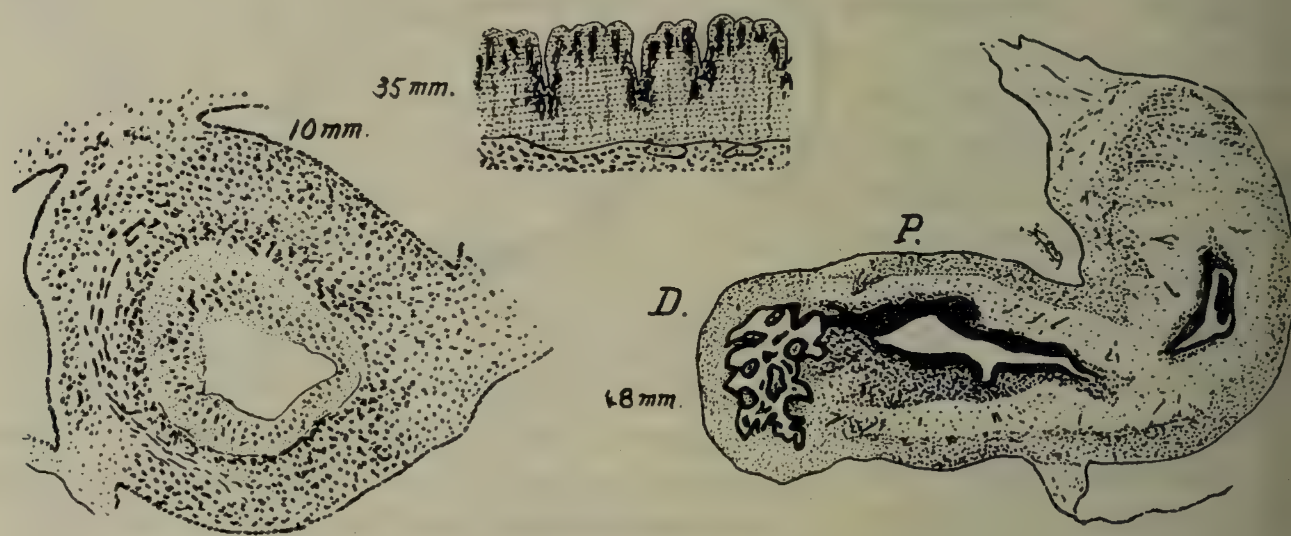


FIG. 496.—THREE SECTIONS IN REGION OF STOMACH AT DIFFEREN
DEVELOPMENTAL STAGES.

The first shows the condition of the wall at 10 mm. The second show
nature of the pits in the lining layer during the third month. The
section illustrates the sudden changes seen in the disposition of the
membrane, etc., in passing from the pyloric region (P) to the duodenum

The *lining layer* of the stomach is fairly thick, and is embedded in a
mesodermal coat. In the fifth week (Fig. 496) a faint indication of the *cir*
muscular coat can be seen on the right side of the viscus (left in figure)
lining epithelium shows several tiers of cells where cut obliquely, but prob
as in the lower part of the section, there are really some three or four layers
the middle of the second month the circular coat is more or less complete,
some indications of the other coats are to be found. The lining layer, beco
thinner as the stomach grows, shows irregularities on its free surface, espec
in the pyloric portion. The organ is now very vascular. During the
month the surface irregularities of the epithelium, now a single cell layer,
definite short pits (Fig. 496), which are not—at any rate at first—mad
folding of the layer as a whole, but by inequalities in height of its cells
mesoderm grows in later between the pits. This pitting of the epithe
appears to be more marked in the pyloric region. The pit-like appearan
due to section; they are really of the nature of *cleft-like* sinkings in the su
layer.

In the fifth month and subsequently glands are formed as secondary
growths of the floors of these pits, starting apparently from certain eosino

s, which constitute altogether or in part the floors. These eosinopile cells n to be the direct precursors of the *parietal cells* of the cardiac glands.

The cavity of the stomach presents certain folds or grooves which appear be fairly constant. Among these are two grooves which run longitudinally g the lines, more or less, of the two curvatures, and two folds project into cavity on either side of the future lesser curvature. These folds enclose the of the 'internal gastric canal,' which is thus almost as well marked in the ryo of the second month as in many adult bodies. These folds and grooves not pass into the pyloric part.

The pyloric portion of the stomach is, in the embryo, a contracted, tube-like l, much longer compared with the rest of the organ than in the adult. It ot, however, to be looked on as part of the duodenum, from which it may be nguished very early (Fig. 496).

Structure of the Intestinal Canal.

Small Intestine.—The wall of the small intestine, which is cylin-al, is composed of four coats—serous, muscular, submucous, and cous.

The **serous coat** is formed by peritoneum derived from the mesen- proper. In the case of the duodenum it is incomplete, but it ns a complete investment to the jejunum and ileum, except along rrow interval corresponding to the mesenteric border of the bowel, re the peritoneal investment becomes continuous with the two rs of the mesentery proper.

The **muscular coat (muscularis externa)** is composed of plain mus-r tissue, disposed in two layers, external or longitudinal, and rnal or circular. The *external* or *longitudinal fibres* are continuous 1 the corresponding fibres of the stomach, and they are best marked g the anti-mesenteric border. The *internal* or *circular fibres* are tinuous with the outermost fibres of the sphincter pylori, and form uch thicker layer than the longitudinal. The muscular coat attains reatest thickness in the duodenum, whence it gradually diminishes. ween the two muscular layers there is a gangliated plexus of non-lullated nerve-fibres, called the **myenteric plexus (Auerbach's plexus)**, also a plexus of lymphatic vessels.

The **submucous coat** is situated between the muscular and mucous s. It is composed of loose areolar tissue, and serves partly as a necting medium and partly as a bed in which the arteries sub-de. It contains a gangliated plexus of non-medullated nerve-es, called the **plexus of the submucosa (Meissner's plexus)**, and a us of lymphatic vessels. In the duodenum this coat lodges the denal glands, and the deep ends of the solitary nodules project it throughout.

The **mucous coat** is red and thick in the upper part of the small stine, but pale and thin in the lower part. It is covered by a le layer of columnar epithelium. The protoplasm of the cells is itudinally fibrillated. Underneath the epithelium there is a base-t membrane, known as the *subepithelial endothelium*, and under-h this is the main part of the mucous coat, which is essentially com-ed of adenoid tissue—that is to say, retiform tissue containing in

its meshes lymph corpuscles. At the deepest part of the mucous and forming a part of it, there is a stratum of plain muscular t called the *muscularis mucosæ* (*muscularis interna*), which in situations is disposed in two layers—outer longitudinal and circular. In some places, however, only the outer longitudinal is present. The mucous coat is beset all over with minute projec called villi, and is sometimes called the **villous coat.** These impart to it a woolly appearance like the nap of velvet. It dimin in thickness from above downwards, and is characterized by the follo structures: (1) circular folds, (2) villi, (3) duodenal glands, (4) intes glands, (5) lymphoid nodules, and (6) aggregated lymphoid nodule

Of the foregoing structures the circular folds, villi, and aggreg nodules constitute the *macroscopical* (naked-eye) characters o mucous membrane, the others forming its *microscopical* character

The **circular folds** (**valvulæ conniventes**) are permanent folds o mucous membrane which cannot be effaced. They are absent the first part of the duodenum for a dis of from 1 to 2 inches from the pylorus. mencing about the upper end of the second of the duodenum as small straggling folds, become large and distinct at the place o trance of the bile-duct and pancreatic (about 4 inches from the pylorus). Throug the rest of the duodenum and in the upper of the jejunum they are still prominent, an placed close to each other. In the lower of the jejunum they become smaller, and placed farther apart. In the upper part o ileum they become still smaller and more gular, and they finally disappear just be the centre of the ileum. They are cresc folds placed across the bowel, and each con of two layers of mucous membrane applied to back, with a little submucous areolar t intervening. Their average length is a $2\frac{1}{2}$ inches, and the average breadth of ea about $\frac{1}{6}$ inch. The majority of them ex round the bowel for from one-half to two-thirds of its circumfer Some, however, describe complete circles, whilst a few are arra in a spiral manner so as to describe from one to three turns roun tube. Some of them begin and terminate in bifurcated extremi whilst others present abrupt single extremities. The purpose se by the circular folds is a twofold one. In the first place they inc the extent of the absorbing and secreting surface of the mucous m brane, and in the second place they delay the passage of the intes contents, and so afford time for digestion and absorption.

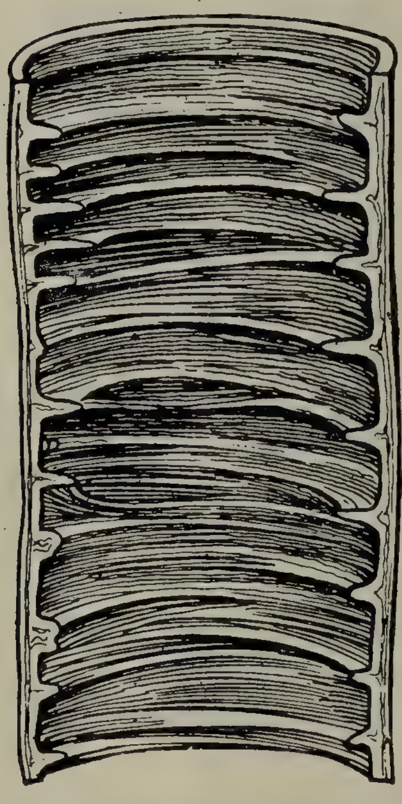


Fig. 497.—The Circular Folds.

In connection with the circular folds of the duodenum the com orifice of the bile-duct and pancreatic duct has to be noted. At

ction of the inner and posterior aspects of the second part of the odenum, where the upper two-thirds and lower third of that part et, there is a small eminence of the mucous membrane, called the **odenal papilla.** It lies at the er end of a vertically-placed l, which bifurcates so as to form ind of hood for it. From the er part of the papilla a fold ends downwards for some disce, which acts as a bridle, and es the apex a downward direc-1. On the summit of this papilla re is an opening which repre-ts the common orifice of the ducts. These ducts, having versed the wall of the second t of the duodenum obliquely $\frac{3}{4}$ inch, unite to form one duct, ch, before piercing the mucous t, presents an enlargement ed the **ampulla,** but subsequently narrows at its final ending. In ampulla a gallstone may become lodged and delayed in its down-'d progress toward the duodenum. About 1 inch above the duodenal papilla there is another small papilla upon which there is another minute opening. This represents the orifice of the accessory pancreatic duct.

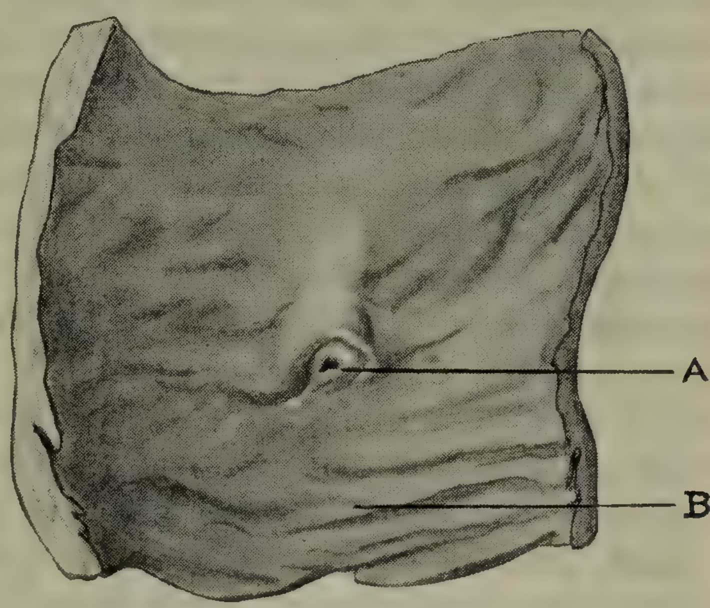


FIG. 498.—DUODENAL PAPILLA.
A, papilla; B, circular folds.

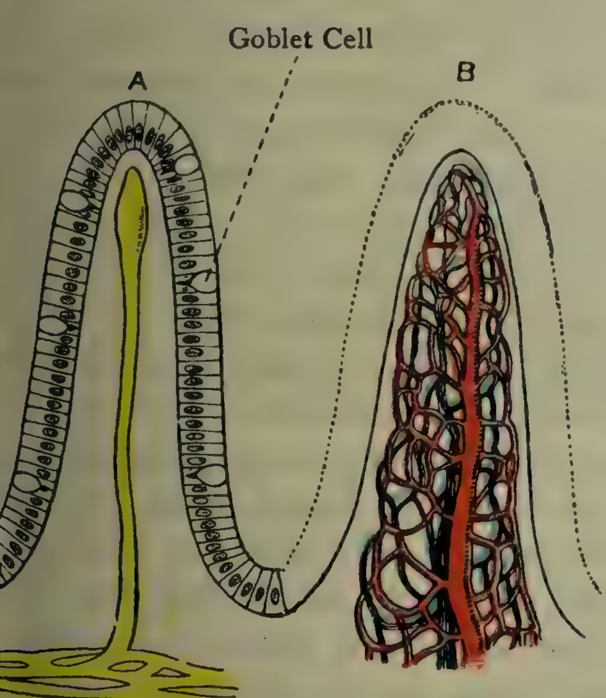


FIG. 499.—TWO VILLI.
villus, showing striated basilar order, columnar epithelium, goblet lls, and lacteal vessel; B, villus, owing the capillary bloodvessels.

The **villi** commence at the beginning of the duodenum on the outer side of the pylorus, and extend as far as the margins of the segments of the ileo-colic valve. They are minute projections of the mucous membrane, to which they impart a velvety appearance, and may be visible to the naked eye, but are more readily seen with the aid of an ordinary lens if a portion of bowel is floated in water. They are closely set upon the mucous membrane (circular folds included), except over the solitary glands. Their total number is said to be about four millions (Krause). The are conical, cylindrical, leaf-like or finger-like processes, varying ength from $\frac{1}{30}$ to $\frac{1}{40}$ inch. They are larger and more numerous he lower part of the duodenum and in the jejunum, especially at

its upper part, than in the ileum, and they diminish both in size number from above downwards, becoming somewhat filiform in ileum. Each villus is an elevation of the mucous membrane coverec a single layer of columnar epithelium. It is composed of (1) ade tissue, (2) a capillary network of bloodvessels, (3) one or more lac vessels ensheathed by plain muscular tissue, and (4) arborization nerve-fibrils derived from the plexus of the submucosa.

Between the columnar epithelial cells of the free surface there amœboid lymph corpuscles. Beneath the epithelium is a basen membrane composed of flattened cells, and known as the *subepith endothelium.* The cells of this basement membrane send proce between the columnar cells of the free surface, and also are conne with the branched cells of the retiform tissue of the adenoid tis One artery (sometimes two) enters the base of the villus and asce to near the centre. Here it breaks up into a number of branc which form a copious capillary network. From this plexus the b is returned by one or two venous radicles, which leave the villu its base, where they open into the venous plexus of the mucous m brane. In the centre of the villus there is a **lacteal vessel,** which c mences near the tip in a blind bulbous extremity, or if there shoul two lacteals, they originate in the forn a loop. The wall of the lacteal vesse formed by a single layer of endothelial pla which are connected by processes with branched cells of the retiform tissue of adenoid tissue. The vessel is ensheathed longitudinal plain muscular fibres der from the muscularis mucosæ, their fi cells being connected with the basen membrane of the villus. The villus is vaded by adenoid tissue—that is to retiform tissue with its meshes filled amœboid lymph corpuscles. The branc cells of this retiform tissue are connected processes, on the one hand, with the en thelial plates which compose the wall of lacteal vessel, and on the other hand the cells of the basement membrane near surface, and these latter in turn send processes between the columnar epith cells of the free surface.

FIG. 500.—SECTION OF THE DUODENUM, SHOWING DUODENAL GLANDS (HIGHLY MAGNIFIED).

The villi play a most important par absorption, partly through their cop capillary networks, and partly through t lacteals. The lacteals serve specially for absorption of fats, which is probably effected in the following man the columnar epithelial cells at the free surface take up the saponi and emulsified fats, which they transfer to the amœboid lymph

iscles between them. These corpuscles then carry the fats inwards rough the adenoid tissue into the lacteal vessel.

Duodenal glands (Brunner's glands) are confined to the duodenum, id are serially continuous with the pyloric glands of the stomach. ney are very numerous in the commencement of the duodenum, nere they form a continuous layer of gland tissue extending as low the entrance of the bile-duct and pancreatic duct. Beyond this int they gradually diminish in number, and ultimately disappear ar the duodeno-jejunal flexure. They belong to the class of race-ose or acino-tubular glands, and they differ from the pyloric glands the stomach in having their tubules more branched and in having

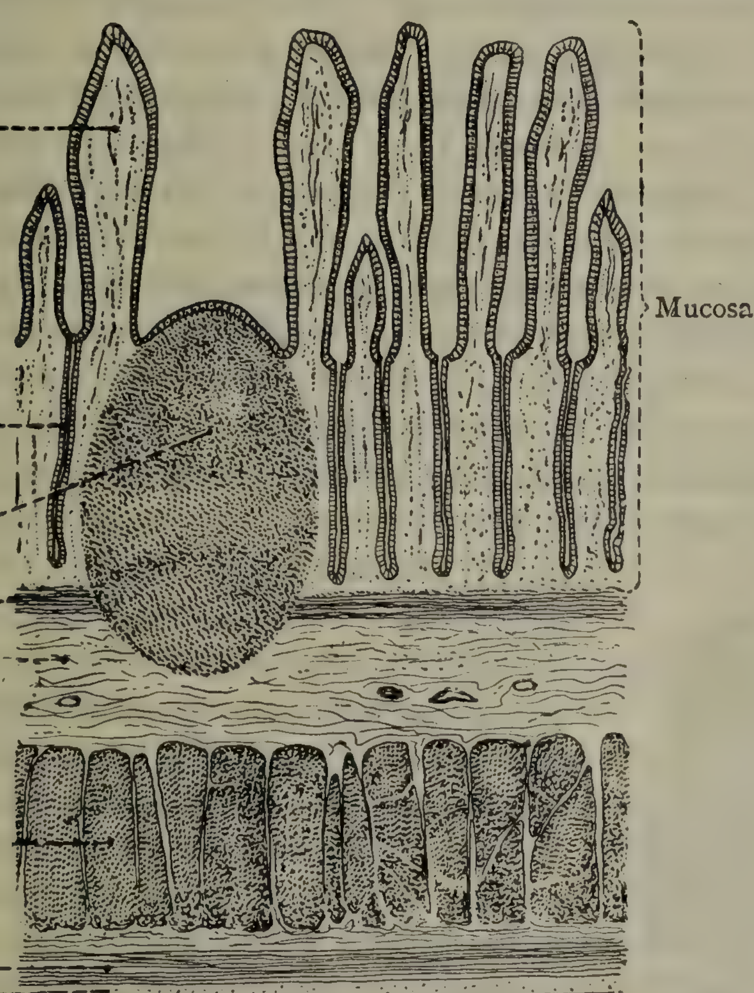


FIG. 501.—VERTICAL TRANSVERSE SECTION OF THE SMALL INTESTINE (HIGHLY MAGNIFIED).

iger ducts. Otherwise the structure of the two kinds of glands is nilar. The duodenal glands lie embedded in the submucous coat, l their long ducts pass through the whole thickness of the mucous it, upon the surface of which they open between the intestinal glands. me of them, however, open into these glands. The glands can easily displayed by removing the peritoneal and muscular coats of the odenum and a little of the submucous areolar tissue, when they oear as small, round, grey-coloured masses like millet seeds, varying diameter from $\frac{1}{12}$ to $\frac{1}{50}$ inch.

The **intestinal glands (crypts of Lieberkühn)** are found in large nbers over the whole of the mucous membrane of the small intestine, well as that of the large bowel. They belong to the class of simple

tubular glands, and are to be regarded as small diverticula of tl mucous membrane. Each gland takes the form of a simple tub which is closed and slightly enlarged at its deep extremity, and oper by its other end on the surface between the villi. The glands ai present on the circular folds as well as in the intervening parts. The are placed vertically and close together, and are confined entirely to tl mucous coat, in which they extend from the free surface to the muscı laris mucosæ. In length they vary from $\frac{1}{60}$ to $\frac{1}{180}$ inch. Each glan is composed of a basement membrane lined with columnar epitheliun and the lumen is of large size.

The **solitary nodules** are present over the whole extent of the mucoı membrane of the small intestine. They assume the form of small, whit round, or oval nodules, which project by their deep ends into the sul mucous coat, whilst their superficial ends give rise to slight elevatior of the free surface, where they have the openings of the intestin: glands placed around them. They are found upon, as well as betweer the circular folds. In structure each solitary nodule is composed (adenoid tissue containing large numbers of lymph corpuscles, and pe: meated by capillary networks. Each nodule is surrounded at its dee part by a copious plexus of lymphatic vessels, or by lymphatic sinuse The solitary nodules are simply lymphoid tissue.

The **aggregated nodules (Peyer's patches)** are peculiar to the sma intestine, and average about thirty in number in the adult, bein more numerous in early life. They are situate along the free or anti-mesenteric border of th bowel, which must therefore be opened alon its attached or mesenteric border in order t preserve them. They are largest, best markec and most plentiful in the lower half of the ileun In the upper part of the ileum and lower pa of the jejunum they become smaller and mo scarce, and they disappear as a rule above th centre of the jejunum. They vary in lengt from $\frac{1}{2}$ inch to 4 inches, their breadth rangin from $\frac{1}{2}$ inch to 1 inch. They are for the mos part oblong, their long axis coinciding with tha of the bowel. In the upper part of the ileur and lower part of the jejunum, however, the are somewhat circular. Each aggregated nodul is composed of a group of solitary lymphoi nodules, surrounded by lymphatic plexuses c lymphatic sinuses. The area of each aggregate nodule is slightly elevated, and there are no vil over the lymphoid nodules, whilst the opening of the intestinal glands are arranged in circular manner round each nodule. There are no circular folds ove the aggregated nodules. The aggregated nodules are best marke in young persons. Towards middle life they fade away, and in ol

FIG. 502.—AN AGGREGATED LYMPHOID NODULE.

persons they are usually only distinguishable as discoloured portions of the mucous membrane.

Blood-supply—Arteries.—The duodenum receives its arteries from the superior pancreatico-duodenal of the gastro-duodenal from the hepatic, and the inferior pancreatico-duodenal of the superior mesenteric. The jejunum receives its arteries from the jejunal branches of the superior mesenteric. The ileum receives its arteries from the ileal arteries, and its terminal part in addition receives its arterial supply from the ileal branch of the ileo-colic from the superior mesenteric.

Veins.—The destination of the venous blood of the small intestine is the superior mesenteric vein, and thereafter the portal vein. The veins are provided with valves which are competent in early life, but in the adult they are incompetent, and therefore allow regurgitation of blood to take place towards the small intestine, as happens in cases of portal obstruction.

Lymphatics.—These form a copious plexus of valved vessels, which is situated in the submucous coat. This plexus receives the lymphatics of the mucous membrane and the lacteals of the villi, and it surrounds the deep ends of the solitary nodules. Its efferent vessels pierce the muscular coat, and in doing so they take up the lymph from an intramuscular plexus of lymphatics, which lies between the longitudinal and circular layers. They then leave the bowel at the mesenteric border, where they pass between the two layers of the mesentery, and on their way to the cisterna chyli they traverse the superior mesenteric glands.

Nerves.—These are derived from the superior mesenteric sympathetic plexus, and they form two gangliated plexuses of non-medullated nerve-fibres. One of these is situated in the muscular coat between the longitudinal and circular layers, and is known as the **myenteric plexus** (**Auerbach's plexus**) (plexus of the muscular coat of the intestine). The other is situated in the submucous coat, and is called the **plexus of the submucosa** (**Meissner's plexus**). The branches of this latter plexus are distributed to the muscularis mucosæ and the mucous membrane with its villi.

Characters of Different Parts of the Small Intestine—Duodenum—*Peritoneum.*—There is no mesentery and only a partial investment of peritoneum. *Muscular coat.*—This is very thick. *Submucous Coat.*—This contains the tubular portions of the duodenal glands. *Mucous Coat.*—The characters of this coat are as follows: (1) circular folds, except in the first 1 or 2 inches, (2) villi, (3) intestinal glands, (4) solitary nodules, (5) ducts of the duodenal glands, (6) common orifice of the bile-duct and pancreatic duct, and (7) orifice of the accessory pancreatic duct.

The diameter of the duodenum is from 1½ to 2 inches.

Jejunum—*Peritoneum.*—There is a mesentery, and the bowel is surrounded by peritoneum except along its mesenteric border. *Muscular Coat.*—This is comparatively thin. *Mucous Coat.*—This has the following characters: (1) circular folds, (2) villi in abundance, (3) intestinal glands, (4) solitary nodules, and (5) aggregated lymphoid nodules in its lower half.

The diameter of the jejunum is about 1½ inches.

Ileum—*Peritoneum.*—In this respect the ileum resembles the jejunum.

Muscular Coat.—This is very thin. *Mucous Coat.*—The characters of this co are as follows: (1) circular folds in upper half, but small and sparse, there bei none in the lower half; (2) villi, but in fewer numbers; (3) intestinal gland (4) solitary nodules; and (5) aggregated lymphoid nodules.

The diameter of the ileum is about 1¼ inches.

Development of Small Intestine.—The *epithelial lining* is at first like th of the stomach, and the *muscular coat* develops also in a similar way. **Vacuol** appear in the epithelium, leading in the duodenum to subdivision of the lume but not in the rest of the gut, where, however, they may produce *pouches.* **Vi** appear in the upper part first, about the seventh week, and are found througho the gut in the fourth month. They may form by the breaking up of longitudin ridges, or may form separately. *Glands* develop as simple pits between villi the fourth month, first in the upper gut. They tend to branch later. *T duodenal glands* seem to be formed from the simple forms by lateral branchi and growth in length during the fourth month. They are not fully formed birth, however.

Large Intestine.—The wall of the large intestine, which is sacculate is composed of four coats—serous, muscular, submucous, and mucou

The **serous coat** forms a complete investment to the vermifor appendix, cæcum, transverse colon, and pelvic colon. As regar the ascending colon and descending colon, it is incomplete, being abse *behind.*

The **muscular coat** (**muscularis externa**) is composed of plain muscul tissue disposed in two layers—external or longitudinal, and internal circular.

The *longitudinal muscular fibres* are for the most part collected in three flat bands, called **tæniæ coli,** except upon the rectum. In t intervals between these bands there are some longitudinal fibres, but the are very few and scattered. The tæniæ, which are about ¼ inch breadth, commence upon the cæcum at the base of the vermiform a pendix, and they extend along the several parts of the large intesti as far as the rectum, where they spread out and form a continuo covering, which completely surrounds that part of the bowel. Upo the cæcum, ascending colon, descending colon, and iliac colon the teni from their disposition are called anterior, postero-internal, and poster external. Upon the transverse colon they are so placed as to be calle anterior or omental (greater omentum), postero-inferior or free, an superior or meso-colic (transverse meso-colon). They are shorter tha the bowel to which they are applied, with the result that the tube drawn together or puckered, and thus thrown into sacculi. The being three tæniæ, there are three rows of sacculi between them, an inasmuch as the tæniæ are placed at nearly equal distances from eac other, the sacculi are pretty much of equal dimensions. Between t successive sacculi there are constrictions, usually containing fat. T sacculi give rise internally to large pouches, and the constrictio between the sacculi produce internally sharp crescentic rugæ, whic separate the pouches from each other. When the tæniæ are divide the sacculi and constrictions entirely disappear, and the large bow becomes elongated into a smooth cylindrical tube. Along the cours of the tæniæ there are a number of small processes of peritoneum co

ining fat, called **appendices epiploicæ.** They are best marked on the ansverse colon and on the upper part of the pelvic colon, and are least arked, as a rule, on the cæcum. Except in the case of the transverse olon, these are chiefly found along the postero-internal tænia, but in ie case of the transverse colon they are principally met with along the ostero-inferior tænia.

The **circular** fibres are thin and scattered over the sacculi, but in ie constrictions between them they become aggregated. Upon the ctum and anal canal they form a thick layer, which in the latter tuation is known as the sphincter ani internus.

The **submucous coat** is in all respects similar to that of the small testine.

The **mucous coat** is pale and greyish in colour, except in the rectum, here it is red. Its epithelium is similar to that of the small intestine. : is destitute of circular folds and villi, and consequently presents a nooth surface. It contains large numbers of intestinal glands, which bound in mucus-secreting goblet cells. It also contains solitary mphoid nodules, which are especially prevalent in the vermiform ppendix and cæcum. The deepest part of the mucous coat is formed y the *muscularis mucosæ* (*muscularis interna*).

Blood-supply—Arteries.—These are as follows: (1) appendicular, or the vermiform appendix; (2) anterior and posterior cæcal, for the æcum; (3) colic of ileo-colic and right colic, for the ascending colon; 4) middle colic, for the transverse colon (all branches of the superior iesenteric); (5) left colic, for the descending colon; and (6) sigmoid rteries, for the iliac colon and pelvic colon (the latter two being branches f the inferior mesenteric).

Veins.—The destination of the venous blood of the vermiform ppendix, cæcum, ascending colon, and transverse colon is the superior iesenteric vein, whilst the blood of the descending colon, iliac colon, nd pelvic colon is carried into the inferior mesenteric vein. In both ases the further destination of the blood is the vena portæ. As in the mall intestine, the veins have valves which are competent in early life, ut not so in the adult.

The **lymphatics** will be found described on pp. 799 and 802.

Nerves.—These are derived from the superior mesenteric sympahetic plexus and the inferior mesenteric plexus, which latter is an ffshoot from the aortic plexus. The disposition of the nerves correponds with that in the small intestine.

The large intestine diminishes gradually in size from its commencenent to its termination. Its diameter varies in different parts, the xtremes being $2\frac{1}{2}$ inches and 1 inch.

Characters of the Large Intestine—*Peritoneal Coat.*—This presents at frequent ntervals small projections called appendices epiploicæ. *Muscular Coat.*—The ongitudinal fibres are for the most part arranged in three tæniæ. *Mucous Coat.*—This is destitute of (*a*) circular folds, (*b*) villi, (*c*) duodenal glands, and *d*) aggregated nodules, but it is provided with (1) intestinal glands, and (2) solitary iodules. *Outline of Tube.*—The bowel presents three rows of sacculi, except in he vermiform appendix and rectum.

Development.—There is nothing remarkable about the *epithelial* grow which resembles that of the small gut. The *lumen* is at first very small and walls thick. The bowel begins to enlarge about the time of its entrance i the belly, but even then is much smaller than the small intestine. *Villi* deve in it during the fourth month, but become smaller and less distinct during succeeding months. *Glands* form between the villi, but the details of their forn tion are not known with certainty. *Villi* are found in the **vermiform appen** in the fourth month, with gland formation.

Structure of the Vermiform Appendix.—The vermiform appenc is entirely covered by peritoneum, which forms a more or less compl

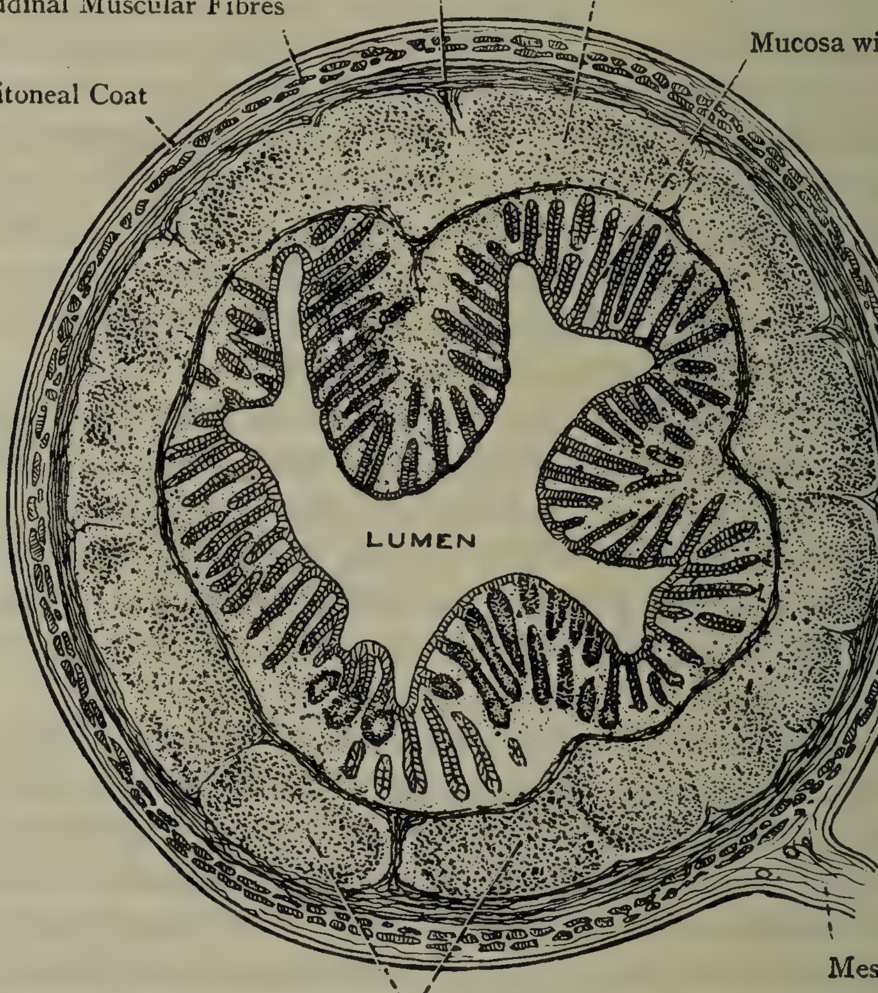


FIG. 503.—TRANSVERSE SECTION OF THE VERMIFORM APPENDIX (MAGNIFIED).

meso-appendix or appendicular mesentery. It has a muscular coa composed of an external longitudinal and internal circular layer, both which completely surround it. The submucous coat contains in grea abundance solitary nodules of large size, and the mucous coat contair a few solitary nodules, as well as a few intestinal glands. The base the appendix is situated at a point on an average rather more tha 1 inch below the ileo-colic valve, according to Treves. The openir by which the appendix communicates with the cæcum is occasionall guarded by a fold of mucous membrane, which is known as the **ileo-col valve (valve of Gerlach).**

The vermiform appendix is usually regarded as the remains of the herbivorous æcum. It is also looked upon as an appendage of the lymphoid system, and as ıch it would belong to the class of structures represented by aggregated nodules –namely, lymphoid organs.

Ileo-colic Valve (Valve of Tulpius).—This valve is situated at the oint where the terminal part of the ileum opens into the junction etween the cæcum and ascending colon. The orifice, as seen from the ıterior of the large intestine, has the form of a slightly oblique cleft bout ½ inch long, and running in an antero-posterior direction. It is ounded above and below by the two segments which form the valve, nd which project into the large intestine. The upper or *ileo-colic egment* is prominent, and occupies an almost horizontal plane. The

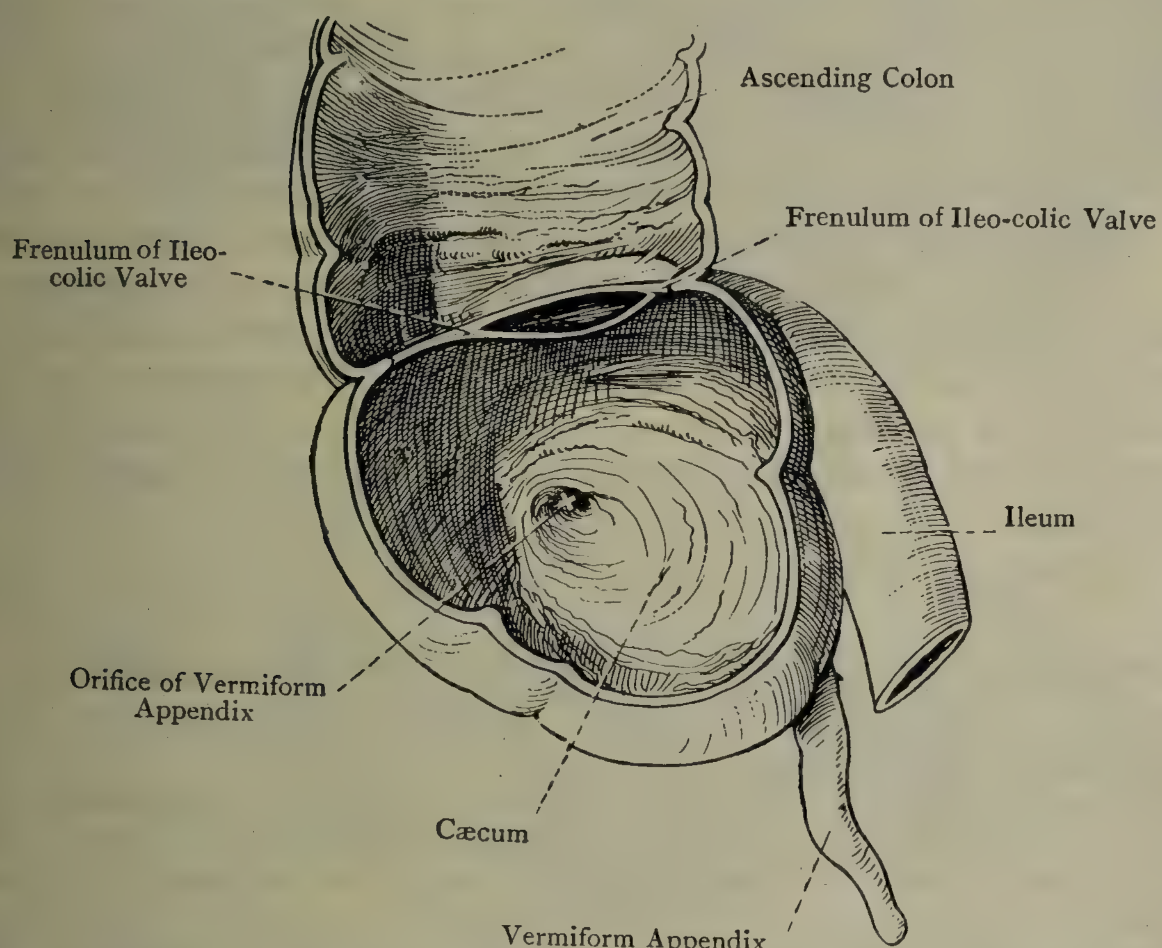


FIG. 504.—THE INTERIOR OF THE CÆCUM AND THE ILEO-COLIC VALVE.

ɔwer or *ileo-cæcal segment,* longer than the upper, is concave superiorly, ınd occupies an oblique plane. The anterior part of the cleft is rounded ff, whilst the posterior part tapers to a point. The segments meet in ront of and behind the cleft, and form two prominent folds, which are ɔrolonged round the wall of the bowel for some distance. These folds ıre known as the **frenula.** Each segment is composed of two layers f mucous membrane, one of which belongs to the ileum, and the other o the cæcum or colon, as the case may be. These two layers are con- inuous with each other at the free margin of the segment, and they ontain between them submucous areolar tissue and circular muscular ibres, both of which are derived partly from the ileum and partly from he large intestine. The longitudinal muscular fibres and the serous or ɔeritoneal coat take no part in the formation of the segments, being

continued uninterruptedly from the ileum to the large intestine. mucous membrane which covers the opposed surfaces of the segme belongs to the ileum, and is therefore provided with villi. The muc membrane of the other surfaces—that is to say, the surfaces which l away from each other (downwards and upwards respectively)—bel to the cæcum and colon, and are destitute of villi. The villi thus appear at the margins of the segments. The valve may be descri as being formed by an inversion of the terminal part of the ileum i the large intestine. That part of the ileum, having passed upwa and to the right with a slight inclination backwards, enters the la intestine. As it does so it leaves behind its serous and longitudi muscular coats, and takes with it its circular muscular, submuco and mucous coats, the corresponding coats of the large intest accompanying it in the inversion. The ileo-colic valve prevents regurgitation of the contents of the cæcum into the ileum. It generally believed that the mode of action of the valve is as follo when the cæcum becomes distended the frenula of the valve are stretc and exercise traction upon its segments, which are thereby brou together. The valve is usually represented in figures as it appears w the cæcum has been inflated and dried. In the fresh condition segments of the valve are thick and tumid, and the appearance is unlike that of the pyloric valve as seen from the duodenum or of cervix uteri as seen from the vagina; the frenula, again, are much l apparent in such a cæcum.

For the structure of the rectum, see p. 960.

Development of Positions of the Stomach and Intestinal Canal.

This subject is dealt with shortly on pp. 61-65 and 79-81. These pa should be studied before reading what follows.

Dorsally, the roof of the mid-gut is at first close to the **notochord**, but, growth goes on, it comes away from this close relationship, drawing out mesoderm between them as it does so, to form the *dorsal mesentery*; the man in which this change is effected is not quite clear.

At an early stage, therefore, the alimentary tube in the abdomen can described as being *short*, *median* in position, extending from the septum tra versum to the cloaca, and, between these limits, making a short *curve*, con ventrally, and suspended by a *median dorsal mesentery*. The **vitelline duct** attached to it at the lowest part of its curve, and as development proceeds intestinal loop lengthens, so that this lowest part of it passes out of the abdom into the 'umbilical sac.' The elongation of the loop implies a correspondi lengthening of the dorsal mesentery opposite it (see Fig. 44).

Stomach.—This is a dilatation of that part of the tube which is resting the septum transversum. Its attachment here lengthens and thins as the li grows in the septum, and at the same time its dorsal mesentery (**meso-gastriu** is pouched out to the left, carrying the stomach with it, and turning it so th its left surface becomes somewhat ventral. The pouch of dorsal meso-gastri is known as the *omental bursa*.

Intestinal Canal.—This canal is at first very short and almost straight, a as has been stated, it communicates freely with the yolk-sac. At this st there is no indication of a division into small and large intestine. When wide opening leading to the yolk-sac becomes constricted and converted i the vitelline duct, the intestinal canal undergoes lengthening, and a conspicu

) is formed, which projects into the cavity of the proximal part of the umbilical l, this cavity being a direct prolongation of the cœlom or body-cavity. This) is spoken of as the **U-loop.** The convexity of the bend of the loop is directed *ralwards,* and the vitelline duct is connected with the convexity. The loop two limbs, which lie at first parallel to each other. One limb is *cephalic, er,* or *proximal,* and leads from the duodenal loop of the gut; the other limb *audal, lower,* or *distal,* and leads to the caudal end of the gut. Upon the *al limb* a bud makes its appearance. This assumes the form of a blind diver- lum, or cul-de-sac, which is the **rudiment of the cæcum.** The appearance of cæcal evagination is the first indication of the division of the intestinal canal) small and large intestine. The *primitive small intestine* is the part on the

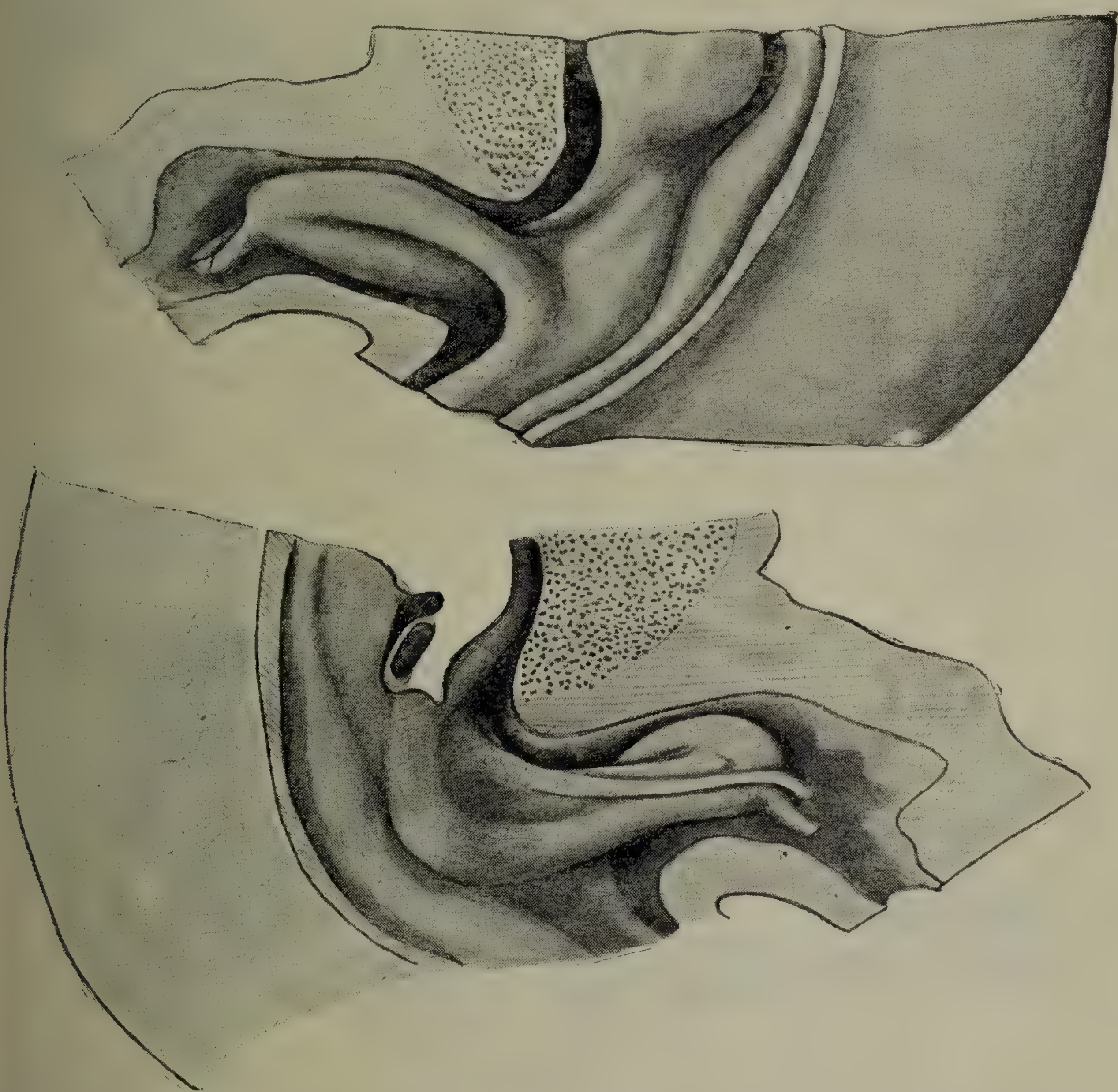


FIG. 505.—THE U-LOOP, 8 MM., JUST PROJECTING INTO THE UMBILICAL SAC. Left and right views. Vitelline duct cut short.

ximal side of the rudimentary cæcum, and the *primitive large intestine* is the rt extending from the rudimentary cæcum to the caudal end of the gut.

The portion of mesentery which is drawn out as the proper **mesentery of the loop** contains the *superior mesenteric* artery between its layers. The artery originally continued on beyond the loop as the **vitelline artery,** but this soon appears and leaves its trunk as the superior mesenteric.

As the stomach lies in the front wall of the **rudimentary lesser sac (bursa entalis),** its pyloric end is directed towards the right, and the very short piece the tube which comes next, the future *duodenum,* lies rather to the right of the ddle line, and is attached to the median common dorsal mesentery by a thick *so-duodenum,* which projects on that side of it, just below the opening of the ser sac.

The intestinal tract is thus seen to consist of intra- and extra-abdom portions, part of the colon being in the abdomen, and the anterior limb of loop being connected with the duodenum by an intra-abdominal duod umbilical loop of gut.

These different parts of the intestinal tract can be seen in Fig. 505, in w the conditions in a 8 mm. embryo simplified are shown from both sides; the lobe of the liver has been cut away to expose the mesentery and gut, for it co down at this stage on the left side of the bursa omentalis and mesentery a as the right lobe on the other side. The neck of the umbilical loop of gut pa out between the two lobes of the liver in a deep notch in the ventral edge of

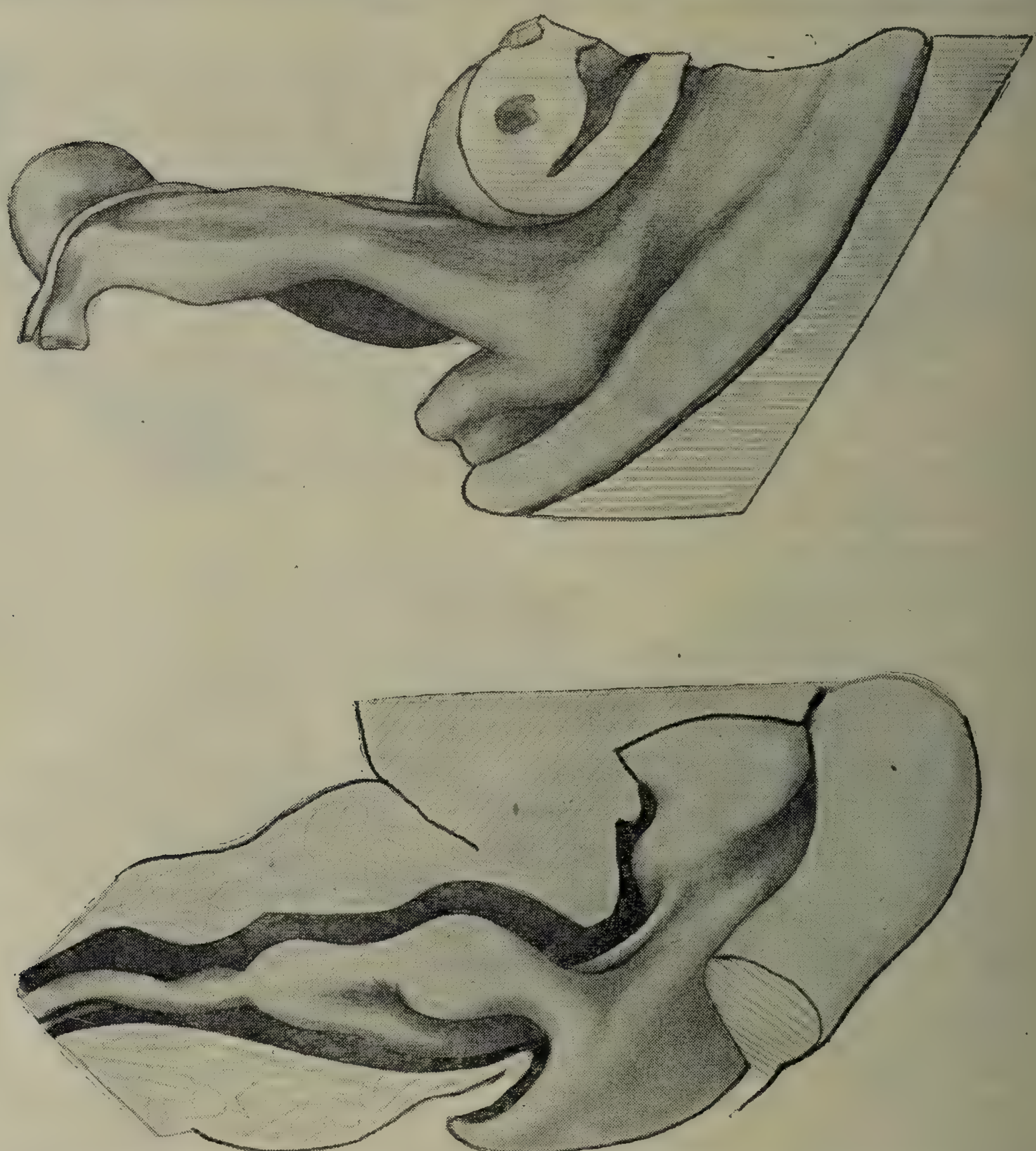


FIG. 506.—LEFT-SIDED VIEWS OF UMBILICAL LOOP AT 9 MM. (ABOVE) AND 10 I (LOWER FIGURE).

organ. An angled bend is seen where the hind-gut is continuous with the hin limb of the loop; this is produced by the attachment here to the gut of a **retent band** in the mesentery, extending from the peri-aortic region in the neighbourho of the cœliac artery. The angle must not be mistaken for the left colic flexu with which it has nothing to do; it is gradually effaced as development procee and its ultimate position, if it persisted, would be some little distance to t left of the mid-point of the transverse colon.

With the exception of the short length of the duodeno-umbilical piece, wh becomes the first coil of the jejunum, the *small intestine* is formed in the umbili sac, as are those parts of the *large gut* which become the *ascending* and *right h of the transverse colon.* Formed in this sac, the gut enters the abdomen a

ain stage, and within this cavity is finally disposed in its proper situations. processes that lead to the 'rotation' of the intestine can thus be divided descriptive purposes into three stages—the development outside the belly, entrance into the abdomen and the immediate mechanical results of this nge, and the subsequent assumption of the definitive positions.

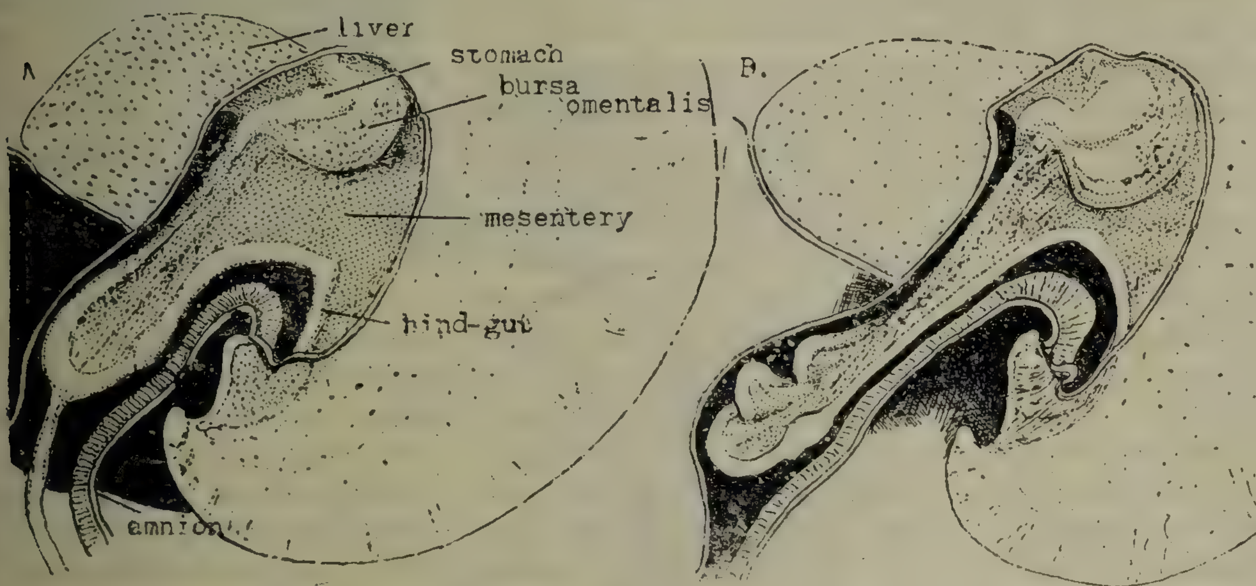
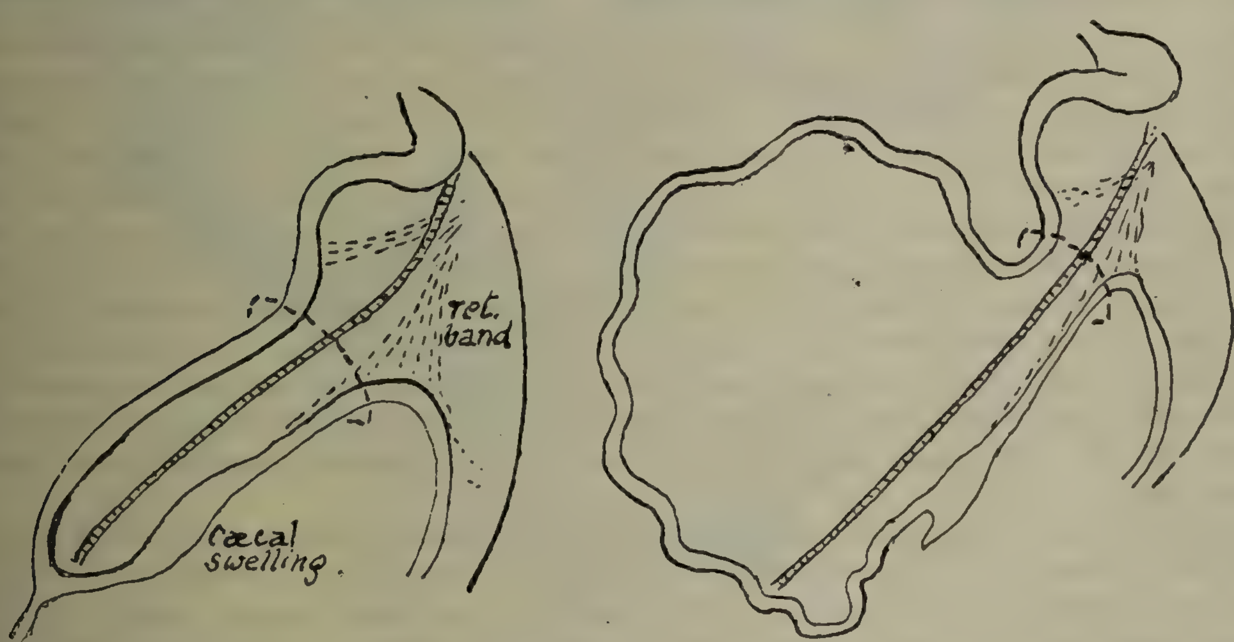


FIG. 507.—TWO DIAGRAMS TO SHOW EARLIER STAGES OF GUT AND MESENTERY WITHIN THE BELLY AND IN THE UMBILICAL SAC.

First Stage.—The general disposition in the earlier part of this stage can be n in Fig. 507, A and B. It is marked by the fairly rapid growth in length of anterior or proximal limb of the umbilical loop, forming coils. The **rudi-ntary lesser sac** enlarges, passing down on the left side of the **median abdominal sentery,** between it and the liver. Two or three points in connection with the



3. 508.—SCHEMES OF THE UMBILICAL LOOP SHOWING THE SORT OF GROWTH-CHANGES THAT OCCUR WITHIN IT (SEE TEXT).

ngating proximal limb must be noted, as they are concerned with the subse-ent entry and disposal of the gut within the belly cavity: in the first place, proximal limb lies, from an early stage *on the right side** of the loop, as can

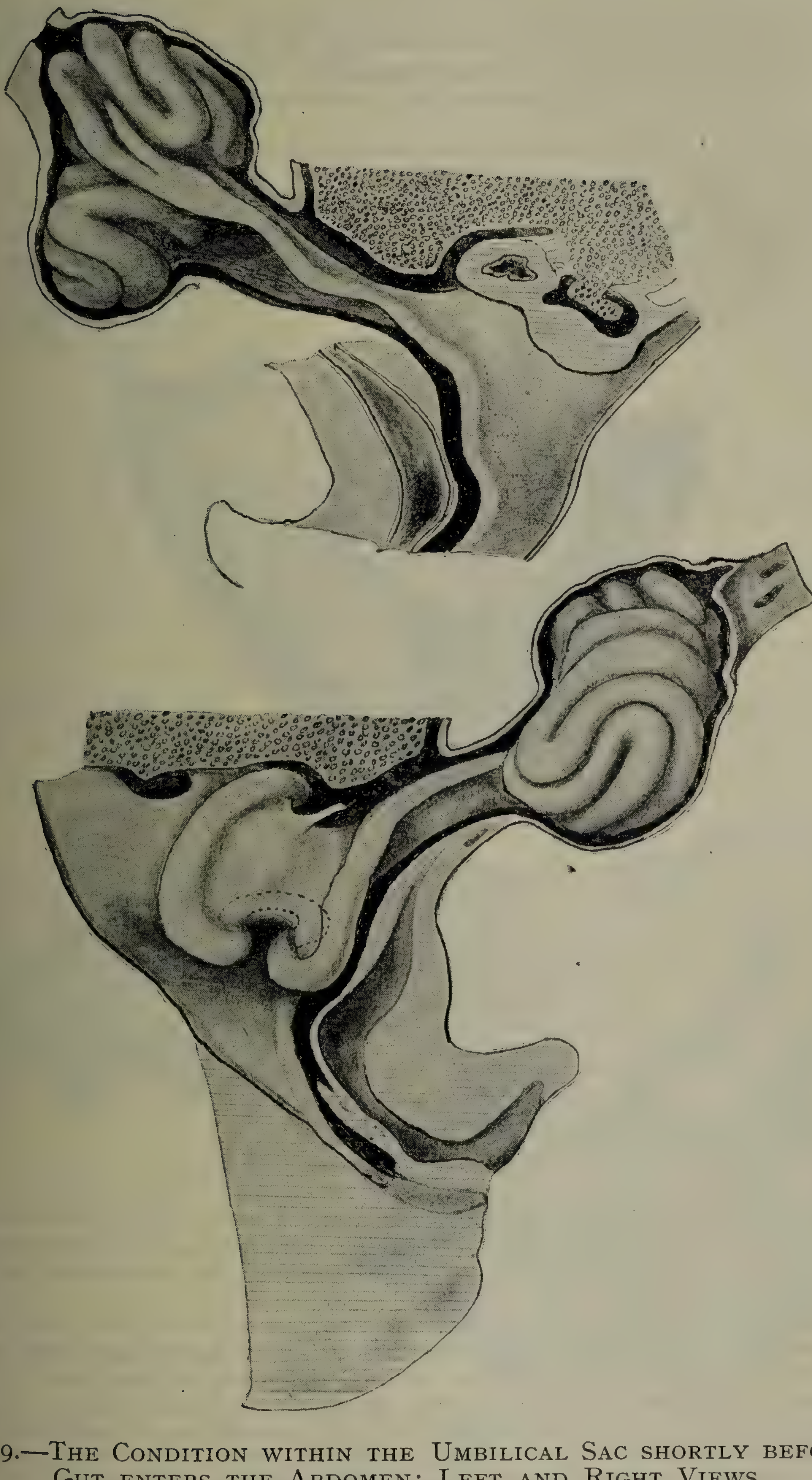
* The immediate cause of this is not certain. It may be due to the position the stomach, making the duodenum pass towards the right, or it may be sociated with the development of the vitello-umbilical anastomosis, which s in the concavity of this part of the limb of the loop, but any definite state-ent on the subject would be unwarranted.

be seen in the figures; secondly, the growth of the proximal limb is associated w marked increase in the depth of the corresponding mesentery of the loop, that the distance between the coils of this limb and the superior mesente artery is much increased; the hinder limb of the loop does not grow like proximal limb, and its distance from the artery remains unchanged, whence comes about that the artery gets *relatively* nearer and nearer to the hinder li of the loop. At the back of the loop, where it is passing through the open in the abdominal wall, the artery is still approximately midway between the t limbs, and it is only distal to this that the unequal growth of the constituent pa of the mesentery of the loop leads to the one-sided position of the vessel.

Fig. 509 illustrates the appearance at the end of the first stage. The **caec** is now a large dilatation with a conical extremity, placed on the left side of mass of coils of small intestine. The mesentery of the small gut is long, and superior mesenteric artery is close to the colon and cæcum. The bursa oment really extends caudally along the whole extent of the left side of the int abdominal colon and meso-colon, separating these from the left lobe of the liv in the figure, however, it is shown as somewhat pushed up, to allow the med colon and meso-colon to be seen. At the end of this stage, then, the intesti coils are on the right of the cæcum and colon in the umbilical sac, the super mesenteric artery is close to the colon and far from the coils, and the bu omentalis is on the left of a ' median abdominal septum ' made of abdominal co and meso-colon.

Second Stage.—The recession of the umbilical gut within the belly is broug about by a fall in ' intra-abdominal tension ' resulting from lessened growth-r of the liver. This organ fills all the available space in the abdomen during second month, growing *pari passu* with the surrounding parts, but in the ea part of the third month its rate of growth falls behind that of these parts. T does not at first affect the mass in the umbilical sac, and is met by increase in amount of blood in the liver vessels, which are consequently dilated. In tenth week, however, approaching the 40 mm. stage, this dilatation of li vessels may be considered to have reached its maximum, and any further incre in the capacity of the abdomen calls for the appearance of some additional su stance to fill the space which otherwise must come into being. The umbili coils are alone able to fulfil this role, and the extra-abdominal or amniotic press not being lessened by the fall in the growth-rate of the liver, the contents of umbilical sac are pushed by it into the abdomen to compensate for the inter fall. It is to be noted now that as the coils enter the abdomen the liver can retr before them by the discharge of blood from its over-dilated vessels. Thus distension of the liver not only leads to the beginning of the intestinal mo ment, but, by its disappearance and the tendency of the organ to return to undistended condition, leads to the completion of the recession and the provisi of space for the entering coils when and where it is needed, without any press on these coils.

The movement having started, all the evidence points to it being rapi completed. Owing to the size of the cæcum, possibly also owing to the gr size of the dilated venous spaces found round it at this stage, and to the sm size and thick wall of the colon, the *cæcum is retained in the sac to the last,* a the *proximal limb passes first into the abdomen.* It does this, not *en masse,* in continuity, slipping into the belly with its mesentery, the elongation of wh allows it to enter the abdomen, although the superior mesenteric vessels a the colic part of the distal limb are still in the sac. But the proximal limb already been seen to be on the right-hand side of the distal limb, so that it ent the abdomen below the right lobe of the liver, which retreats before it—that the coils of intestine *enter the belly on the right-hand side of the median colic ' septu* (Fig. 509) already mentioned. This ' septum ' of abdominal colon and me colon is thus pushed over to the left by the coils, as seen in Fig. 510, and l back against the left dorsal wall of the abdomen, the coils lying on its vent (originally right) surface. Crossing in this way to the left, the coils *necessar pass below the colic part of the distal limb of the loop and the mesenteric artery,* wh



. 509.—The Condition within the Umbilical Sac shortly before the Gut enters the Abdomen: Left and Right Views.

is, as already seen, associated with this limb. Moreover, in going to the le and in pushing the median septum to this side, the coils have passed on tl dorsal side of the lower part of the omental bursa, which now hangs down ov them; this is the first form of the **greater omentum** of the definitive state, althou there is as yet no adhesion between the overhanging layers and the colon, between it and the dorsal wall.

The *cæcum is the last structure to enter the abdomen,* and, on entering, it li (Fig. 512) on the mass of coils of small intestine. It forms an angle, howeve with the rest of the colon when it lies in this situation, and as the colon is thic walled, there is a tendency for the bent piece to straighten itself and come in line with the rest; this, and doubtless also the rapid increase in size of the coils the small gut, which now begins, cause the cæcum to assume a right dors

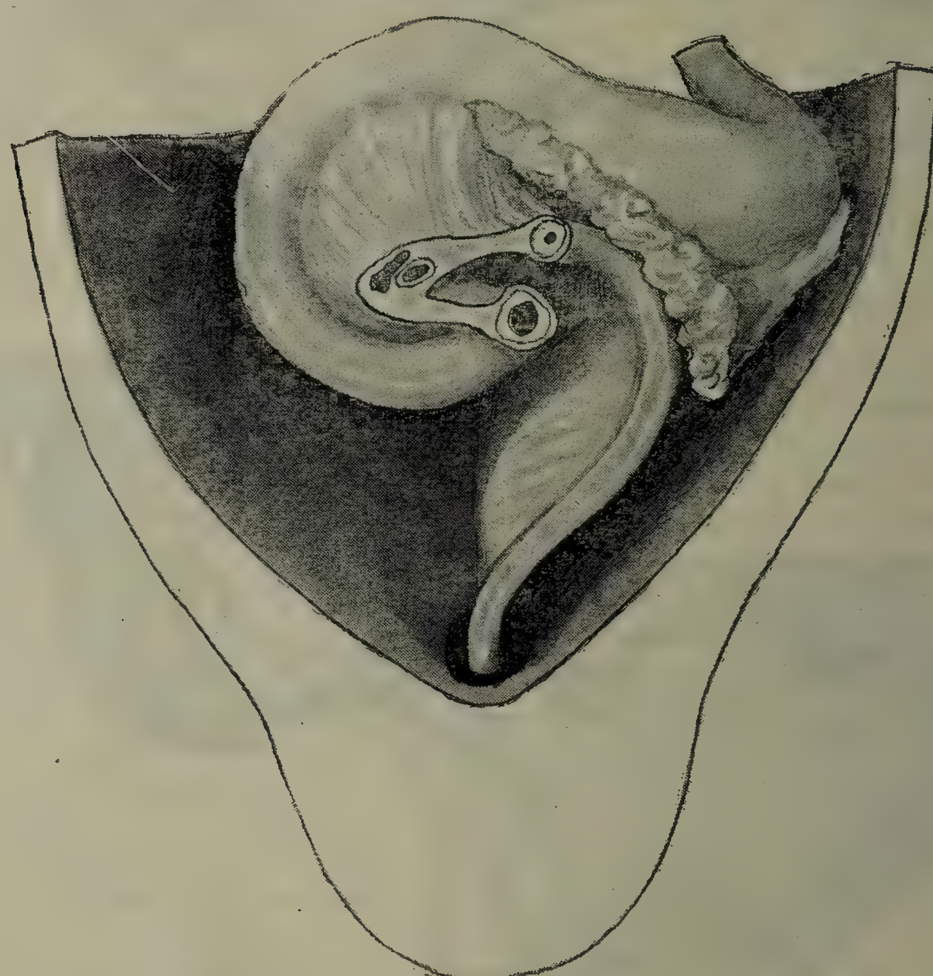


FIG. 510.—DIAGRAM OF SECTION THROUGH ROOT OF THE LOOP, SHOWING HO ITS CRANIAL LIMB, BEING BELOW AND ON THE RIGHT OF THE OTHER, MU PASS BELOW THE CAUDAL LIMB AND THE MAIN VESSELS AND PUSH TH INTRA-ABDOMINAL MESO-COLON TO THE LEFT.

Overhanging omental bursa is represented as rolled up.

position with reference to the mass of coils, on the right side of the neck of tl mass, and thus to come into its proper plane. This is found to occur a few da after the entrance of the gut into the belly, and with its occurrence the secor stage comes to an end.

Third Stage.—It can be understood from a consideration of the figures that tl cæcum and end of the colon, when they move to the right, must *pass over t line of the superior mesenteric artery,* for the mesentery of the small intesti is attached along the line of the artery on its lower aspect. Thus the **colo** will come to lie across the duodenum, and the **cæcum** below and to the rig of this, and the **artery** will cross the duodenum lower down. This complet the twist of the mesentery of the loop, which finishes the second stage, ar leaves the peritoneal layers now in a position which can be understood from tl scheme in Fig. 463.

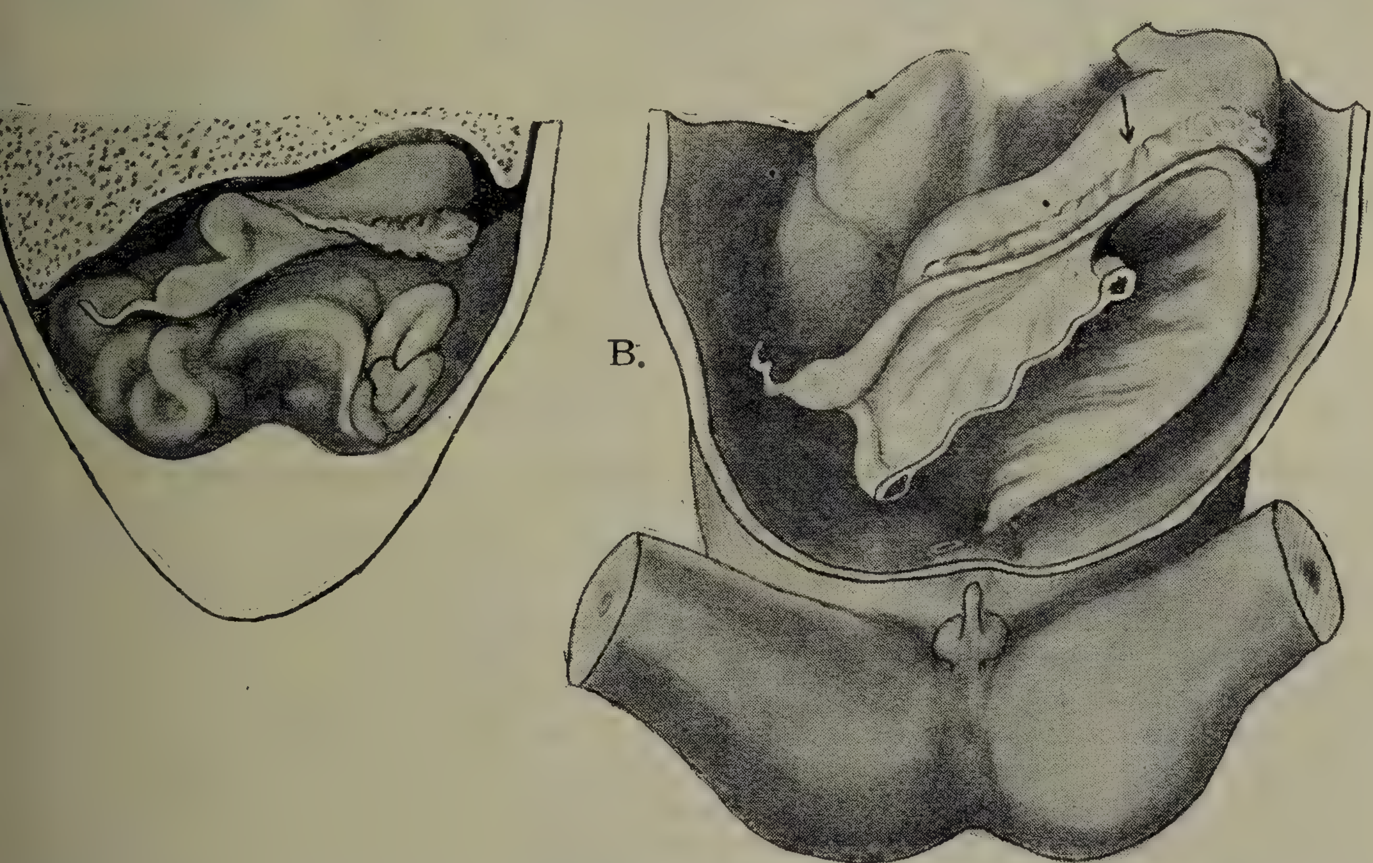
The intestines are now essentially in their proper 'planes,' and the third ;e comprises only the developments and extensions in these positions that l to the conditions found in the adult. The descending meso-colon, laid

. 511.—Scheme to show Result)f Entry of Proximal Limb to the Right of Median Septum, which it pushes to the Left and Dorsally against the Dorsal Wall: Cæcum remains n the Sac.

Fig. 512.—Conditions immediately after the Entrance is accomplished.

The cæcum and mesenteric vessels lie on the mass of coils, the vessels to the right.

k against the left dorsal wall, as seen in Fig. 463, is, at the beginning of this ;e, relatively short, so that the left colon only reaches the inner edge of the nt aspect of the left kidney; as growth proceeds, this meso-colon lengthens,



. 513.—Actual Conditions in Embryo just after Cæcum has entered the Belly at the End of Second Stage.

l the colon thus comes to lie farther out, finally reaching its definitive position, l the *meso-colon becomes adherent to the dorsal wall.* This dorsal adhesion gresses from within outwards, and when the colon has reached its final posi-

tion, extends to the line of the gut, and thus fixes the bowel *in situ*. Or right side the colon, about the end of the third month, becomes attached v it crosses the duodenum, and at its cæcal end. Between these two fixed the colon and meso-colon are free at first, but attachment of the meso-c just to the right of the superior mesenteric vessels is soon found. The b between the fixed parts slowly lengthens as the liver gets relatively sm and as it lengthens it becomes curved out with a convexity upwards and t right, ultimately forming in this way the hepatic flexure with the ascer and right portion of the tranvserse colon. The formation of these parts slow process, not really completed at birth. It is accompanied by an exter of the area of meso-colic adhesion, this, however, falling short of the lir advancing colon, so that this is free to lengthen farther. Thus the meso- part of the original loop mesentery becomes attached to the dorsal wall, the

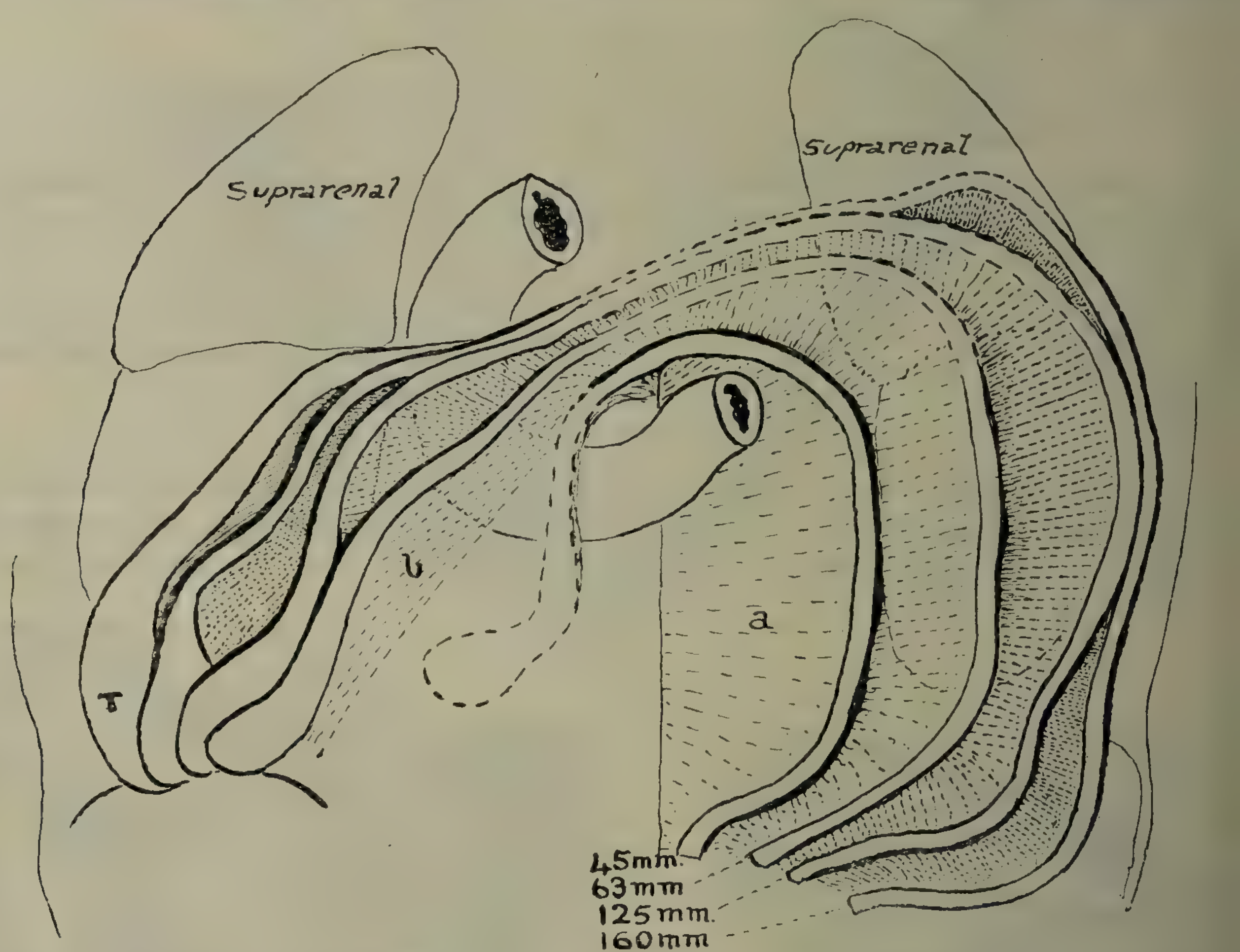


FIG. 514.—SCHEMES TO SHOW POSITION OF MESO-COLON AND COLON AT VAR STAGES, INDICATED BY THE MEASUREMENTS.

a, *b*, left and right mesocolons; T, position at birth.

remaining free as the **mesentery** of descriptive anatomy; the *line of attach of the mesentery* is therefore in reality the limit of adhesion of the right meso-cc

Between the upper end of the fixed meso-colon on the left and the att ment to the duodenum on the right the free colon and meso-colon are app to the dorsal aspct of the lower part of the rudimentary lesser sac, invagina this somewhat. The colon stands away from the dorsal wall here, and it is dorsal surface of the meso-colon, the surface continuous with the adhe surfaces of the right and left meso-colons, that is applied (see Fig. 463) to wall of lesser sac. The adhesion of these applied parts to each other, extendin far as the position of the pancreas in the wall of lesser sac, brings into existence *transverse meso-colon* and the incidental *attachment of the greater omentum to transverse colon*; by extension of the adherent area the bursal wall above pancreatic line becomes fixed to the dorsal wall, and constitutes the *post wall of the small sac.*

Cæcum and Vermiform Appendix.—The cæcum appears about the week of embryonic life as a bud in connection with the distal limb of the **U**-

intestine. It assumes the form of a blind diverticulum, which is at first of iiform dimensions. It soon, however, becomes conical. The proximal part idergoes enlargement, and represents the **permanent cæcum.** The distal part mains long and narrow, and represents the **vermiform appendix,** which ultimately ecomes connected with the left and posterior part of the cæcum. The various ositions occupied by the cæcum and its migration to the right iliac fossa have st been referred to. Suffice it to say that it lies at first on the left side of the edian line, then it crosses to the right side, being at this stage below the liver, id finally is *left in position as the liver retracts.*

Peritoneal Structures.

1. **Meso-gastrium.**—It has been pointed out that the part of the *dorsal* ommon mesentery which carries the stomach becomes pouched out *to the left;* ie resulting sac is frequently termed the meso-gastrium, but more appropriately ie **rudimentary lesser sac (bursa omentalis).** Its opening, to the right, is just oove the thick part of the mesentery known as the **meso-duodenum,** and is latively small. The sac is the result of rapid increase of a right-sided depression the mesentery, the *pneumato-enteric recess*; a left-sided recess shows itself ery early, but disappears almost at once. The opening corresponds in the dult with the line of the **pancreatico-gastric folds.** The portion of the **lesser sac** etween these and the opening into lesser sac is added later as an additional ecess to the right of the mesenteric line, associated with the growth of the iferior vena cava.

The rudimentary lesser sac is at first ' free ' towards the left. After the return f the bowel, which (see Fig. 511) has caused the colon to invaginate its lower 'all, the *dorsal* wall of the sac becomes attached to the abdominal wall, while the olon becomes fixed to its *lower* aspect. Thus the left half of the **transverse ieso-colon** comes into existence, attached dorsally, while the **pancreas,** which ad extended in the back layers of the sac, now becomes fixed dorsally, the iyers behind it disappearing. The **spleen** forms in the outer part of the sac all, which, as the result of the fixation just described, has now a dorsal attachient towards the left.

The outer part of the sac wall, thus left still ' free,' is therefore the structure ermed the **' meso-gastrium '** in the adult; the spleen, placed in this, is held by to the dorsal wall on the one hand (**lieno-renal fold**) and, on the other, to the omach (**gastro-splenic ligament**).

The **greater omentum** is evidently made by the bulging of the front and lower art of the rudimentary sac over the colon, to which it acquires a secondary ttachment. The **lesser omentum** (ventral mesentery) is drawn out from the eptum transversum.

2. The **meso-duodenum** is a thickening of the median mesentery just below the pening into the lesser sac. The duodenum is attached on its right front, and at first a very short segment of the tube. The two pancreatic outgrowths ccur into the meso-duodenum, the *upper* one being immediately below the pening into lesser sac and opposite the attachment of its lower and back wall, *ito which it extends.* The *lower* growth, forming the head of the gland, *enlarges i the meso-duodenum,* with corresponding lengthening of the duodenum, which lso begins to assume a curved form round the growing head. The whole curve f the duodenum is ultimately formed in this way as a result of the growth of the ead of the pancreas. It is clear, then, that this curve has nothing to do with he rotation of the gut returning to the abdomen, but it is possible that the xtreme end of the duodenum *may* belong to the commencement of the proximal mb of the loop, secondarily fixed in position.

3. **Cæcum.**—The cæcum, being originally a bud or *outgrowth* of the gut, has o mesentery, and is originally entirely surrounded by peritoneum.

4. **Vermiform Appendix.**—The vermiform appendix, being originally the lind narrowed end of the cæcum, or, in other words, a diverticulum of the æcum, is also destitute of a mesentery, properly so called, and is invested by

an extension of the peritoneal envelope of the cæcum. There is, however, most cases a fold of peritoneum pertaining to the vermiform appendix, wh extends along it for about one-half or two-thirds of its length. This fold called the **meso-appendix** or **appendicular mesentery,** and it is derived from t left or inferior layer of the mesentery proper, close to the ileo-colic juncti Its presence is due to the drawing out of vessels as the appendix is formed.

Structure of the Liver.

The **liver** has two coats, external and internal. The *external serous coat* is formed by the peritoneum, and is incomplete (see p. 77 Within the serous coat is the fibrous or areolar coat, which is know as the *fibrous capsule* of the organ. It is for the most part thin, exce where the peritoneal coat is deficient. It is continuous all over t surface with the scanty amount of areolar tissue which pervades t interior of the organ and connects the hepatic lobules. At the por hepatis it surrounds the common hepatic duct, hepatic artery, a vena portæ, under the name of the *capsule of Glisson.* The subdivisio of this capsule accompany the various branches of the duct, arter and vein as these ramify throughout the liver in the portal cana

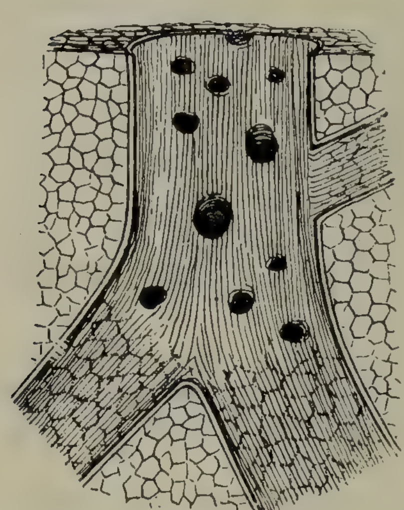


Fig. 515.—Section of the Liver, showing a Large Hepatic Vein and its Tributaries (after Kiernan).

The liver substance is composed of a gre number of small polyhedral masses, call hepatic lobules, which are closely pack together, and at the centre of each of whi is an intralobular or central vein. In m there is very little areolar tissue between t lobules, which are therefore for the most pa confluent. In some animals, however, notab the pig and camel, there is a very distin amount of areolar tissue between the lobule which therefore stand clearly apart from ea other.

The average diameter of a **hepatic lobule** $\frac{1}{20}$ inch. One of its surfaces is called the *bas* It is by this surface that the lobule is set up the wall of a sublobular vein, and the intr lobular or central vein, having emerged fro the lobule through the centre of its bas opens at once into the sublobular vein. The lobules, therefore, rel tively to the sublobular veins, on which they are ranged, are sessil When a sublobular vein is opened and viewed from within, an appearan something like mosaic work presents itself, the closely-set bases of t lobules being visible through the thin wall of the vein, and the minu opening of the intralobular or central veins appearing in the centre each base. Each lobule is composed of hepatic cells, permeated b capillary networks of bloodvessels and bile-capillaries.

Bloodvessels.—The liver derives its blood from two sources—namel the portal vein and the hepatic artery. These two vessels, togeth with the hepatic duct, are invested by the capsule of Glisson at th

ɔrtal fissure. Their several branches, ensheathed by prolongations of lisson's capsule, ramify from this point throughout the liver, being ɔntained in the system of canals known as **portal canals.** Each of these .nals contains (1) a branch of the portal vein, (2) a branch of the ɛpatic artery accompanied by a plexus of nerves, (3) lymphatic vessels, ıd (4) a minute duct, all these being loosely surrounded by a prolonga- ɔn of Glisson's capsule.

The **portal vein** ramifies within the liver like an artery. In the ɔrtal canals its branches receive as tributaries small *capsular* and *ginal veins*, and they go on ramifying until they arrive at the inter- bular areas. Here they anastomose freely with one another around e lobules, and so form the *interlobular plexuses*. The branches which ise from these plexuses enter the lobules on all sides except their ɪses, and form in the interior of each lobule an *intralobular plexus*. ·om this plexus a few radicles converge towards the centre of the bule, where they form by their ɪion the *intralobular* or *central vein*. ıe portal blood, though dark in lour, is very rich, being derived ɔm, amongst other sources, the ɔmach and small intestine.

The **hepatic artery** is a branch of e cœliac artery. As its branches ɪverse the portal canals they give f *capsular branches* to the fibrous psule of the liver, and *vaginal anches*, which supply the walls of e vessels in the portal canals, as ell as their Glissonian sheaths. The anches of the artery finally end minute *interlobular arteries*, which pply the walls of the interlobular ins and bile-ducts. According to me authorities they send minute pillary branches into the interior each lobule to join the intra- ɔular plexus of the portal vein, but is view is not held by others.

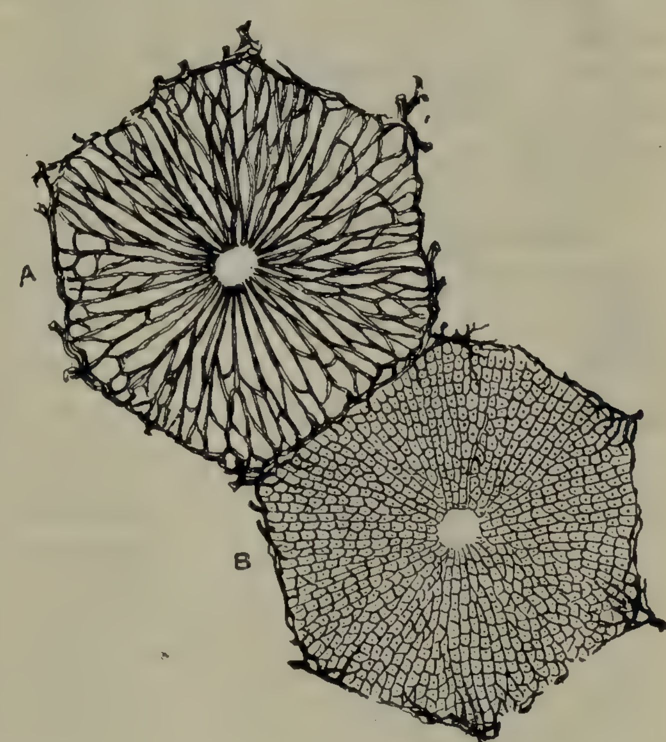


FIG. 516.—TWO HEPATIC LOBULES (HIGHLY MAGNIFIED).

A, lobule showing the intralobular plexus; B, lobule showing the hepatic cells.

The function of the hepatic artery and its branches is to nourish e tissues of the liver, whilst the portal blood supplies the materials ɪich are elaborated by the hepatic cells.

The **hepatic veins** commence in the centre of each lobule as an *ralobular* or *central vein*. The intralobular veins open into the *blobular veins*, which are closely adherent to the bases of the lobules. ıe sublobular veins join to form larger sublobular veins, and these turn terminate in the *hepatic veins*, which are not in direct contact th the lobules. The hepatic veins pass to the fossa for vena cava on e posterior surface of the liver, towards which they converge, taking

up sublobular veins in their course. The passages which contain t veins are known as the **hepatic canals.** On arriving at the upper pa of the fossa for vena cava they are reduced to two or three in numb which pour their contents directly into the inferior vena cava. It is be noted that the hepatic veins converge to the fossa on the poster surface, whilst the branches of the portal vein radiate in all directic from the portal fissure. The hepatic veins are accompanied only lymphatic vessels, and are surrounded by a very scanty amount areolar tissue, which explains why they present open mouths when c across.

Distinguishing Characters of the Hepatic and Portal Veins—Hepatic Veins (1) These present open mouths when cut across. (2) They are accompan only by lymphatic vessels. (3) Their walls are very thin, and are practica in direct contact with the substance of the liver. (4) They converge towa the caval fossa on the posterior surface.

Portal Veins.—(1) The mouths of these veins are practically closed or c lapsed when cut across. (2) The veins are accompanied by branches of hepatic artery, and by ducts. (3) Their walls are fairly thick, and are separa from the substance of the liver by the sheaths derived from Glisson's capsu (4) They radiate in all directions from the porta hepatis in portal canals.

Hepatic Cells.—These are situated within the lobules. They a polyhedral, granular cells, having a diameter of $\frac{1}{1000}$ inch, and ea contains a round nucleus. They have no cell-wall, properly so call and they are connected by a delicate supporting tissue. The ce which are capable of amœboid movement, lie between and around t capillary vessels, where they are arranged in radiating rows convergi towards the centre of the lobule.

Bile-ducts.—These commence within the lobules as *bile-capillar* or *bile-canaliculi,* which are in reality intercellular passages. Th have a very delicate wall, and are bounded on all sides by the hepa cells—hence the name *intercellular passages.* According to Pflüg and Kupffer, the cells contain *vacuoles,* which communicate by int cellular passages with the bile-capillaries. The hepatic cells interve between the bile-capillaries and the capillary bloodvessels. At t circumference of the lobule the bile-capillaries pass into the sm *interlobular bile-ducts.* These join to form larger ducts, and these turn go on joining until, on arriving at the porta hepatis, only t ducts result, which emerge one from each lobe. These now join to fo the *common hepatic duct,* and this joins the cystic duct to form the bi duct. The walls of the interlobular ducts are very thin, being co posed of a basement membrane lined with polygonal epithelium. T larger ducts in the portal canals have thicker walls, which, from witho inwards, are composed of a fibro-elastic coat, containing plain muscu tissue, arranged longitudinally and circularly, and a mucous coat lin with columnar epithelium. The mucous membrane of the larger du presents numerous openings, which lead into blind mucus-secreti recesses. The structure of the hepatic and bile-ducts is similar to t preceding, though on an increased scale.

Lymphatics.—The lymphatic vessels of the liver are arranged in o groups—superficial and deep.

Superficial Lymphatics.—These form plexuses beneath the periıeal coat, and have different destinations.

Supero-anterior Surface.—(1) The lymphatics from the vicinity of e falciform ligament enter that ligament, and, passing through the ıphragm into the thorax, they terminate in the *anterior* group of the *pradiaphragmatic glands.* (2) The lymphatics from the right part the superior surface and those from the right lateral surface enter e right triangular ligament, and, ssing through the diaphragm, they minate in the *middle* group of the *perior diaphragmatic glands* of the *ht* side. (3) The lymphatics from e left part of the superior surface d those from the left extremity ter the left triangular ligament, and ss to the *peri-œsophageal glands* in ation to the lower end of the sophagus, the *efferent* vessels of ıich terminate in the *cœliac glands.* The lymphatics from the anterior rt of the supero-anterior surface, cept those from the vicinity of the ciform ligament, turn round the terior border of the liver, and end the *hepatic glands* within the lesser ıentum. (5) The lymphatics from e posterior surface of the right lobe ss between the two layers of the ronary ligament, and, having pierced e diaphragm, they terminate in the *na caval* group of *diaphragmatic ınds* within the thorax.

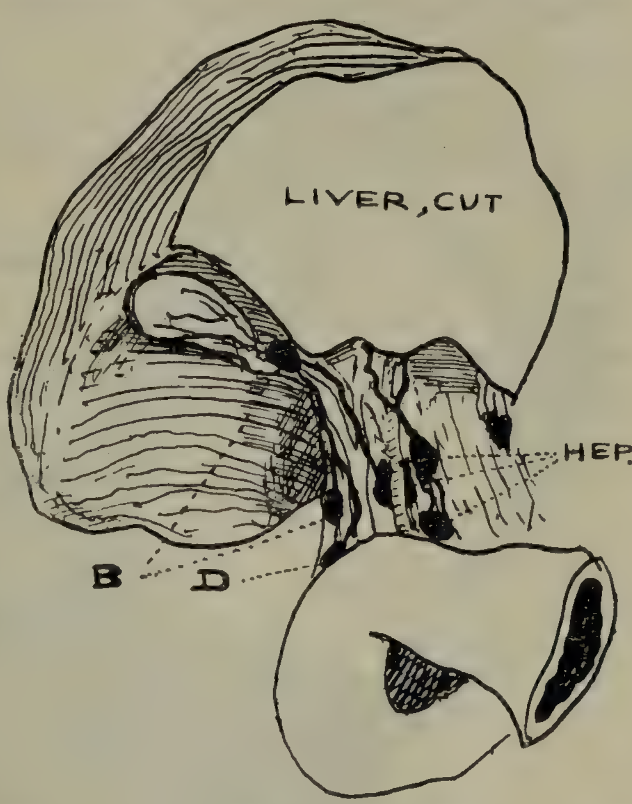


FIG. 517.—LYMPH GLANDS IN THE HEPATIC PORTAL REGION (AFTER ROUVIÈRE).

HEP, hepatic group, round the artery and concerned with deep hepatic drainage; B, a cystic gland above, and (below) a gland connected with this and with the retro-duodenal gland; D, above the head of pancreas. These glands are more particularly concerned with the drainage of the system of biliary ducts.

Inferior Surface.—(1) The lymıatics from the greater part of the ferior surface of the right lobe, inıding those of the quadrate lobe, ss to the *hepatic glands.* (2) The lymphatics from the posterior rt of the inferior surface of the right lobe pierce the diaphragm, ıd end in the *caval glands.* (3) The lymphatics from the greater rt of the caudate lobe pierce the diaphragm, and end in the *caval ınds*; whilst those from the lower part of this lobe pass to the *hepatic ınds.* (4) The lymphatics from the inferior surface of the left lobe ss to the *hepatic glands.*

Deep Lymphatics.—These vessels form two distinct sets. Some them accompany the branches of the *portal vein,* and having emerged rough the porta hepatis, they terminate in the *hepatic glands.* Others

pass with the *hepatic veins* to the caval fossa of the liver, and therea they enter the thorax along with the inferior vena cava, their destinat being the *caval glands.*

Nerves.—The nerves of the liver are derived from the hepatic plex which is an offshoot of the cœliac plexus. The cœliac plexus, thou principally composed of sympathetic fibres, is reinforced by a twigs from the *right* vagus nerve. The hepatic plexus accompanies hepatic artery to the porta hepatis, where it receives branches from *left* vagus nerve, which have ascended from the antero-superior surf of the stomach between the two layers of the lesser omentum. In liver the nerves, which are chiefly non-medullated, are distributed the walls of the bloodvessels and ducts, penetrating as far as the int spaces between the hepatic cells.

Development of the Liver.

Liver.—The hepatic cells and the epithelium of the bile-ducts are of en**dermic** origin, whilst the connective tissue of the gland and its vascular c stituents are developed from the **mesoderm.**

The rudiment of the liver appears as a longitudinal groove on the inner asp of the *ventral wall* of the **duodenal portion** of the primitive gut. This gro

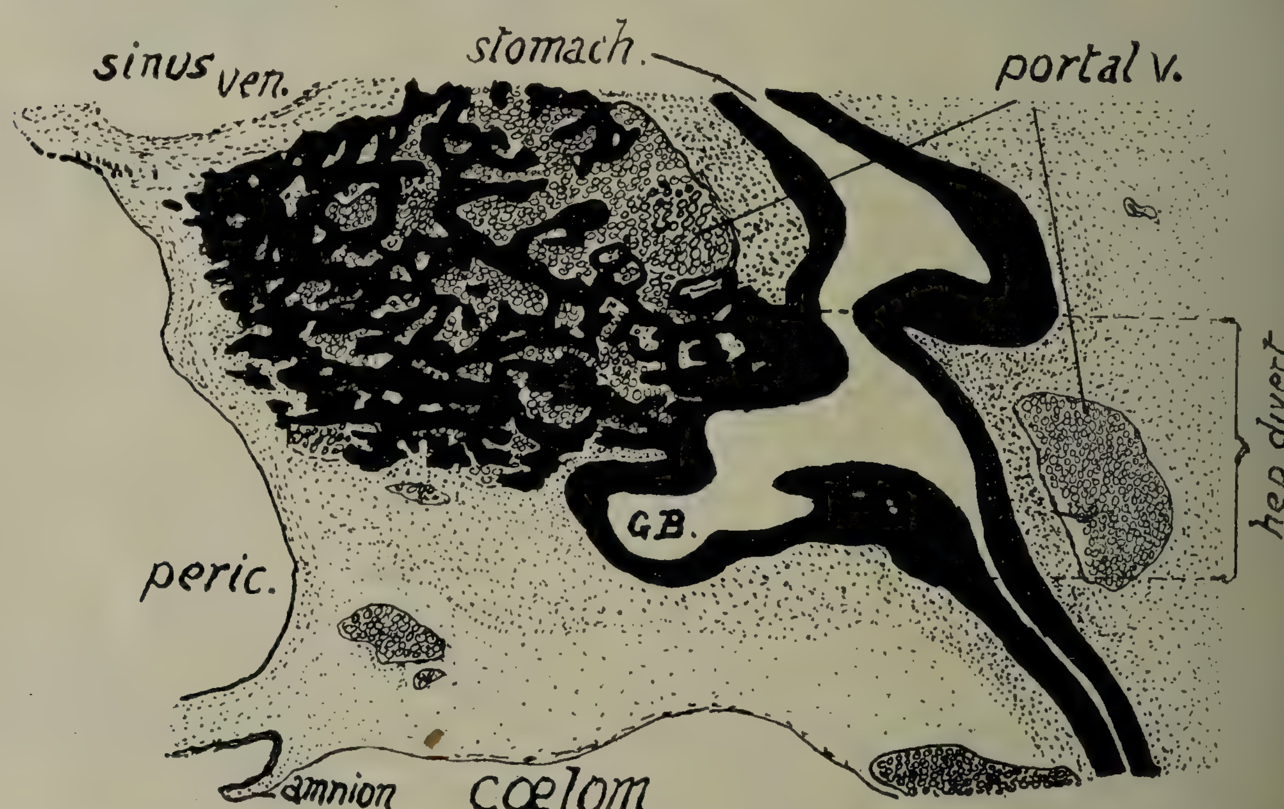


FIG. 518.—SAGITTAL SECTION THROUGH SEPTUM TRANSVERSUM AND CAUD END OF FORE-GUT IN AN EMBRYO OF 4·5 MM., TO SHOW HEPATIC DIVI TICULUM AND GROWTH OF HEPATIC CYLINDERS AND GALL-BLADDER.

The cylinders have broken up the vitelline veins, represented here by the por vein, into sinusoids. The entoderm is shown by solid black.

gives origin to a diverticulum or evagination of the entoderm of the vent duodenal wall, called the **hepatic diverticulum** or **liver-bud,** which has at firs wide communication with the gut. At a later period this communication becon constricted, and forms a *pedicle,* which, after undergoing elongation, gives r to the **bile-duct.** From this pedicle, close to the duodenal wall, the vent diverticulum of the pancreas arises.

The hepatic diverticulum or liver-bud invades the lower or caudal layer of septum transversum, composed of mesoderm, within which it bifurcates) two divisions, the *right* and *left hepatic ducts*.

The cells of these two divisions of the hepatic diverticulum undergo pro-:ation within the mesoderm of the lower layer of the septum transversum, thereafter each division breaks up into a number of *solid* trabeculæ, which known as the **hepatic cylinders.** These cylinders give off secondary solid)eculæ, and these again ramify extensively. The subdivisions of the various)eculæ anastomose freely, and in this manner intricate networks are formed und the vitelline and umbilical veins, which veins traverse the septum ısversum as they pass to the sinus venosus. The hepatic cylinders invade se veins, carrying the endothelial walls of the vessels before them. The ıs are thus freely subdivided into od-channels, which are known as *sinu-ls*. These sinusoids form capillary works, which occupy the meshes of net-works formed by the hepatic inders.

Many of the solid trabeculæ become ular, and give rise to the **bile-capil-es** or **bile-canaliculi,** and **bile-ducts.** ıers give rise to the **hepatic cells.** : liver thus consists originally of *in-ate reticula of solid cellular trabeculæ, hepatic cylinders, disposed around the lline and umbilical veins.*

As the liver increases in size it pro-ts downwards, carrying with it the 'er layer of the septum transversum, ich forms its capsule and connective sue. The organ now lies between the) layers of the ventral mesentery, ich gives rise to—(1) the falciform ıment; (2) the coronary ligament; and the lesser omentum (see p. 79).

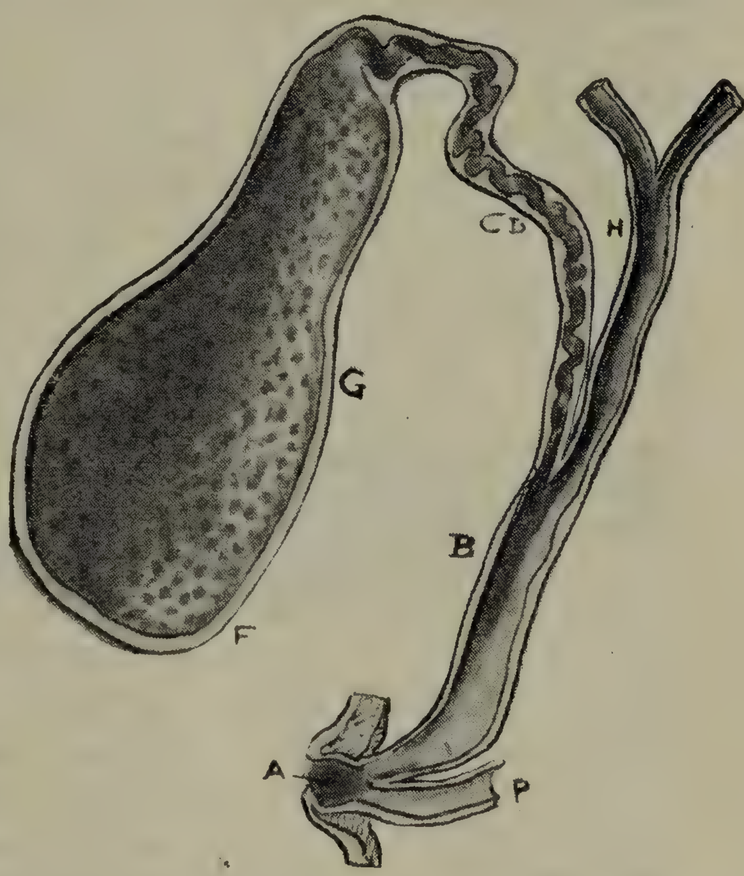


Fig. 519.—The Excretory Apparatus of the Liver.

G, gall-bladder; F, fundus; CD, cystic duct; H, common hepatic duct; B, bile duct; P, pancreatic duct; A, ampulla in duodenal wall into which both ducts open.

About the middle of intra-uterine life : liver occupies a large part of the lominal cavity, and the right and left es are of equal size. In the latter lf of intra-uterine life, however, the ht lobe gradually attains greater size ın the left. About the period of birth : liver extends almost as low as the ıbilicus. After birth it undergoes dimi-tion in size, the circulation of placental)od through it by the umbilical vein having been permanently arrested at th. The liver decreases in relative size largely owing to slower growth, but :re is also actual degeneration of part of its substance already formed. This plains the occurrence of degenerated remnants, *vasa aberrantia* and *Kiernan's ıules*, found near its edge, in the left triangular ligament and by the inferior ıa cava.

At an early period in development the liver has indications of four lobes, o vitelline and two umbilical, but these are not so well marked as in some ıer animals. The **umbilical** lobes form the two *lateral lobes*, but the **vitelline**)es are lost in the parts round the vena cava. The other small lobes on the :ceral surface are secondary, formed round large vessels or from surface rela-ns; the free extremity of the caudate lobe has a small process which is the nnant of a part originally projecting into the bursa omentalis through its ening.

The hepatic cylinders appear solid, but they contain no doubt poten lumina. These become apparent as *bile-capillaries* about the beginning of fourth month.

Hepatic *lobules* are not well formed before the first few years after bi They are produced as a result of growth and branching of terminal twigs of **hepatic veins,** round which the cylinder cells group themselves, with their po vessels.

Structure of the Gall-bladder.—The wall of the gall-bladder composed of three coats—serous, fibro-muscular, and mucous.

The **serous coat** is formed by the peritoneum, and is usually inco plete, being confined to the inferior and lateral surfaces. Son times, however, the peritoneum completely surrounds the organ, a attaches its superior surface to the fossa for gall-bladder of the liver a ligamentous fold.

The **fibro-muscular coat** is composed of fibrous and plain muscu tissues. The fibrous bands are disposed in all directions, and int lace freely with one another. The muscular fibres, which int mingle with the fibro bands, are arranged bo longitudinally and tra versely. Around the t minations of the bile-du and pancreatic duct a their continuation in the ampulla the circul muscular fibres are abu dant, forming the *sphinc of Oddi* (Fig. 520).

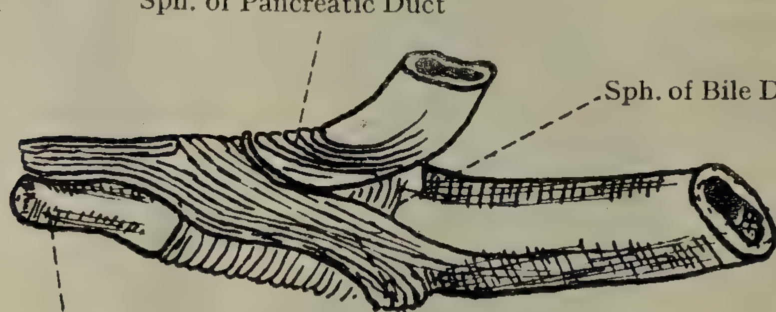


Fig. 520.—Sphincter of Oddi (after Hendrickson).

The **mucous coat** covered by columnar e thelium. Its surface presents a great number of small ridges, whi interlace in all directions and enclose polygonal depressions or alve of various sizes. This pitted appearance bears a resemblance honeycomb, and the mucous membrane of the seminal vesicle of t male is similarly arranged. The mucous coat is richly provided wi mucous glands. In the neck of the gall-bladder, which describes t curves, there are two fibro-mucous folds, which project into the interi one opposite each curve, and serve as valves.

Structure of the Cystic Duct.—The wall of the duct is compos of a fibro-elastic and muscular coat and a mucous coat. The form resembles that of the gall-bladder. The mucous coat, which is cover by columnar epithelium, presents several crescentic folds dispos obliquely round the wall in a spiral or somewhat corkscrew mann and succeeding each other at frequent intervals. When the duct distended, its exterior presents a series of spiral constrictions wi intervening swellings. The spiral folds in the interior serve as valve which are known as the **spiral valve (valves of Heister).**

Blood-supply.—The gall-bladder is supplied by the **cystic arter** which is a branch of the right division of the hepatic. Its cour

forwards between the hepatic and cystic ducts to the neck of the gan, where it divides into two branches, superior and inferior. ıe *superior branch* ramifies on the upper surface of the organ, between and the fossa for gall-bladder of the liver, whilst the *inferior branch* distributed over the inferior surface beneath the peritoneum. The **stic vein,** which is formed by the union of superior and inferior anches, usually opens into the *right division* of the portal vein. ›me of the veins from the gall-bladder may enter the liver to join e right branch of the portal vein. This fact explains the venous emorrhage which sometimes occurs when the gall-bladder is lifted ıt of its fossa.

Lymphatics.—These pass between the two layers of the lesser nentum to the *hepatic glands.*

Nerves.—These are derived from the hepatic sympathetic plexus.

Development of Gall-bladder and Duct.—An early stage is seen in Fig. 518. ıe hepatic diverticulum is elongated in the line of the gut, and its **lower end** dilated to form the *gall-bladder,* the **upper part** alone giving origin to *hepatic linders.* The lower part of the groove is blocked by cell-growth, the bladder us opening into the upper part which will become the liver-duct. The bladder latation grows ventrally in the mesoderm below the liver, its neck thus being retched out between the duct and the bladder, and becoming the *cystic duct.*

Structure of the Pancreas.

The pancreas belongs to the class of compound racemose or acinoıbular glands, and bears a close resemblance to a serous or true ılivary gland—*e.g.*, the parotid. It has a greyish-pink colour, and somewhat soft in consistence. It is from 6 to 8 inches long, from to $1\frac{1}{2}$ inches deep, except at the right and left extremities, and from to $\frac{3}{4}$ inch thick. Its weight is about $3\frac{1}{2}$ ounces. It is destitute of fibrous capsule, properly so called, and is invested merely by a thin onnective-tissue covering, which readily allows the outline of the ›bules to be seen.

It is composed of a number of lobules, which are loosely held ogether by ducts and areolar tissue. Each **lobule** consists of a group f alveoli or acini which are long, tubular, and convoluted, wherein hey differ from the saccular alveoli of such a gland as the parotid. From each lobule a duct passes off, which unites with the ducts of djacent lobules in the left extremity of the gland to form the comıencement of the principal duct. Within the lobule the lobular duct s formed from junctional ducts, each of which belongs to an acinus, nd is lined with flattened cells.

The **alveoli** or **acini** are each composed of a basement membrane, eticular in structure, and lined with secreting columnar epithelium, he basement membrane being continuous with the wall of the junctional luct. The lumen of each acinus is small, and is usually occupied by pindle-shaped cells, known as the *centro-acinar cells of Langerhans,* vhich are continuous with the cells of the junctional duct. The

connective tissue which covers the pancreas sends expansions inw between the lobules, along which the bloodvessels are condu Further, the interlobular connective tissue penetrates into the lob and so conducts the bloodvessels into their interior. The *interalv* connective tissue has a loose position, and in certain parts tains small groups of epithelium cells, surrounded by large convol capillary vessels. These gr constitute the **islets of Langerh** which are characteristic of pancreas.

Fig. 521.—Structure of the Pancreas (highly magnified).

Excretory Apparatus of the I creas.—There is one principal d called the **pancreatic duct (duc Wirsung)**. It is buried in the stance of the gland, and is rea recognized by its white colour. lies nearer the posterior than anterior surface, and rather ne the lower than the upper part of gland. It commences in the whence it runs through the b as far as the neck, receiving in course a great many tributa On arriving at the neck it eff a communication with the ac sory pancreatic duct, then descri a bend, and passes into the head in a direction downwards, backwa and to the right. Finally, on leaving the pancreas it meets the b duct, and the two, entering the wall of the second part of the duoden terminate in the manner already described (see p. 779).

The **accessory pancreatic duct (duct of Santorini)** is comparativ small, and varies much in size. If well developed, it commen in the lower part of the head, where it takes up the ducts of the lob of that part. It then passes upwards with an inclination to the right, divides into two branches. One of these joins the pancreatic main d in the neck, whilst the other opens into the second part of the duoden at a point about 1 inch above the common opening of the bile-d and the pancreatic duct. The secretion conveyed by the access duct is believed in early life to flow into the duodenum, whereas in adult it is largely diverted into the pancreatic duct.

The tributaries of the principal duct, as well as of the access duct, when followed into the pancreas, become in succession *int lobular* and *intralobular ducts*. The intralobular ducts pass wit the lobules, and end in *intermediary, junctional*, or *intercalary** *du* with which the alveoli or acini are directly connected. The p

* Interposed or inserted between the alveoli and the intralobular ducts.

he duct between the intermediary and the intralobular duct is ed the *neck*. The walls of the intermediary ducts are thin, and formed of a basement membrane covered by flattened epithelial s, the neck being lined by polyhedral cells. In the larger ducts onnective-tissue coat is superadded to the basement membrane, ch is now covered by columnar epithelium. The pancreatic duct, ıgh of comparatively large size, has a thin wall destitute of muscular es except near its termination, and composed of two coats— rnal fibrous and internal mucous. The mucous coat is smooth and ered by columnar epithelium.

/arieties—(1) **Small Pancreas.**—This consists in a permanent detachment he unciform process, or that part of the pancreas which extends along the er aspect of the third part of the duodenum and has the superior mesenteric els in front of it. (2) The head of the pancreas may surround the second of the duodenum more or less completely. (3) **Accessory Pancreas.**— en an accessory pancreas is present it is usually met with in the wall of the

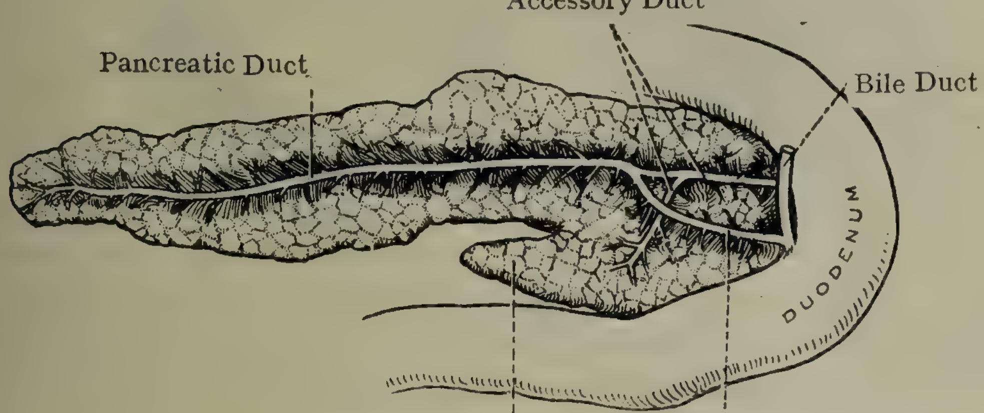


FIG. 522.—THE PANCREAS AND ITS DUCTS (POSTERIOR VIEW).

er part of the jejunum, but it may be found in the wall of the stomach or er part of ileum. (4) The pancreatic duct sometimes opens into the duodenum ependently of, but close to, the bile-duct.

Blood-supply.—The pancreas derives its **arteries** from (1) the ıcreatic branches of the splenic artery, one of which accompanies principal duct from left to right, and is known as the *arteria pan-atic magna*; (2) the superior pancreatico-duodenal of the gastro-odenal from the hepatic; and (3) the inferior pancreatico-duodenal the superior mesenteric.

The **veins** are (1) the pancreatic veins, which open into the splenic n; and (2) the pancreatico-duodenal veins, which terminate in superior mesenteric or portal veins. All the pancreatic venous od eventually passes into the portal vein.

Lymphatics.—These commence as lymphatic clefts around the eoli, and pass chiefly to the *cœliac glands*. Some of them, however, minate first in the superior mesenteric glands in contact with the per part of the superior mesenteric artery.

Nerves.—These are derived from offshoots of the hepatic, splenic, l superior mesenteric plexuses, and accompany the arteries. They chiefly composed of non-medullated fibres.

Development of the Pancreas.—The tubular portion of the pancreas *entodermic* origin, but its connective tissue and vascular elements are deve from *mesoderm*.

The pancreas is developed from two entodermic diverticula—dorsa ventral. The **dorsal diverticulum** is an evagination of the entoderm of the *wall* of the **duodenal portion** of the primitive gut. The **ventral diverti** springs from the primitive hepatic diverticulum close to the ventral wall duodenum, which diverticulum subsequently forms the bile-duct. The **diverticulum** extends between the two layers of the meso-gastrium, wh comes into relation with the developing spleen. This diverticulum giv lateral epithelial tubes, which ramify freely, and so build up an acino-tu

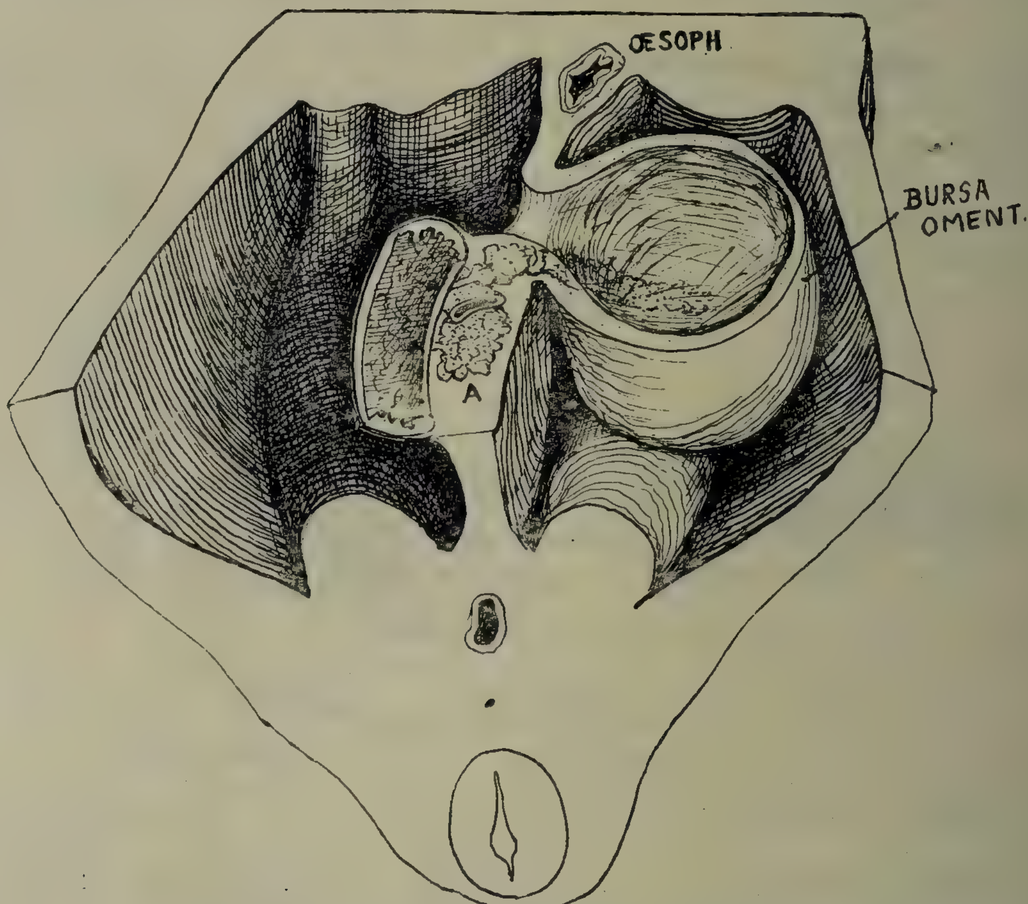


Fig. 523.—Diagram to show the Relations of the Pancreatic Outgrowths to the Median Mesentery.

The dorsal wall of the duodenum is left on the meso-duodenum, and bet this and the œsophagus the stomach has been removed with the front of the bursa omentalis, leaving the posterior wall and opening of the The ventral outgrowth A is growing in the meso-duodenum, but the d growth, being higher up, is able to extend into the wall of the primitive The portal vein passes backwards, upwards, and to the right betwee two outgrowths.

gland. The acini appear as enlargements of the walls of the terminal t By means of the ramifications of the dorsal diverticulum the greater part o **head, body,** and **tail** of the adult pancreas are formed.

The **ventral diverticulum** is at first double, right and left outgrowths ar *from the liver-bud.* The left formation quickly disappears, while the right coming into relation with the portal vein, grows round this *into the meso-duode* where it enlarges, being placed with the vein behind the duodenum as this cu out toward the right. It forms the **pancreatic duct**, and gives outgrowth form the lower part of the head of the pancreas.

The ventral and dorsal parts of the pancreas join, and the dorsal d ticulum (pancreatic duct) and ventral diverticulum now communicate by fr anastomosing branches. Thereafter the duodenal portion of the pancre

ıct usually atrophies and disappears. It may, however, persist, and open as ı independent duct into the second part of the duodenum. The accessory ıncreatic duct is persistent, and constitutes the principal duct of the fully veloped pancreas. From its mode of development it necessarily opens into e bile-duct.

The **islets of Langerhans,** which are characteristic of the pancreas, are formed cells derived from the walls of the original epithelial tubes. These cells become fferentiated, and by their multiplication they give rise to isolated cell-groups, ing in the mesodermic connective tissue between the lobules of the gland, where ey are soon permeated by bloodvessels.

The development of the *head* of the pancreas proceeds within the meso-duonum (Fig. 523) dorsal and caudal to the vitelline vein, which enters the meso-ıodenum here to form the beginning of the portal vein. The head, by its large owth, widens out the meso-duodenum to a very considerable extent, and oduces the curve of the duodenum round its mass. The *body and tail* of the gan extend into the dorsal wall of the bursa omentalis, growing rapidly in this ward the left. They thus come to be directed transversely, and are laid down the dorsal wall of the abdomen. When the peritoneum of this wall adheres the bursal wall, and the two adherent layers disappear, the gland is left in a *ro-peritoneal* position behind the completed lesser sac; rarely, however, the hesion and disappearance of the layers is incomplete, and thus a cyst may be rmed behind the gland from fluid within a persisting part of the peritoneum re.

Structure of the Spleen.

The spleen is the largest ductless gland in the body. It has two ats, serous and fibrous, inseparably connected together. The *serous at* is formed by the peritoneum. The *fibrous coat* or *tunica propria* composed of fibrous tissue, with a considerable admixture of elastic ssue, and a certain amount of plain muscular tissue, all of which ild up a strong distensible tunic.

The organ is composed of a trabecular network, the spleen pulp, oodvessels, and Malpighian corpuscles.

The tunica propria sends into the organ a number of trabeculæ ıich, like the tunica propria, are composed of fibrous, elastic, and ain muscular tissues. These divide and subdivide, and unite with e another, as well as with processes derived from the sheaths which e bloodvessels carry in with them at the hilum. There is thus rmed a **trabecular network,** which pervades the interior, and conins in its meshes the splenic pulp, capillary tufts, and lymphatic dules.

The **splenic pulp** occupies the meshes of the network formed by the abeculæ. It is soft, and has a dark red colour, which, however, comes brighter on exposure to the air. The matrix of the spleen lp is reticular, and is formed by branched connective-tissue corıscles, which constitute the *sustentacular cells* of the organ. The atrix is, therefore, in reality retiform tissues. The interstices of e reticulum contain blood, in which there is a large number of white rpuscles, and also special cells characteristic of the spleen, and lled the *splenic cells.* These latter are of large size, and are amœboid. ıey contain pigment, and red blood-corpuscles in various stages of sintegration.

Bloodvessels and Lymphatic Nodules (Malpighian Corpuscle **Arteries.**—The splenic artery furnishes five or six large branches wh enter the organ at the hilum, and carry in with them trabecular shea from the tunica propria. In the interior they divide and subdiv and finally terminate in pencil-like clusters of capillary vessels, which time they have laid aside all their coats except the endothe lining. The endothelial cells then become separated from each ot by spaces, and being continuous with the sustentacular cells of spleen pulp, the blood flows directly into the interstices of the reticul of the pulp. The arteries, which are at first accompanied by trabecu sheaths, ultimately lose these sheaths, and enter the splenic pulp end in clusters of capillaries. fore they terminate in these c ters their external coat underg an important modification, wh consists in its transformation i lymphoid or adenoid tissue. T lymphoid tissue forms at interv small round or oval enlargeme called **lymphatic nodules (Ma ghian corpuscles)**, which on sect appear as minute white specks the dark red spleen pulp. Th corpuscles are simply locali expansions of the lymphoid tis which forms the external coat the small arteries. The expans may be confined to one side the artery, or it may include whole of its circumference. Ea corpuscle receives minute tw from the artery on which it is and contains large numbers lymph corpuscles, as well capillary bloodvessels.

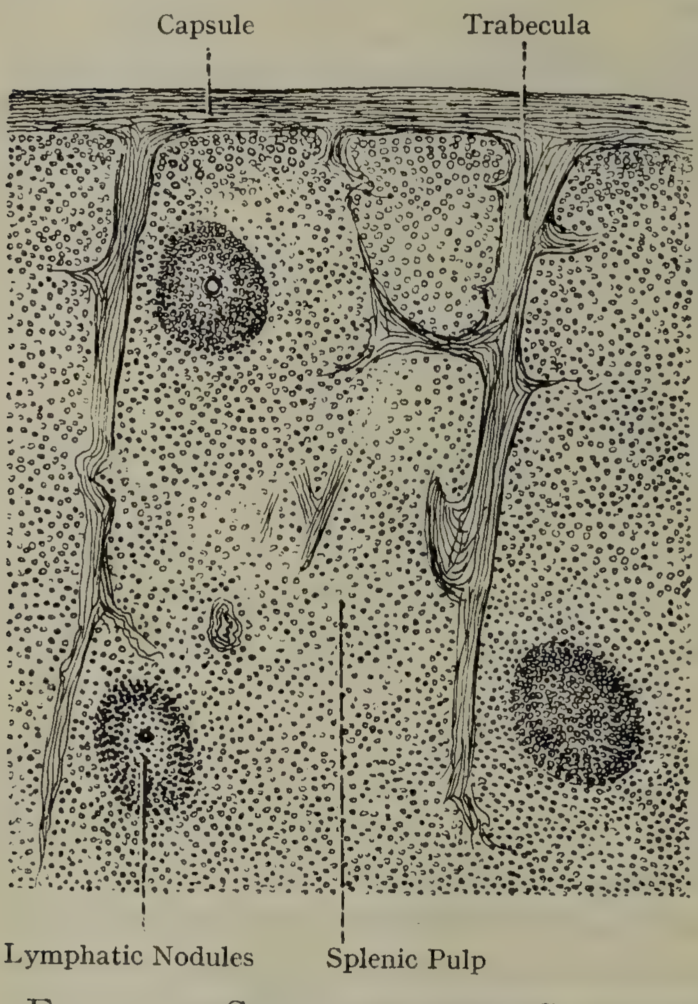


FIG. 524.—SECTION OF THE SPLEEN.

Veins.—The arterial blood, on leaving the capillary vessels, flo directly into the interstices of the reticular matrix of the spleen pu and from these it is taken up by radicle veins which commence i manner similar to that in which the capillaries end. Endothe cells, continuous with the sustentacular cells of the pulp, come togetl and cohere, so as to form very delicate tubular vessels having clo walls. As these radicle veins unite and become larger the other co are superadded to the endothelial lining. Ultimately five or six ve leave the spleen at the hilum, which unite to form the splenic ve this in turn uniting with the superior mesenteric vein to form the po vein.

It is to be noted that, in the circulation through the spleen, arterial blood leaves tubular vessels and flows through the intersti

he reticulum of the spleen pulp, where it bathes the Malpighian ɔuscles, after which it enters tubular vessels of the nature of veins.

Fhe **cells of the spleen** are of three kinds as follows: (1) the sustenılar cells of the retiform tissue of the spleen pulp; (2) the splenic-; and (3) lymphoid corpuscles.

Lymphatics.—These are arranged in two groups—trabecular and vascular. The *trabecular lymphatics* are contained in the traılæ, and communicate with a lymphatic network in the tunica ɔria underneath the peritoneal coat. The *perivascular lymphatics* mence in the lymphoid tissue which forms the external coat of smaller arteries. At the hilum both sets of lymphatics meet and s to the *splenic glands*, and thence to the *cœliac glands*.

Nerves.—These are derived from the splenic plexus, which is an hoot from the cœliac plexus. The fibres, which are mostly nonlullated, are derived partly from the sympathetic system and partly n the right vagus nerve.

Development of the Spleen.—The spleen is formed from the mesodermal of the bursa omentalis. In the fifth week the sac wall in its upper, dorsal, left part shows a certain amount of thickening, with vascularization, and ease in size of the mesothelial cells covering its outer surface. A little later e covering cells proliferate, and cells pass from the layer into the mesenchyme ie wall. As the mass enlarges it projects outwards into the peritoneal cavity. he processes take place at several points the organ is lobed; although the d appearance is lost by subsequent fusion, the original divisions are indicated he fissures. The cells arrange themselves in trabecular bands, and small gather round the small branches of the splenic artery and form the **lymphatic les** (*Malpighian corpuscles*) about the seventh month. When the dorsal of the bursa omentalis becomes adherent to the wall of the abdomen, the en, lying just outside the area of adhesion, is now attached to the outer edge his area by the intervening strip of non-adherent sac wall—*i.e.*, by what is wn as the lieno-renal fold. As it projects toward the left, away from the ty of the sac, it is covered by peritoneum of the greater sac, and is separated 1 that of the lesser sac by the vessels in the wall of the latter.

Structure of the Suprarenal Glands.

The **suprarenal glands** (*adrenals*) belong to the so-called ductless ıds. Each gland is enclosed in a thin sheath of connective tissue, n the deep part of which processes are given off into the interior, ere they form a supporting stroma. The proper substance of the ıd is divided into an external or cortical, and internal or medullary t.

The **cortex** has a somewhat yellowish tint, due to the presence of poid substance, and is composed of cells supported by a fibrous ɔma. The cells being variously arranged in different parts, the tex is divisible into three zones, named, from without inwards, zona merulosa, zona fasciculata, and zona reticularis. The **zona glomeru-**, which is narrow, lies immediately within the external capsule, l is so named because its component cells are grouped in such anner as to form glomeruli, which are embedded in a fibrous stroma.

The cells are polyhedral, and each contains a clear round nucl The **zona fasciculata** forms the chief part of the cortex, and is so na because its component cells are arranged in columns or fasciculi. cells are similar to those of the zona glomerulosa, and the cell colu are separated from one another by fibrous trabeculæ, which ac carriers of the bloodvessels, nerves, and lymphatics. The **zona ret laris,** which is narrow, lies within the zona fasciculata, and is so na because its component groups of polyhedral cells are connected one another in such a manner as to form a reticulum.

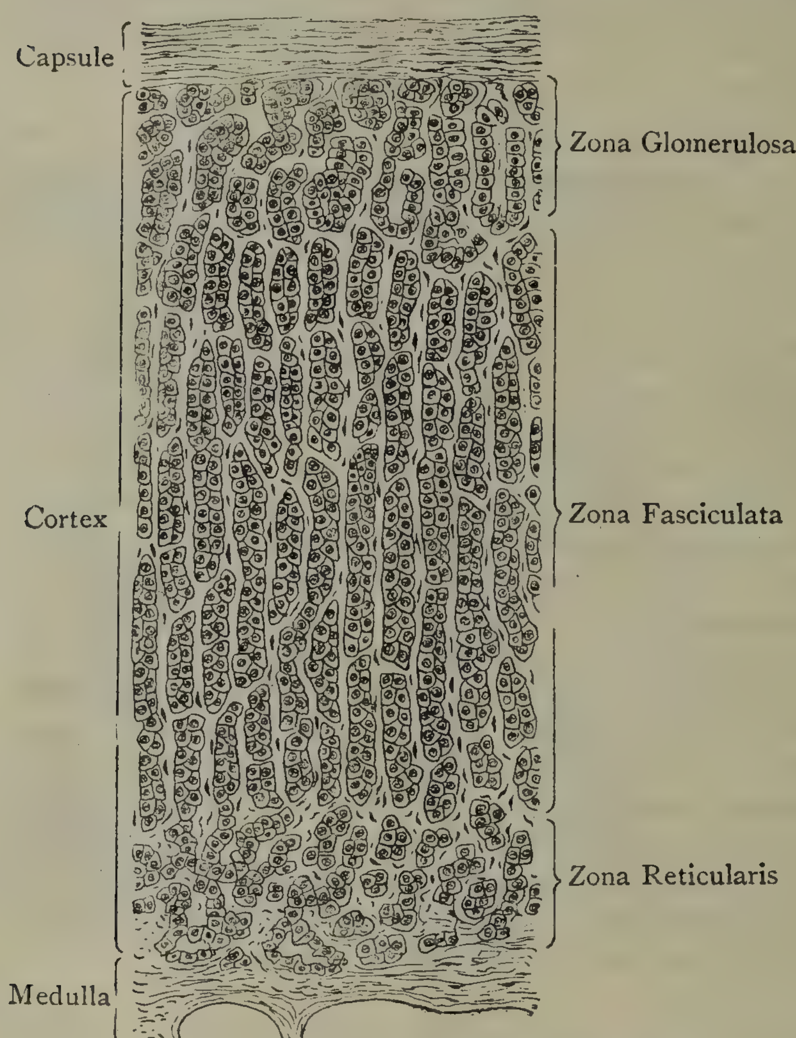


FIG. 525.—SECTION OF THE SUPRARENAL CAPSULE.

The **medulla** is confi to the centre of the gl in the adult, is soft in c sistence, and has a redd brown colour, due to contained venous blood. supporting fibrous strom the cortex pervades it, is arranged in a retic manner. The meshes of reticulum are occupied cells, larger and more irre lar than those of the cor further differing from t in containing granules wh stain deeply with chrom salts.

Blood-supply—Arterie These are (1) the supe suprarenal of the phre from the abdominal ao (2) the middle suprare from the abdominal ao and (3) the inferior sup renal from the renal.

The **veins** of each gl eventually unite to form suprarenal vein. This vessel emerges through the hilum, and on *right* side it opens directly into the inferior vena cava, whilst on *left* side it terminates in the left renal vein.

The **lymphatics** terminate in the *juxta-aortic glands*. The lym vessels accompany the vessels connected with the glands. Th issuing with the main vein drain the medullary region, and p (Fig. 526) to aortic glands below the levels of the renal pedicles; one two pass behind these to glands behind the renal arteries. Vess accompanying the suprarenal arteries drain the cortex, and reach gla above the renal pedicles; on the right some pass behind the infe vena cava. Additional lymphatics, shown in the figure by interrup lines, run up on the diaphragm, which they pierce, to enter glands

thoracic aorta at about the level of the ninth or tenth thoracic tebræ.

Nerves.—The suprarenal glands are very richly supplied with nerves, ch are derived from (1) the phrenic plexus from the cœliac ganglion cœliac plexus, (2) the suprarenal plexus from the cœliac ganglion cœliac plexus, and (3) offshoots from the renal plexus. According Bergmann, the suprarenal glands also receive fibres from the phrenic vagi nerves. The fibres, which are chiefly non-medullated, form plexuses in the medulla, where they have numerous ganglion cells nected with them.

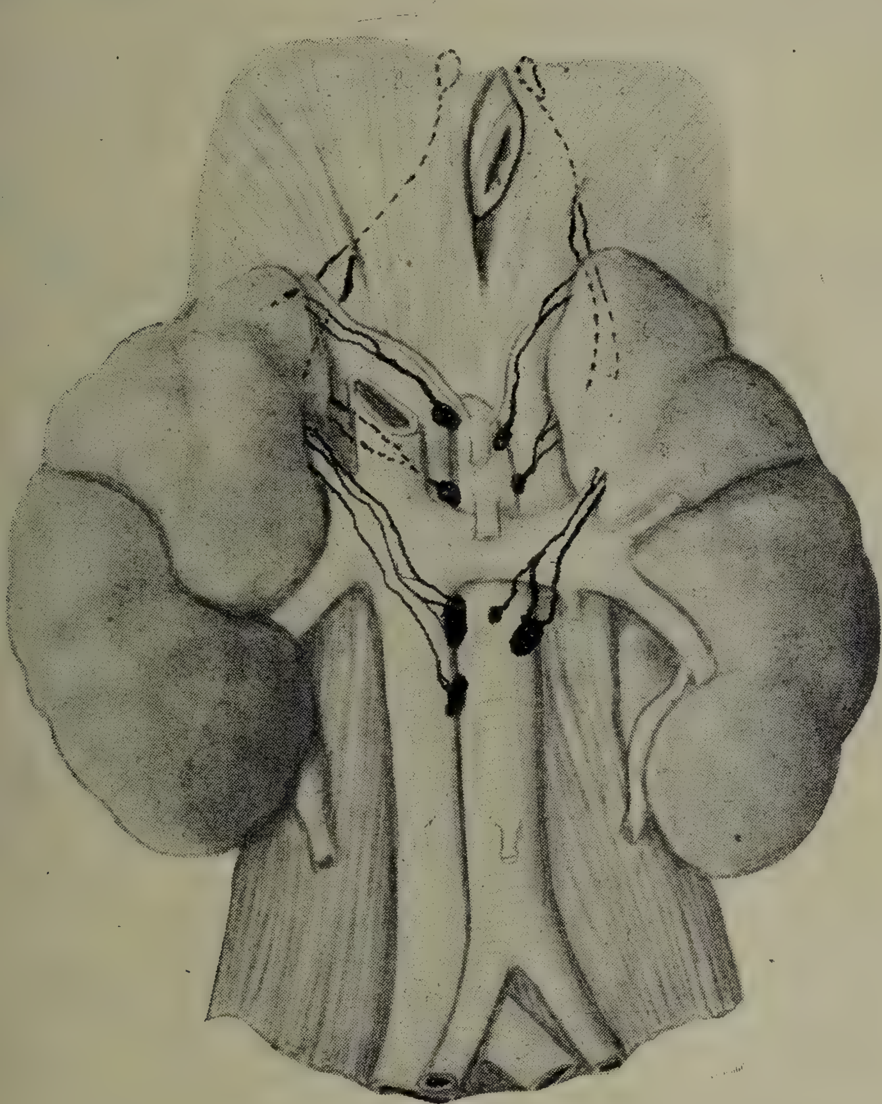


FIG. 526.—LYMPHATICS OF SUPRARENAL GLANDS (AFTER ROUVIÈRE).

Development.—The suprarenal gland makes its appearance medial to the sonephros. The cortex is of mesodermic origin, and the medulla is developed n the cells of the primitive abdominal sympathetic system.

The **cortex** is developed from cellular outgrowths of the mesothelium of the om, or body-cavity, on the mesial aspect of the mesonephros. These outwths soon become separated from the cœlomic mesothelium, and unite to n a solid mass, which constitutes the cortex.

The **medulla** is derived from the primitive abdominal sympathetic cells. ups of cells grow out from the ganglia (these cells being consequently of odermic origin), and they invade the cortex. They become differentiated two groups. The cells of one group are *chromaffin cells,* and stain a dark ow colour with chromic acid salts. The cells of the other group are *ganglion* s. All the cells developed from the sympathetic ganglia gradually pass to the tre, where they constitute the medulla.

The suprarenal gland thus develops in two parts—cortex, derived fron cœlomic mesothelium (mesoderm), and medulla, derived from the abdor sympathetic ganglia, and therefore of ectodermic origin. The cortical begins to form in the fourth week, and the ganglion cells begin their inv three weeks later; the process goes on till after birth, and ill-understood fo tive changes continue for some years.

Structure of the Kidneys.

The kidneys are compound tubular glands. Each organ is vested by a capsule, composed of fibrous tissue with a certain am of elastic fibres. The deep surface of this capsule is attached to peripheral portion of the renal substance by fine fibrous processes small bloodvessels. Un neath it there is a ce amount of plain musc fibre, arranged in a so what plexiform manner. the hilum on the inner bo it is prolonged inwards line a cavity to which hilum leads, called the *r sinus*, where it becomes tinuous with the fibrous c of the calyces.

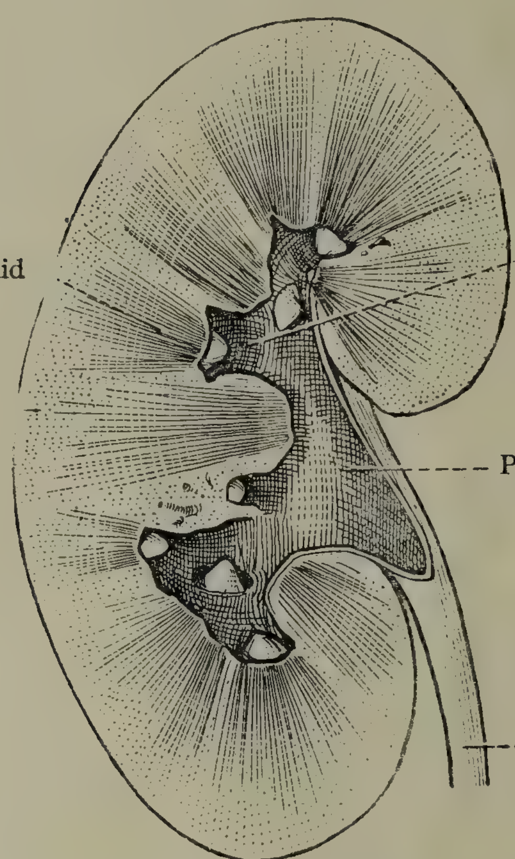


FIG. 527.—DIAGRAM OF THE KIDNEY IN LONGITUDINAL SECTION.

When a kidney is into two halves by a lo tudinal incision carried f the outer to the inner bo it is seen to be comp of two parts—cortex medulla.

The **medulla,** which internal in position, is ranged in conical bunc termed **renal pyramids (pyramids of Malpighi)**, which vary in num from eight to eighteen, the average number being about twe The bases of these pyramids are directed towards the circumfere whilst their apical parts, called **renal papillæ,** project into the sinus, wh they are grasped by the calyces. Each renal pyramid is divided three parts—namely, the *basal part*, the *papillary zone*, and the *a* The basal parts of the pyramids form collectively the *boundary zon* the kidney. They abut against the cortical substance, which se prolongations between them, called **renal columns** (*columnæ Bert* These prolongations extend as far as the commencement of the ap parts of the papillary zones, where they cease, so that these ap parts project into the calyces free from cortical investments. E renal pyramid is composed of straight, slightly converging urinifer tubules (*tubuli recti*) and straight bloodvessels, the number of tub

ıg very much greater in the basal part than elsewhere. This ight arrangement of tubules and bloodvessels imparts to each amid a longitudinally striated appearance from apex to base. The al parts have a dark reddish-brown colour, which becomes brighter he papillary zones.

The **cortex** of the kidney is mainly situated within the fibrous sule. It has a reddish-brown colour, and, as already stated, sends longations between the renal pyramids. Like the medullary part, composed of uriniferous tubules and bloodvessels, but the tubules principally convoluted (*tubuli contorti*), though there are also dles of straight tubules (*tubuli recti*) which have issued from the al pyramids, and form the **medullary rays.**

Cortex.—The cortical part is composed of the labyrinth and the lullary rays.

Labyrinth.—This portion of the cortex is so named from the very nplicated arrangement of its tubules. It is situated in the inter-ces between the medullary rays, and is composed of convoluted iferous tubules, bloodvessels, and glomeruli, each of the latter being losed within a capsule of Bowman.

Uriniferous Tubules.—Each tubule commences in the labyrinth he cortex in a spherical dilatation, called the *capsule of Bowman,* hin which there is a tuft of convoluted capillary bloodvessels, known a **Malpighian glomerulus** (**Malpighian corpuscle**). Bowman's capsule sents two poles. One of these is formed by two bloodvessels, afferent efferent, which pierce the capsule at separate points, but close to each er. At the other pole Bowman's capsule becomes constricted, and ns the **neck** of a cylindrical tubule. After the tubule has passed the k it becomes convoluted, and forms the **first convoluted tubule.** The ement membrane and lining epithelium of Bowman's capsule are con-ious with the basement membrane and lining epithelium of the first voluted tubule, and the space between Bowman's capsule and the nerulus is continuous with the lumen of the tubule. The first voluted tubule soon becomes straight, though slightly wavy, and, ring a medullary ray, it forms the **spiral tubule.** This tubule, on hing the junction of the cortex and boundary zone, becomes denly very narrow, and traverses the basal part of a renal pyramid. s known as the **descending limb of Henle's loop.** On leaving the ndary zone it enters the papillary zone, and after a short course escribes a very sharp bend, called the **loop of Henle.** It now re-ces its steps from the papillary zone into the boundary zone of a al pyramid, in which latter situation it becomes suddenly enlarged. s part, which retraces its steps, is called the **ascending limb of Henle's .** It re-enters the cortex, where it becomes narrower, and passes a medullary ray, in which it lies for a short distance. It sub-iently, however, leaves the ray, and, entering the labyrinth, ds between the convoluted tubules as the **irregular or zigzag tubule,** ch has become slightly enlarged. This irregular tubule then passes the **second convoluted tubule.** This tubule, becoming narrow,

passes into the **junctional tubule,** which is slightly wavy. The
tional tubule leads into the **straight or collecting tubule,** which is sli
enlarged, and is situated in a medullary ray. This straight colle
tubule now passes to the basal part of a renal pyramid, taking

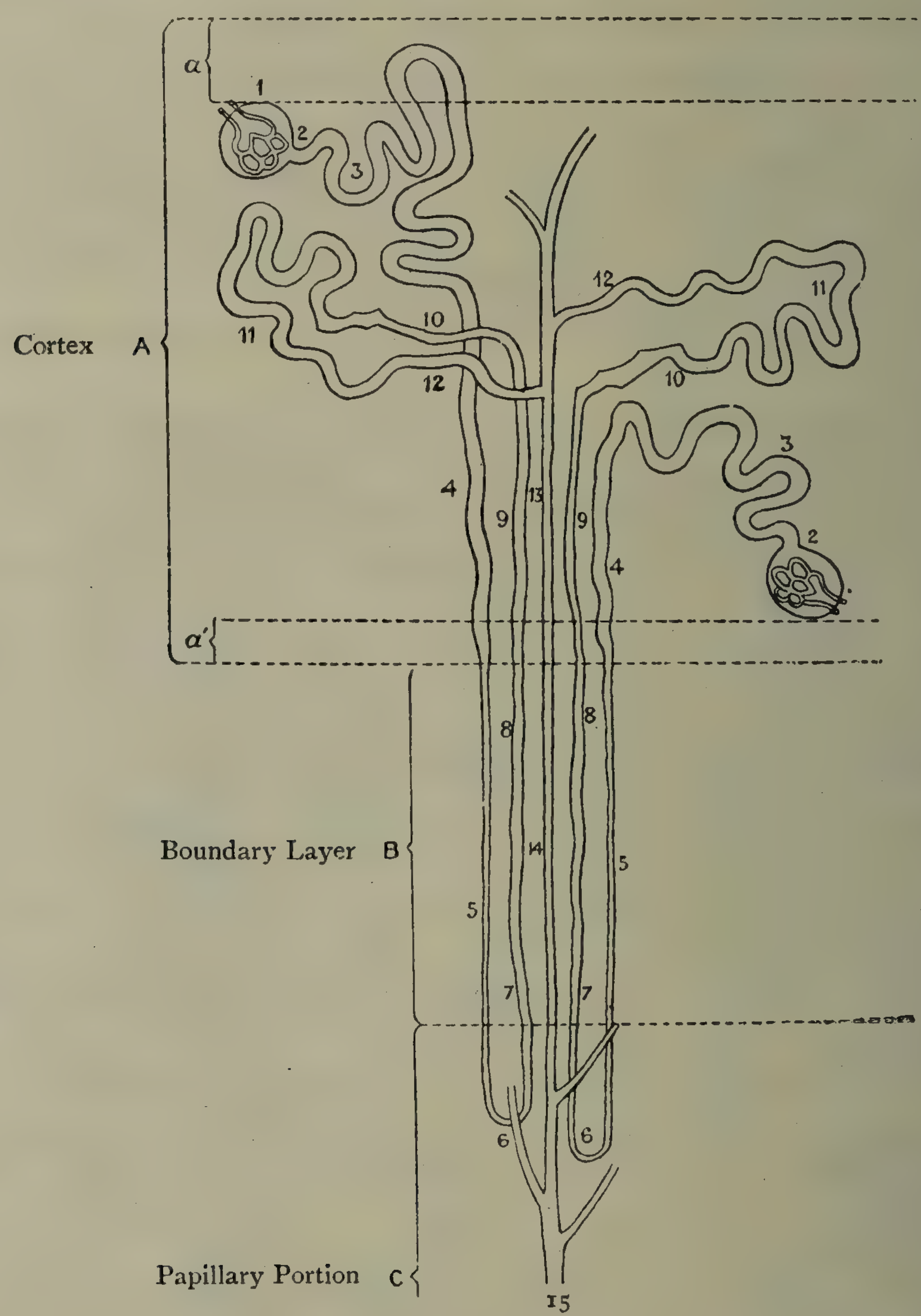


FIG. 528.—DIAGRAM OF THE URINIFEROUS TUBULES OF THE KIDNEY (K

a and *a'*, outer and inner zones of cortex, which are free from Malpighian bodies.

1. 1. Capsule of Bowman
2. 2. Neck of Capsule
3. 3. First Convoluted Tubule
4. 4. Spiral Tubule
5. 5. Descending Limb of Henle's Loop
6 6. Loop of Henle
7. 7., 8. 8., 9. 9., Ascending Limb of Henle's Loop
10. 10. Irregular Tubule
11. 11. Second Convoluted Tubule
12. 12. Junctional Tubule
13. 14. Collecting Tubule
15. Duct of Bellini

its course other junctional tubules from the labyrinth. In pa
through the various parts of a renal pyramid the collecting tu
unite at acute angles, and so become less numerous and at the same
larger. They run in straight, slightly converging lines toward

x of a papilla, where they are very much reduced in numbers, but of ge size. In this final part of their course each collecting tubule ns the **duct of Bellini.** These excretory tubes open on the apex of apilla, where there is often a *foveola* or small depression, and through se openings the urine escapes into a calyx.

The diameter of the ducts of Bellini is about $\frac{1}{200}$ inch.

Summary of a Tubule from Beginning to End.

1. The **capsule of Bowman,** containing a glomerulus in the *labyrinth.*
2. The **neck,** in the *labyrinth.*
3. The **first convoluted tubule,** in the *labyrinth.*
4. The **spiral tubule,** in a *medullary ray.*
5. The **descending limb of Henle's loop** (small), in a *basal part,* and in *part papillary zone,* of a *renal pyramid.*
6. The **loop of Henle,** in a *papillary zone.*
7. The **ascending limb of Henle's loop** (large), in *part of a papillary zone,* a *l part,* and the *cortex,* in which latter it is in a *medullary ray.*
8. The **irregular** or **zigzag tubule,** in the *labyrinth.*
9. The **second convoluted tubule,** in the *labyrinth.*
10. The **junctional tubule,** in the *labyrinth* on its way to a medullary ray.
11. The **collecting tubule,** in a *medullary ray* of the *cortex,* and in a *basal part renal pyramid.*
12. The **duct of Bellini,** in a *papillary zone* of a *renal pyramid.*

Structure of the Uriniferous Tubules.—The tubules are composed of a base-t membrane lined with a single layer of epithelial cells. The basement nbrane itself consists of flattened epithelial cells. The tubules vary in but their average diameter may be stated as $\frac{1}{600}$ inch. The characters he lining epithelial cells present differences in the different tubules, which now be considered in order.

1. The **capsule of Bowman** is lined with a single layer of *flattened epithelium,* ch is reflected over the glomerulus, where it is more distinct in early life than ne adult.
2. The **neck** is lined with *cubical epithelium.*
3. The **first convoluted tubule** is also lined with *cubical epithelium,* but the cells, ch are thick, are peculiar. The inner part of each cell—that is, the part next lumen of the tubule—including the spherical nucleus, has *granular* protoplasm, st the outer part—that is, the part next the basement membrane—has its oplasm *striated* or *fibrillated,* owing to the presence of rod-shaped fibrils disposed ically to the basement membrane (Heidenhain). These fibrillated cells are vided laterally with processes by which they embrace one another. The en of the tubule is distinct.
4. The **spiral tubule** is lined with epithelium similar to that of the first con-ited tubule, and its lumen is distinct.
5. The **descending limb of Henle's loop** is lined with clear, thin, *flattened cells.* tubule, though narrow, has a distinct lumen.
6. The **loop of Henle** is lined with epithelium which resembles that of the ending limb.
7. The **ascending limb of Henle's loop** is lined with *fibrillated, cubical epithelial* like those of the first convoluted and spiral tubules. Though it is of com-tively large size, its lumen is small.
8. The **irregular** or **zigzag tubule** is lined with *cubical epithelial cells,* which markedly fibrillated, and its lumen is minute.
9. The **second convoluted tubule** is lined with epithelium which resembles of the first convoluted tubule, with the following differences: (*a*) the cells longer; and (*b*) they are highly refractive. In size it corresponds with the convoluted tubule.

10. The **junctional tubule** is lined with clear, *flattened, cubical epithelial* and its lumen is large.

11. The **collecting tubule** is lined with epithelial cells, which in its earlier are clear and *cubical,* but in its later part they are *columnar,* and the lum very distinct.

12. The **duct of Bellini** is lined with epithelial cells which are clear *columnar.*

Medullary Rays or Pyramids of Ferrein.—These take the forn pyramidal bundles of uriniferous tubules, which are separated f each other by portions of the labyrinth. The tubules are strai and emerge from the basal parts of the pyramids. As these medul rays are followed from the basal parts to the periphery, each gradu diminishes in breadth, and ultimately tapers to a point, which st a short distance from the fibrous capsule, being separated from it a portion of the labyrinth. The rays are thus conical, their bases b at the basal parts of the renal pyramids, and their apices near the fibr capsule—hence the name 'pyramids.' The explanation of this sh is that the tubules at the circumference of a medullary ray enter labyrinth sooner than those in the centre, which latter form the a of the ray.

Summary of a Medullary Ray.—Each contains the following tubules: (1) sp tubules; (2) ascending limbs of Henle's loops; and (3) collecting tubules.

Medulla of the Kidney.—The medullary portion has been alre generally described. It is composed of renal pyramids, consist of uriniferous tubules and bloodvessels (true and false).

The tubules in the various parts of the renal pyramids are as follo

1. *Basal Part.*—This contains the following tubules:
   Portions of the **descending limbs of Henle's loops.**
   Portions of the **ascending limbs of Henle's loops.**
   Collecting tubules.
2. *Papillary Zone.*—This contains the following tubules:
   Portions of the **descending limbs of Henle's loops.**
   The **loops of Henle.**
   Portions of the **ascending limbs of Henle's loops.**
   The **ducts of Bellini.**
3. *Apex of the Papillary Zone.*—This contains only the **ducts Bellini.**

Bloodvessels of the Kidneys—Arteries.—Each kidney receives large amount of blood from the renal artery, which is a branch of abdominal aorta. This vessel, as it approaches the hilum, divides i four or five branches, which enter the sinus, where they are embedd in fat along with the calyces. They then subdivide into **interlo branches,** which pass between the renal pyramids, where they conti to subdivide. On arriving at the junction of the cortex and bound zone they form a series of arches, which are independent of one anoth and are called the **cortico-medullary arches.** Alongside of these th are venous arches, which, unlike the arterial arches, anastomose fre

ith one another. The convexities of the incomplete arterial arches :e directed towards the cortex, and the concavities towards the renal yramids. The branches of the arches are interlobular and arteriæ ɔctæ.

The **interlobular arteries** (cortical) arise from the convexities of the rches and enter the labyrinth of the cortex, in which they pass outards between the medullary rays. hey give off afferent and capsular ranches.

The *afferent branches* are so named ecause they carry blood to the omeruli. They arise from the in- ɛrlobular arteries at frequent interals, and each passes to a capsule f Bowman without giving off any ranch. Having pierced the capsule t one pole, the afferent vessel breaks p into a number of convoluted apillary vessels, which form a small ascular ball, called a **glomerulus** *Malpighian corpuscle*). The blood is onveyed away from the glomerulus y an *efferent vessel,* which is variously ɛgarded as an artery and a vein. 'his efferent vessel is smaller than he afferent artery. It pierces 3owman's capsule at the same pole s the afferent artery, but separate :om, though close to, it. Thereafter it breaks up into a network of apillary vessels, which invest the orresponding first convoluted urini- ɛrous tubule, the meshes of the netvork being polygonal. The efferent 'essels of those glomeruli which lie ıearest to the renal pyramids are lisposed in a different manner. They reak up into bundles of straight 'essels, called *false vasa recta,* which nter the basal parts of the pyramids, vhere they supply to a large extent the uriniferous tubules, upon the valls of which they form capillary networks with elongated meshes. t is, however, to be noted that the renal pyramids also receive true ırteriæ rectæ from the cortico-medullary arterial arches.

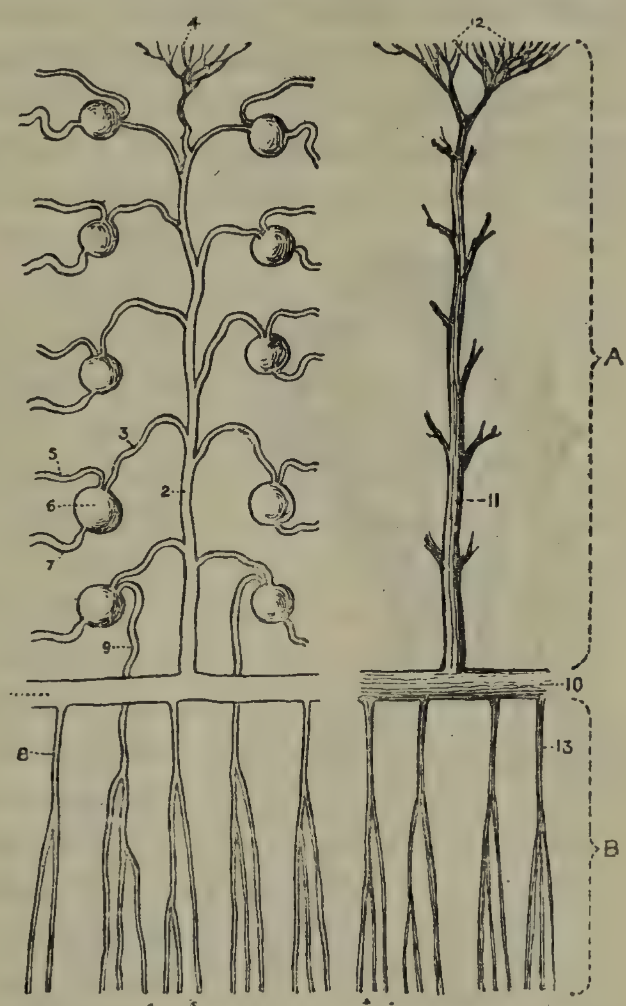


FIG. 529.—DIAGRAM OF THE BLOOD-VESSELS OF THE KIDNEY.

A, cortex; B, medulla.

1. Arterial Arch
2. Interlobular Artery
3. Afferent Artery of Glomerulus
4. Capsular Branches
5. Efferent Vessel of Glomerulus
6. Glomerulus
7. First Convoluted Tubule
8. True Arteria Recta
9. False Arteria Recta
10. Venous Arch
11. Interlobular Vein
12. Venæ Stellatæ
13. Venæ Rectæ

The Glomerulus (Malpighian Corpuscle).—A glomerulus of the kidney s a small ball of convoluted capillary bloodvessels, having two vessels onnected with it, one of which is an afferent artery and the other an fferent vessel. The vessels of many of the glomeruli are collected into

bundles, an arrangement which renders these glomeruli lobulated, number of lobules varying from two to five. Each glomerulus within a capsule of Bowman, and the flattened epithelium of the caps is reflected over the glomerulus from the points of entrance and exi the afferent and efferent vessels. The epithelial cells covering the c puscle are thicker and less flattened than those lining the capsule Bowman, and are better marked in early life than in the adult. the case of the lobulated glomeruli the epithelial investment dips between the component lobules. The epithelium of Bowman's caps and the epithelium of the glomerulus, which in each case forms a sin layer, are separated from one another by a slight interspace. diameter of a glomerulus is about $\frac{1}{200}$ in The glomeruli are confined to the cortex of kidney, where they lie in rows in the labyri between the medullary rays. There is a narr zone immediately within the external capsu and another narrow zone close to the re pyramids, from both of which glomeruli absent.

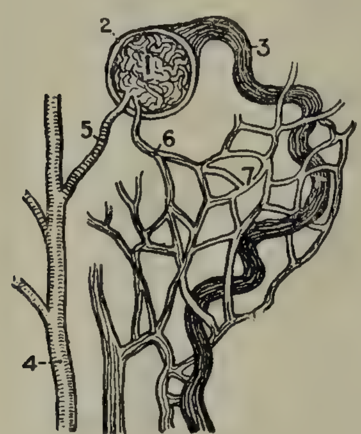


Fig. 530. — Diagram showing a Glomerulus of the Kidney with its Afferent and Efferent Vessels, and a Proximal Convoluted Tubule with its Venous Plexus (Bowman).

1. Glomerulus
2. Bowman's Capsule
3. Uriniferous Tubule
4. Interlobular Artery
5. Afferent Vessel
6. Efferent Vessel
7. Venous Plexus around Tubule
8. Interlobular Vein

The *capsular branches* of the interlobu arteries supply the external fibrous capsule the kidney, in which they anastomose w branches of the lumbar arteries from the a dominal aorta.

The **arteriæ rectæ** (medullary), or vasa re (true), arise from the concavities of the corti medullary arterial arches, and at once enter t basal parts of the renal pyramids. Here th break up into bundles of straight, sligh diverging arterioles, which run between t bundles of straight, slightly converging uri ferous tubules, a mutual arrangement whi imparts to the renal pyramids a longitudina striated appearance. The capillary netwo formed by these arterioles have necessar elongated meshes. It is to be noted that t renal pyramids derive their blood-supply fr two sources—namely, (1) the arteriæ rectæ, or vasa recta (true), fr the cortico-medullary arterial arches; and (2) the false vasa recta fr the efferent vessels of those glomeruli which lie nearest the re pyramids. It is also to be noted that a glomerulus of the kidney is ball of convoluted capillary bloodvessels, which is enclosed with a capsule of Bowman, whereas a Malpighian body of the spleen is collection of lymphoid or adenoid tissue which is a localized expansi of the external or lymphoid coat of the small arteries in the inter of that organ.

Veins—*Veins of the Cortex.*—These are called the *interlobular vei* Some of them commence on the surface of the kidney beneath t

psule, from which they return blood, and these are called *venæ stellatæ*, cause the venous radicles which give rise to them converge to a int, and so present a star-like appearance. Others originate in the xuses around the uriniferous tubules. The interlobular veins rminate by joining the convexities of the venous arches, which are uated between the cortex and the renal pyramids.

Veins of the Medulla.—The veins of the renal pyramids commence plexuses which surround the ducts of Bellini in the apical parts of the pillary zones, and they are called *venæ rectæ*. As these traverse the ramids they are collected into bundles of straight vessels, which en into the concavities of the cortico-medullary venous arches.

Cortico-medullary Venous Arches.—These arches, which are com-ete, are situated between the cortex and the renal pyramids, where ey lie alongside of the incomplete arterial arches. They derive their ood from the interlobular veins of the cortex and the venæ rectæ the renal pyramids. The veins which proceed from these arches ss between the pyramids to the sinus of the kidney, where they ite to form the renal vein, which terminates in the inferior vena cava.

Lymphatics.—These consist of two groups, superficial and deep. e **superficial lymphatics,** which are few in number, form a plexus in e fibrous capsule, and communicate with lymph spaces between the iniferous tubules in the outer part of the cortex. They terminate joining the deep lymphatics at the hilum. The **deep lymphatics** company the bloodvessels, and communicate with lymph spaces tween the uriniferous tubules of the cortex and boundary zone. n emerging at the hilum they receive the superficial lymphatics, d then pass to the *juxta-aortic group of lumbar glands.*

Nerves.—The kidney receives numerous nerves from the renal exus, which derives its fibres from (1) the aórtico-renal ganglion, which the lesser splanchnic nerve terminates; (2) the cœliac plexus; d (3) the aortic plexus. If there is a lowest splanchnic nerve present reinforces the renal plexus. The nerve-fibres are partly sympathetic, rtly spinal through the lesser and lowest splanchnic nerves, and in rt derived from the right vagus through the cœliac plexus. They company the arterial branches, and ramify upon the walls of the ssels and uriniferous tubules.

Excretory Apparatus of the Kidney.—This consists of the calyces, elvis, and ureter.

Ureter.—This is the excretory duct of the kidney, and it has the rm of a cylindrical tube, like a goose-quill, its colour being a dull hite. Its length varies from 12 to 16 inches, and its diameter is bout $\frac{1}{5}$ inch. At its lower extremity it opens into the bladder, and t the hilum of the kidney it joins the **pelvis of the kidney,** which is nnel-shaped, being wide above and narrow below. The pelvis is attened from before backwards, and lies partly in the sinus and artly outside the hilum, its direction being downwards and inwards. t is formed by the union of two or three primary divisions or **greater alyces (infundibula)** within the sinus, and these again are formed by

the union of about nine secondary divisions, called **lesser calyces.** T number of lesser calyces thus usually falls short of the number of re pyramids (8 to 18), the explanation being that one lesser calyx m grasp two papillæ or even three. The lesser calyces embrace papillæ of the renal pyramids, which thus project into them, and th receive the urine as it oozes through the pores on the apices of papillæ, these pores being the openings of the ducts of Bellini. T interspaces between the lesser calyces in the renal sinus are occup by the branches of the renal bloodvessels and by fat.

Structure of the Ureter.—The ureter is a thick-walled muscu tube, lined with mucous membrane, and consists of three coats external or fibrous, middle or muscular, and internal or muco

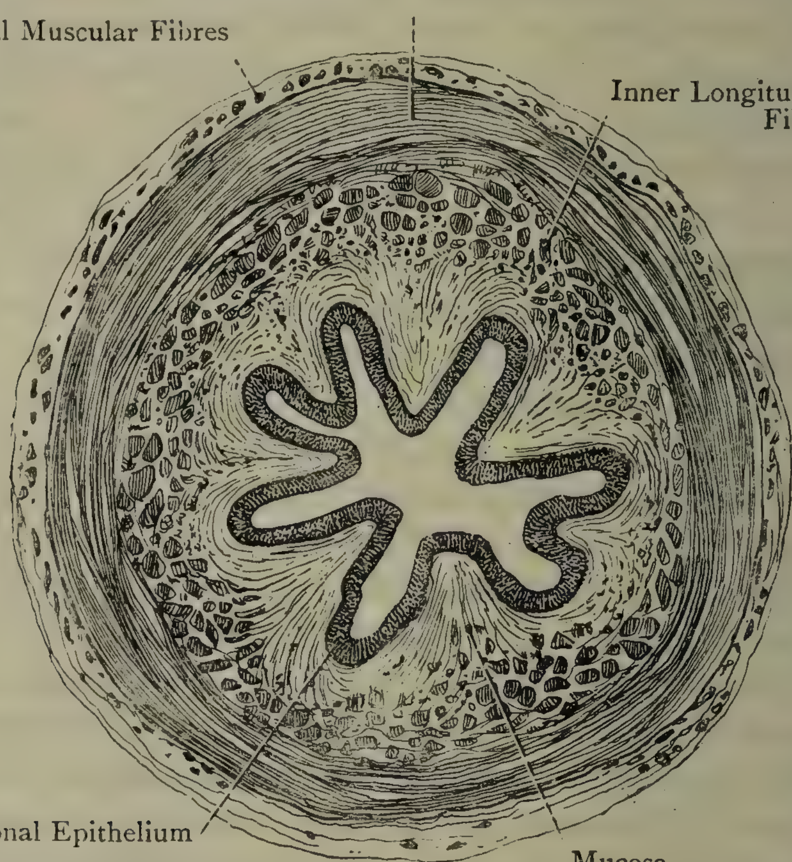


FIG. 531.—TRANSVERSE SECTION OF THE LOWER PART OF THE URETER, SHOWING ITS MINUTE STRUCTURE.

The **fibrous coat** is composed of fibrous tissue, very compactly arrange and contains the bloodvessels and nerves, which here subdivide. Th **muscular coat** is composed of plain muscular tissue, which is dispose in three layers—*outer longitudinal, middle circular,* and *internal long tudinal.* The outer longitudinal layer is best marked in the lower ha of the ureter, where it forms a continuous investment. In the uppe half of the tube its bundles are somewhat scattered. The **mucou coat** superiorly is continued over the papillæ of the renal pyramids, an inferiorly becomes continuous with the mucous membrane of th bladder. It is covered by stratified transitional epithelium, the cel being arranged in four layers. In the most superficial layer (neares the lumen of the tube) the cells are cubical, and present depressions o

eir deep surfaces, which receive the round ends of the pyriform cells the layer beneath. In the second layer the cells are pyriform, the und superficial ends being capped by the cubical cells of the first yer, and the narrow deep ends projecting between the deeper cells. the third and fourth layers the cells are round or oval. The mucous embrane is thrown into longitudinal folds, and the lumen of the be, which is of small size, presents under the microscope a branched pearance on cross-section.

Around the lower end of the ureter for a distance of 3 or 4 mm. a fibrous-tissue covering known as Waldeyer's sheath. Between is sheath and the ureteral wall proper is some loose bursal tissue, ich serves to facilitate the slight but important movement which kes place between the lower end of the ureter and the vesical wall contraction and relaxation of the bladder, and which has for its rpose the prevention of regurgitation of urine.

Blood-supply—Arteries.—The ureter receives branches from the nal, testicular (ovarian in the female), common iliac, and superior sical arteries.

The **veins** terminate in the vessels corresponding to these arteries.

Lymphatics.—These pass to the *juxta-aortic group of lumbar glands,* d to the *internal iliac glands.*

Nerves.—These accompany the arteries, and are derived from e renal, testicular (ovarian in the female), and pelvic plexuses. The res form plexuses in the fibrous and muscular coats, which contain all ganglia.

Structure of the Pelvis and Calyces.—The structure of these parts the excretory apparatus resembles that of the ureter, with the ception that they have only two layers of plain muscular tissue, stead of three as in the ureter. The layer which is wanting is the *ter longitudinal layer.* The lesser calyces are attached to the bases the papillæ, and in these situations their fibrous coats become con-uous with that part of the fibrous capsule of the kidney which is olonged inwards through the hilum to line the sinus. The internal ngitudinal muscular fibres disappear towards the papilla, but the rcular muscular fibres accompany a lesser calyx to its termination, here they are arranged in the form of a circular band, which surrounds e base of a papilla at the line of attachment of a calyx. The stratified ansitional epithelium of the mucous coat of a lesser calyx is pro-nged over the apex of each papilla.

Stroma of the Kidneys.—Between the uriniferous tubules and oodvessels there is a certain amount of connective tissue, which present in greatest abundance in the region of the papillary zones. his constitutes what is known as the **fibrous** or **intestinal stroma,** which there is a very small amount.

Early Condition of the Kidneys.—The kidneys of a child at the period of birth e lobulated, each lobule representing a renal pyramid surrounded by cortical bstance. In this respect they resemble the permanently lobulated kidneys of rtain animals—*e.g.*, the ox. The lobules first become apparent towards the

end of the third month of intra-uterine life, and all traces of them have usı disappeared by the eighth or tenth year. They may, however, remain persis to a greater or less extent throug life, though this condition is of rare occurrence. It is, however, uncommon to find the surface o adult kidney marked by faint gro indicative of its original lobul condition. The disappearance of lobulated condition is brought a by the adjacent lobules coalescing, being accompanied by an incre development of cortical substanc the surface. The portions of cor substance which remain in the sp between the renal pyramids (ex their apical parts) form the r columns.

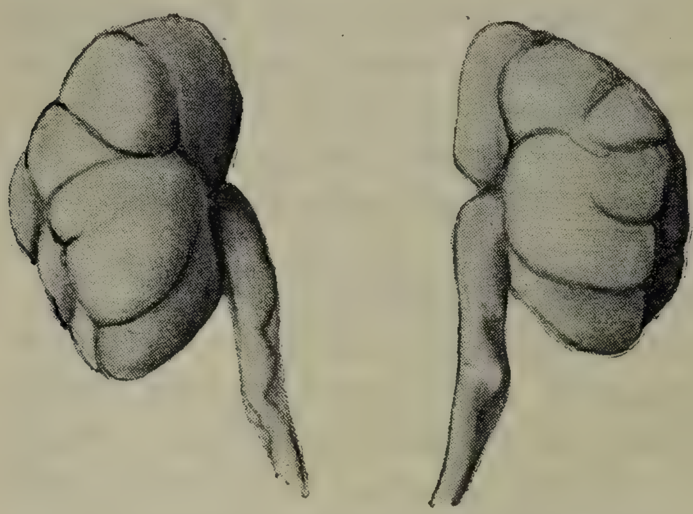


FIG. 532.—KIDNEY OF A CHILD SHORTLY BEFORE BIRTH.

Development of the Kidney and Ureter.

The **metanephros,** or permanent kidney, is the last of the serie excretory organs formed in the human embryo. For the acco of these organs, see p. 94 *et seq.*

The **ureteric bud,** the earliest formation in association with metanephros, begins to grow from the mesonephric duct when embryo is about 5 mm. long. It is a club-shaped, hollow outgrov which (Fig. 533) is surmounted from an early stage by a blastemal c formed by metanephric mesoderm. The markedly condensed d or inner layer of this cap is a very noticeable feature. The hol outgrowth elongates fairly rapidly, growing in a cranial directi dorsal to the mesonephros, and carrying its blastemal cap on extremity as it grows. The bulbous end soon divides into two, a from these secondary outgrowths take place, each process carrying own blastemal cap upon it. In this way the cavities of the *grea and lesser calyces* are marked out. The process continues of elongat of outgrowth, subdivision, and consequent new outgrowths, and so and thus the collecting tubes of the kidney are made, each advanc end being covered by its *metanephric cap* of blastemal tissue.

At a later stage the earliest formed generations of these collecting-t systems are taken up into the calyces, so that the final number of collecting tu is not the same as the whole number formed, and more tubes come to open i the calyces directly than originally grew from them.

The formation of outgrowths goes on during the second, thi and fourth months, and probably for a considerable time after tl About the beginning of the third month, however, some of the tul subdivisions have reached their terminal stages, and the blasten caps of these terminal outgrowths begin to show activities whi ultimately lead to the formation of the secretory parts of the tubı system. The inner zone of the cap forms a solid mass of cells, whi

on becomes hollow, and is termed the *renal vesicle*. A curved short bule grows from this towards the bent end of the terminal collecting be, with which it becomes connected. The renal vesicle is in the antime invaginated, and thus constitutes a *glomerulus*. The short rved tubule, somewhat in the shape of an **S**, elongates slowly. The

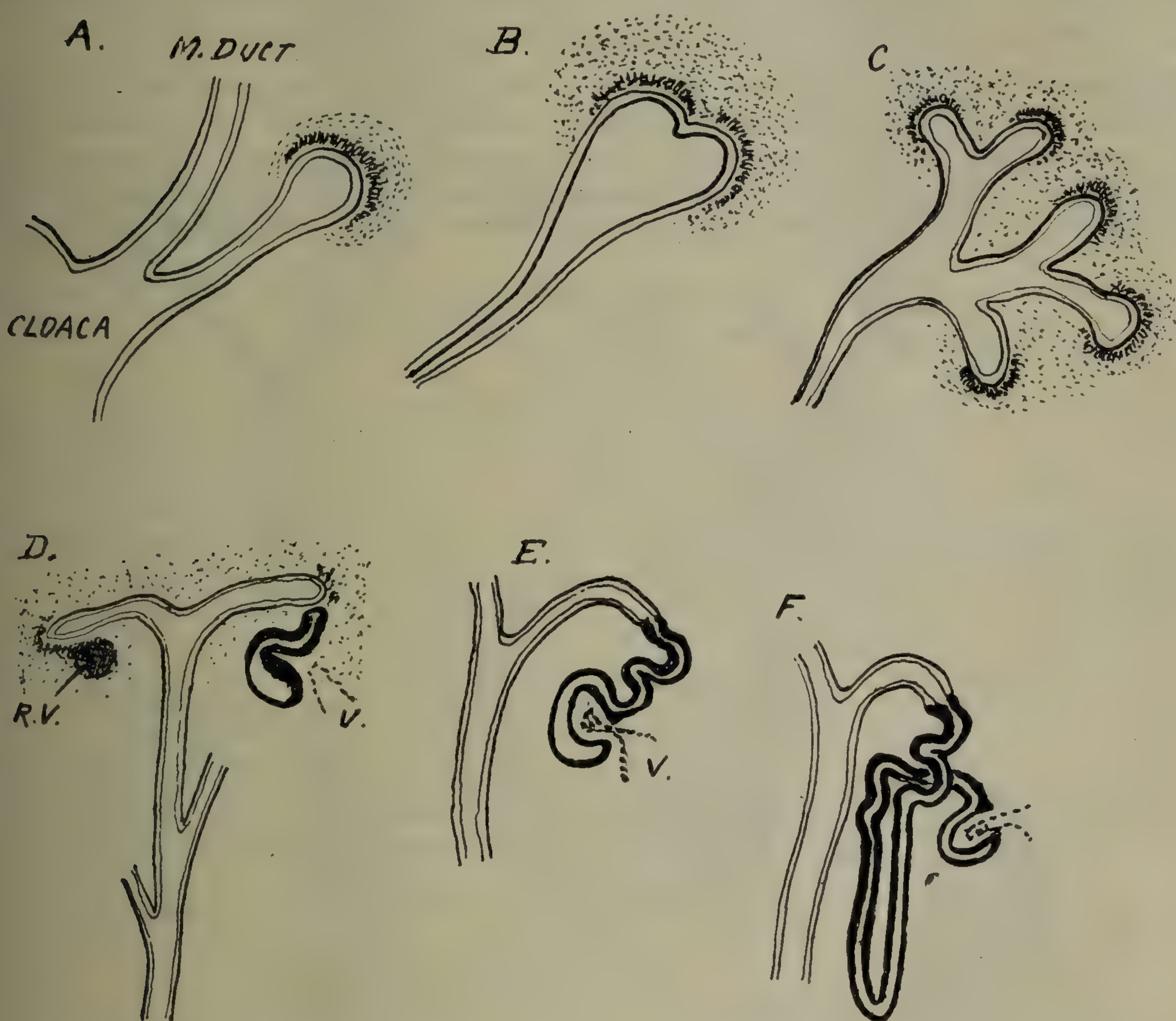


FIG. 533.—SCHEMATIC DRAWINGS TO ILLUSTRATE THE FORMATION OF THE TUBULAR SYSTEM OF THE KIDNEYS.

A the ureteric outgrowth is shown arising from the mesonephric duct close to where this enters the cloaca. The enlarged end of the bud is covered by its blastemal cap. The enlarged end becomes bilobed. *B*, each lobe covered by its cap. Further subdivisions are seen in *C*. Terminal subdivisions are shown in *D*, where the cap is forming, on the left, a rounded 'renal vesicle,' *R.V.* On the right a tubule is growing from the vesicle toward the end of the collecting terminal. In *E* and *F* the tubule has fused with the terminal, and by elongating is making convoluted tubules and a loop of Henle. A vascular loop *V* grows against the renal vesicle and the adjoining part of its tubule, and invaginates them, producing a glomerulus.

cond convoluted tubule is formed from the upper limb of the curve, e first convoluted tubule from its lower limb, and the intervening rtion is lengthened into Henle's loop. Henle's loops can be disctly recognized during the fourth month. The other descriptive rts of the system of tubules are gradually formed as elongation prosses.

It is seen, then, that the tubule system, from the glomerulus to t arched collecting duct, is derived from the *metanephric mesoder* while the whole system of collecting ducts is formed by outgrov from the original ureteric growth. The junction between the t parts of the whole tubule system is effected shortly after the blaster tubule begins its growth; it is the failure of this junction which m lead to one of the varieties of congenital cystic kidney.

The secondary junction between outgrowths from the mesonephric duct on one hand, and tubules formed separately in the mesoderm on the other ha is not in itself an extraordinary or out-of-the-way occurrence. It is well knc to occur in several species of animals, and it is apparently represented in development of the secondary tubules of the human mesonephros, which, wl

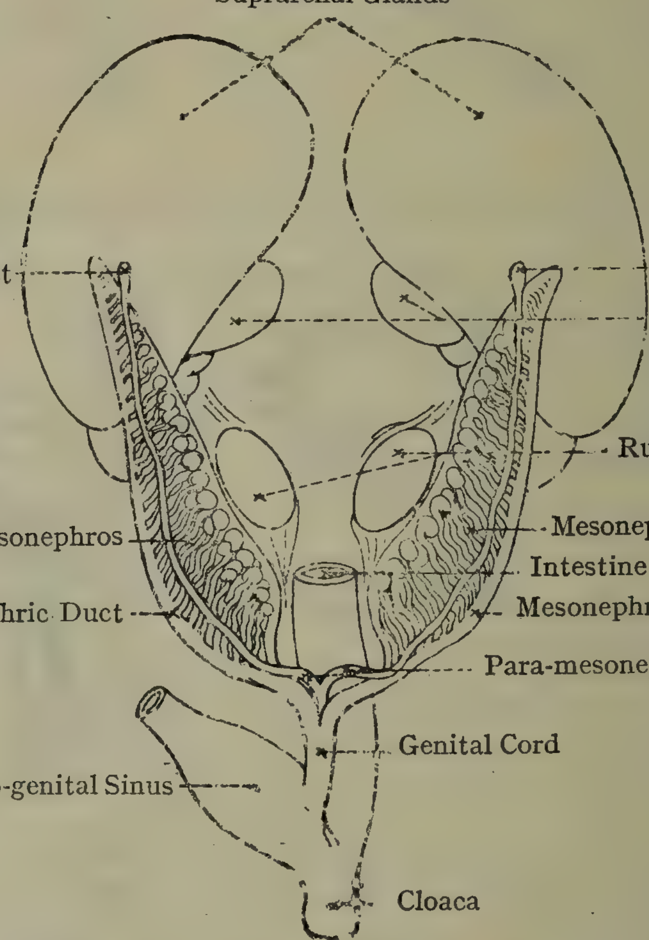


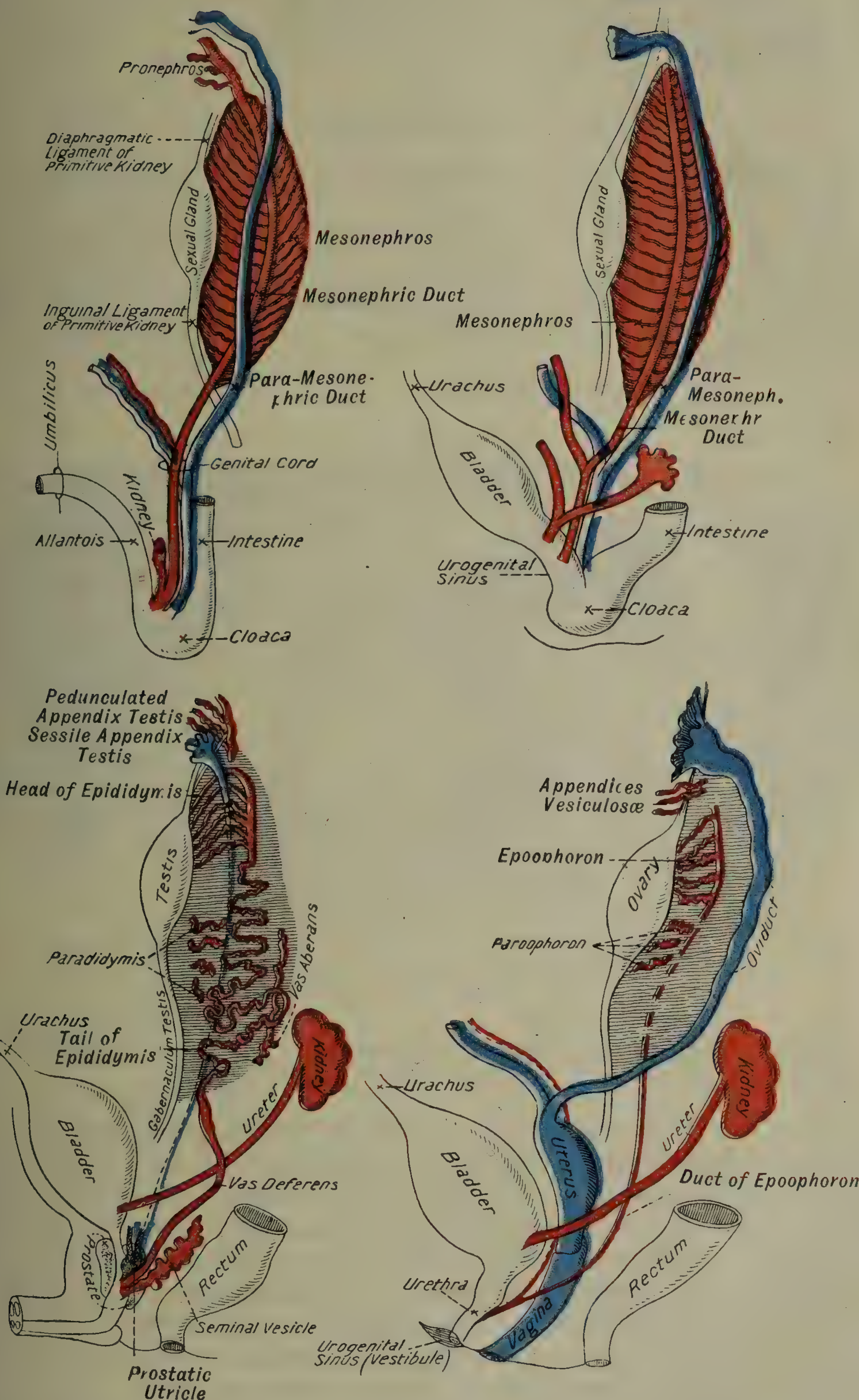
FIG. 534.—THE MESONEPHRO, MESONEPHRIC, AND PARA-MESONEPHRIC DUC AND CONTIGUOUS PARTS (ALLEN THOMSON).

they are formed, extend toward the mesonephric duct, and meet secondary p jections from this duct in their direction. In the case of the metanephros t may, in the light of what has just been said, be looked on as corresponding w these secondary tubules of the mesonephros coming into relation with enormou elongated outgrowths from the mesonephric duct.

The vascular constituents, the interstitial connective-tissue stroma, t renal columns, and the renal capsule are developed from the metanephric blaster

The **ureter** of either side, which originally opens into the uro-genital si in common with the mesonephric duct, becomes detached from that duct a opens by an independent orifice into the uro-genital sinus on its dorsal aspe It may here be stated that the urinary bladder is developed from the u genital sinus.

Summary.—The **pronephros** is functional in lower vertebrates—*e.g.*, cert Fishes, and Amphibia during the larval stage. In Man it is rudimentary. T pronephric duct persists as the mesonephric duct.



535.—DEVELOPMENT OF THE URO-GENITAL SYSTEM (AFTER HEISLE).

The **mesonephros** or **Wolffian body** succeeds to the pronephros, and pe as the functional kidney in Fishes and Amphibia. In Man it atrophies large extent, and is replaced by the metanephros.

The **metanephros** is the *permanent human kidney.*

THE PELVIS.

The pelvis is the lower division of the abdomen which lies b the level of the pectineal lines and sacral promontory. Unlike abdomen proper, the walls of the pelvis are chiefly osseous. posterior wall is constructed by the sacrum and coccyx, with the ori of the pyriformes muscles. Each lateral wall is formed by the body spine of the ischium, and is covered by the obturator internus mu

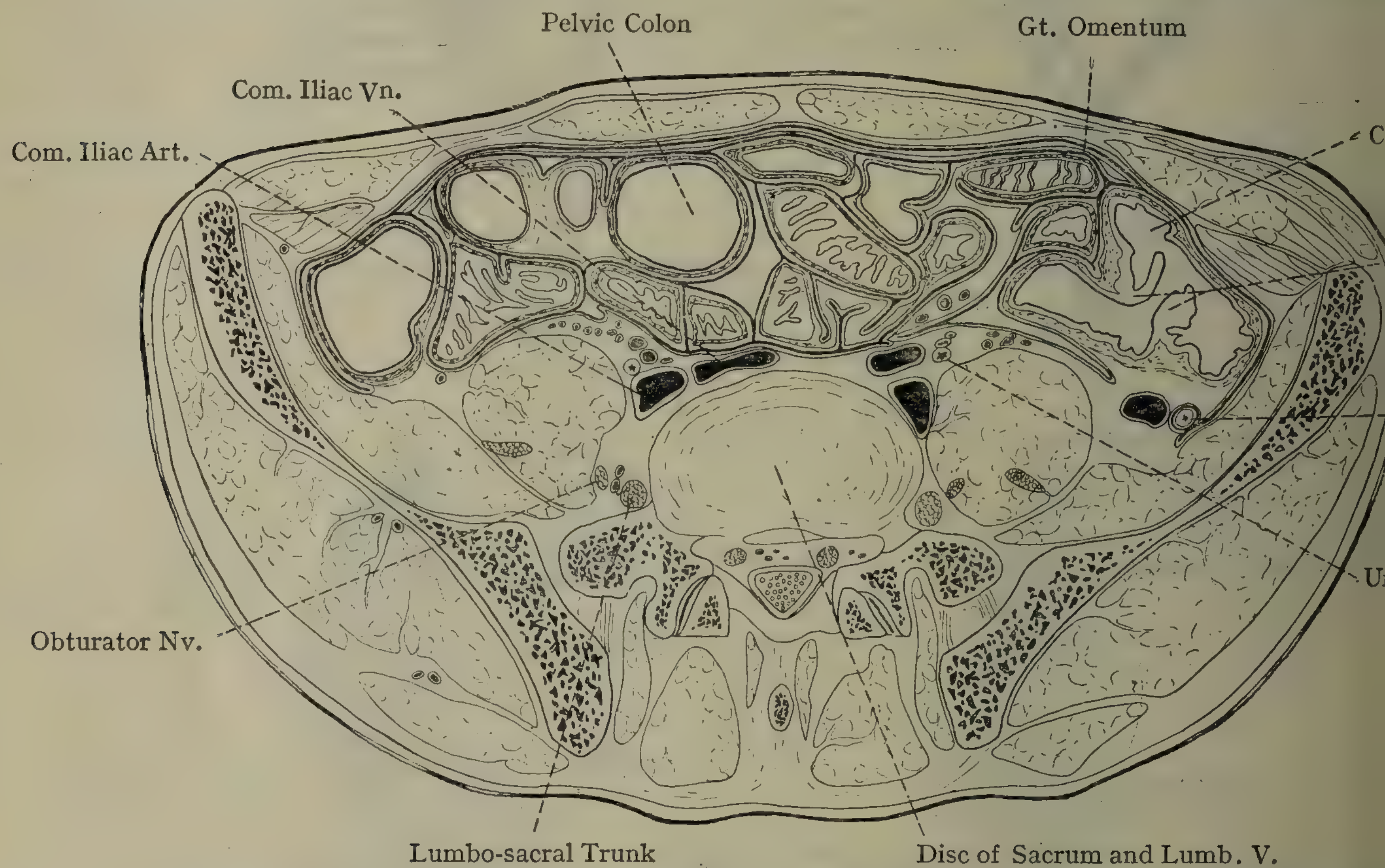


FIG. 536.—TRANSVERSE SECTION AT LEVEL OF LUMBO-SACRAL JUNCTION (AFTER SYMINGTON).

The anterior wall is formed by the bodies of the pubic bones, whic the median line construct the symphysis pubis. Between the poste wall and each lateral wall is a large space, which is partly closed by powerful sacro-tuberous and sacro-spinous ligaments. This spac divided into two parts by the sacro-spinous ligament and the spin the ischium. The upper part forms the greater sciatic foramen, wh transmits the pyriformis muscle; the superior gluteal vessels, lymphat and nerves; the inferior gluteal vessels, lymphatics, sciatic nerve, posterior cutaneous nerve of thigh; the internal pudendal vessels lymphatics and pudendal nerve; the nerve to the obturator inter and gemellus superior; and the nerve to the quadratus femoris gemellus inferior. The lower part forms the lesser sciatic foram which transmits the obturator internus muscle and its nerve,

rnal pudendal vessels, and the pudendal nerve. At each lateral t of the anterior wall is the obturator foramen, which is closed, ept superiorly, by the obturator membrane, covered by the obturator rnus muscle. Below the symphysis pubis is the pubic arch, which ccupied by the perineal membrane. The pelvic wall, thus con-icted, is clothed by the pelvic fascia. Superiorly the pelvic cavity uite open and in free communication with the abdomen proper. eriorly it is for the most part closed, a complex septum separating rom the perineum underneath. This septum is partly muscular partly fascial. The muscles entering into it are the levatores ani the coccygei, which construct the pelvic diaphragm. The fascial nent is formed on either side by the visceral pelvic fascia, which hes the superior or pelvic surface of the muscular diaphragm, and the anal fascia, which covers its inferior or perineal surface. The

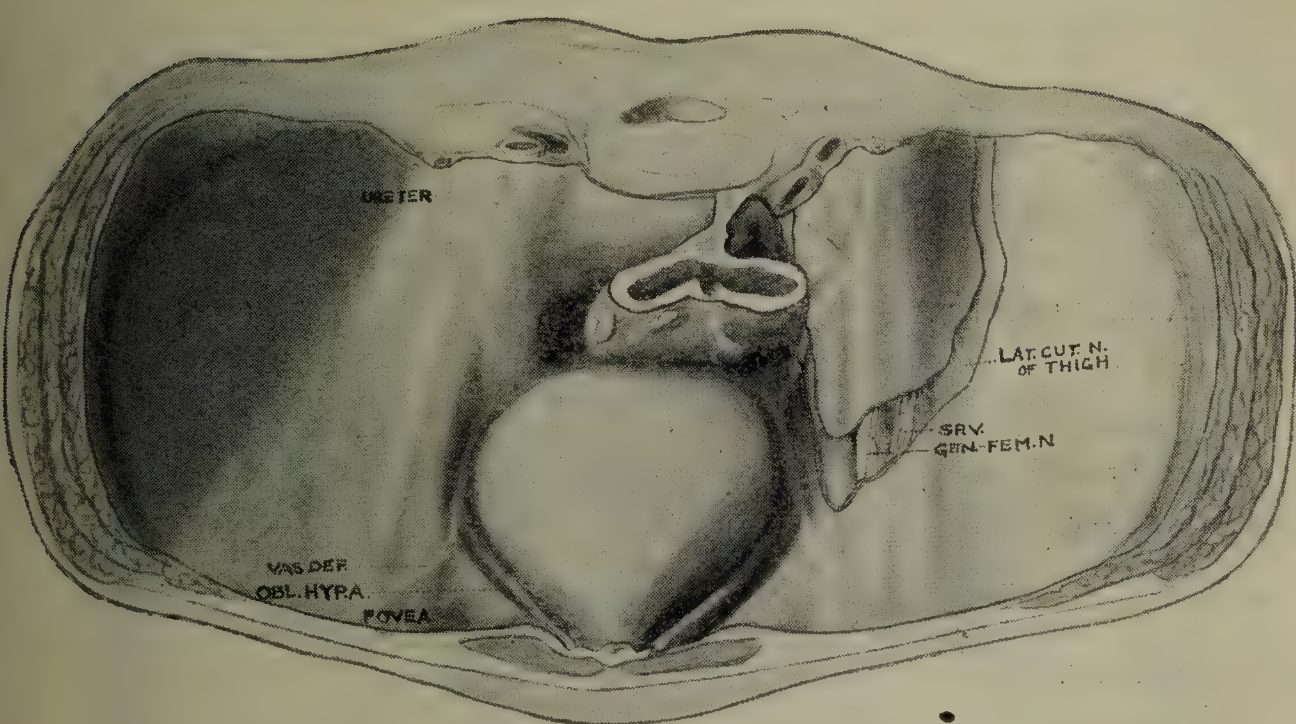


FIG. 537.—MALE PELVIC REGION SEEN FROM ABOVE.

r of the pelvis is consequently movable, being capable of ascending descending. It affords passage to the rectum and urethra, and, in ition, in the female to the vagina.

Contents of the Pelvis.—The contents of the **male pelvis** are as ows: the pelvic colon and rectum; the bladder, with the lower tions of the ureters and the prostate gland, the latter containing prostatic part of the urethra; the seminal vesicles and the lower tions of the vasa deferentia; the internal iliac vessels and their nches; portions of the superior rectal and median sacral vessels; rectal, vesical, and prostatic venous plexuses, the latter receiving dorsal vein of the penis in two divisions; the sacral and coccygeal xuses and their branches; the pelvic portions of the gangliated npathetic trunks; and the obturator nerves in part of their course.

The differences in the contents of the **female pelvis**, as compared h those of the male, are as follows:

For the prostate gland and prostatic portion of the urethra sub-tute the female urethra, uterus, and vagina. For the seminal vesi and portions of the vasa deferentia substitute the broad ligament the uterus and their contents—namely, the uterine tubes, the ova with their ligaments, and the ligamenta teres of the uterus. Add portions of the superior rectal and median sacral vessels portions of ovarian vessels. For the prostatic venous plexus substitute the pud dal plexus, and add the uterine and ovarian venous plexuses.

THE MALE PELVIS.

General Position of the Viscera.—The pelvic colon and rect are situated upon the posterior wall, the pelvic colon reaching as low the third sacral vertebra, and the rectum extending thence downwa

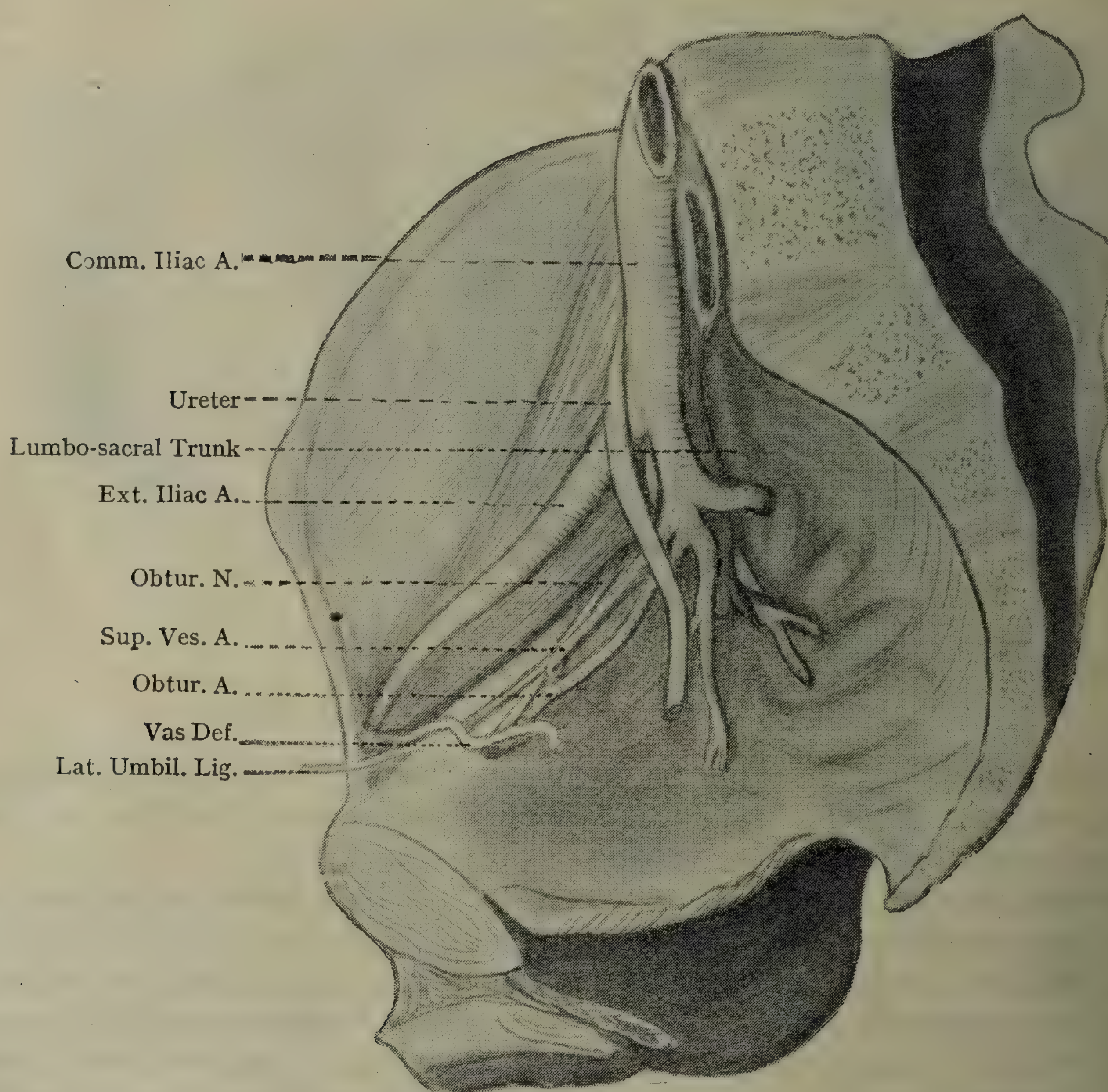


FIG. 538.—STRUCTURES ON SIDE WALL OF MALE PELVIS.

and forwards to the interval between the levatores ani muscles, wh it is succeeded by the anal canal. The bladder is anterior in positi being situated behind the bodies of the pubic bones, and resting by base upon the rectum. The seminal vesicles and the lower portions

vasa deferentia lie in contact with the base of the bladder, between nd the rectum. The prostate gland surrounds the prostatic part he urethra.

Peritoneum.—The disposition of the peritoneum will be simplified lefining the limits of the pelvic colon and rectum, and the different ts of the bladder. The **pelvic colon** extends from the inner border he left psoas major, just anterior to the left sacro-iliac articulation, he level of the third sacral vertebra. The **rectum** extends from the d sacral vertebra to a point $1\frac{1}{2}$ inches in front of and below the tip he coccyx, where it pierces the pelvic diaphragm to terminate in anal canal, which is the part of the large gut surrounded by the incter muscles. The **bladder,** when empty, presents the following ts: (1) an apex, which is directed forwards, and lies behind the upper

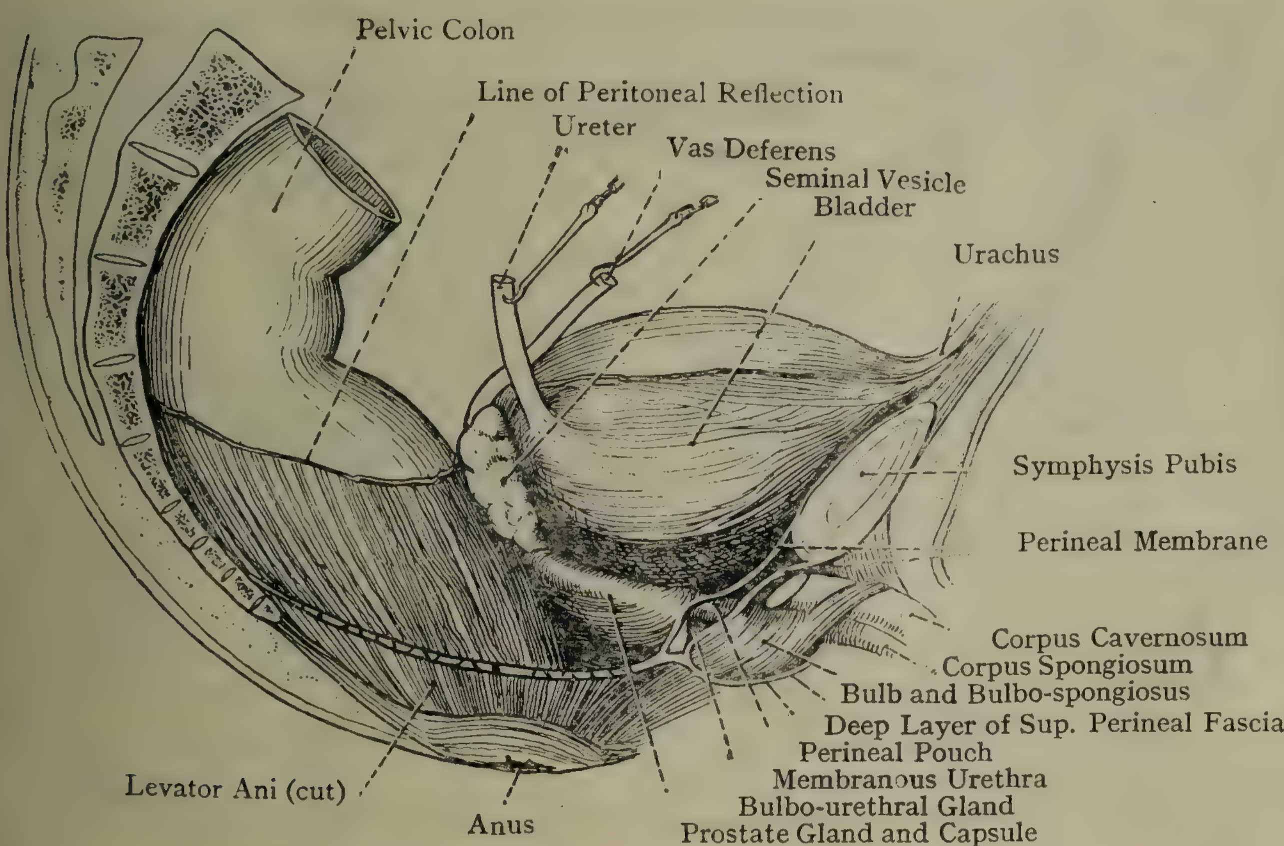


FIG. 539.—THE VISCERA OF THE MALE PELVIS (LATERAL VIEW).

t of the symphysis pubis, where it has connected with it the median bilical ligament representing the urachus; (2) a fundus (base) or terior surface, directed backwards and downwards towards the um, from which it is separated by the seminal vesicles and vasa erentia; and (3) a body which has a superior and two infero-lateral aces. Four borders are described, two being lateral, and serving separate the superior and infero-lateral surfaces; one posterior, arating the fundus from the superior surface, and stretching between two ureters as they pierce the bladder wall; and one faintly marked erior border, which separates the two infero-lateral surfaces. The er enters the bladder at the junction of the fundus with the superior infero-lateral surfaces at what is known as the *lateral angle.*

The peritoneum, having descended from the posterior wall of the omen over the common iliac vessels, enters the back part of the

pelvic cavity, where it invests the pelvic colon, forming behind it expanded, wavy mesentery, called the *pelvic meso-colon,* which attac it to the front of the sacrum as low as the third sacral vertebra. peritoneum is then prolonged upon the rectum, the **upper third** of wh it covers *anteriorly* and *laterally,* but not posteriorly, the **middle t** being covered by it only *anteriorly,* whilst the **lower third** is desti of peritoneal covering. The point at which the peritoneum leaves rectum is fully 3 inches above the anus. The membrane is now car forwards to the upper ends of the seminal vesicles and the adjac portions of the vasa deferentia, which it covers. It then pa forwards over the superior surface of the bladder, which it comple

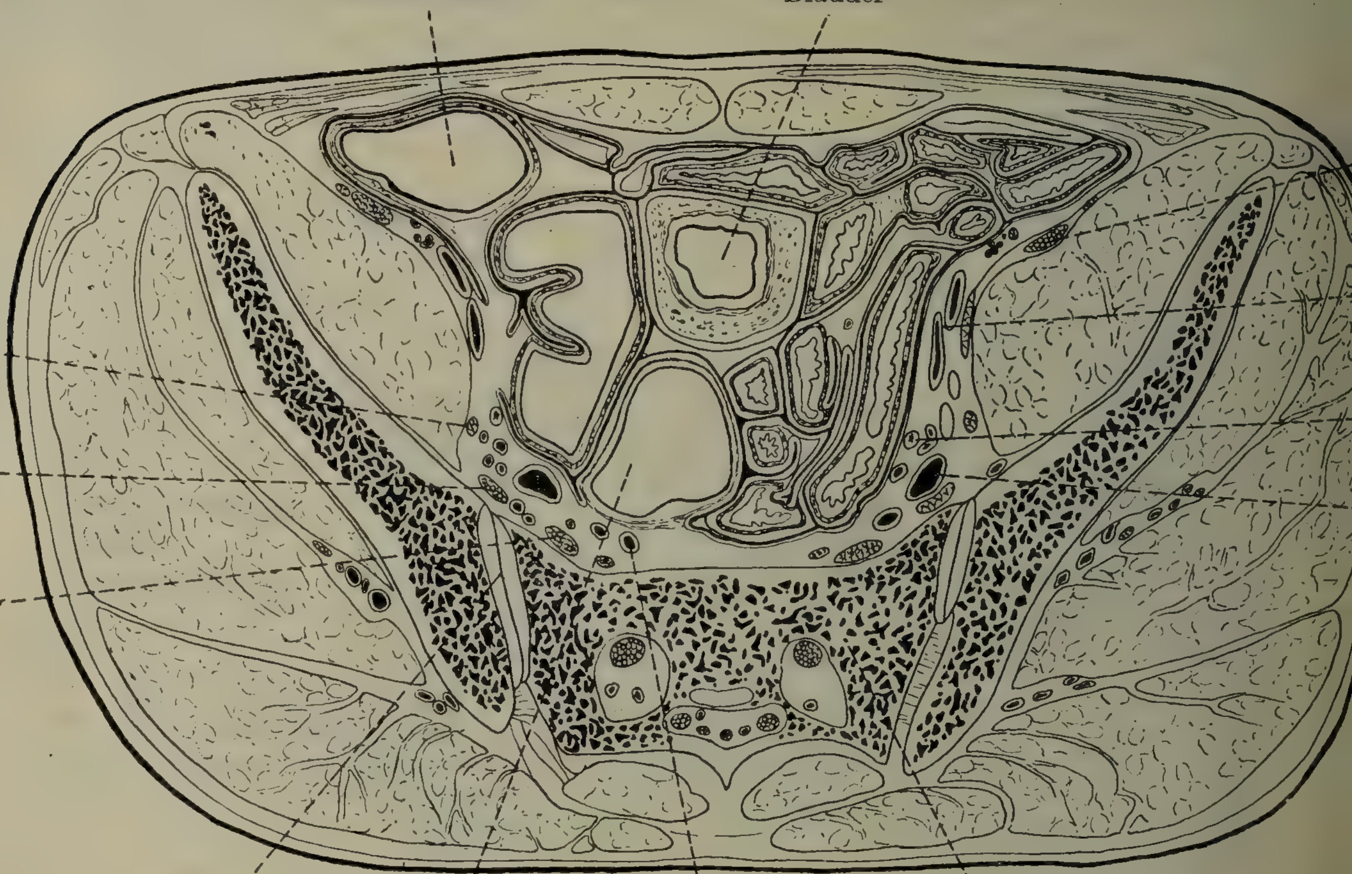


FIG. 540.—TRANSVERSE SECTION THROUGH THE SECOND SACRAL VERTEBR (AFTER SYMINGTON).

covers as far as the apex. Here it meets the median umbilical ligame and by this is conducted from the bladder to the posterior surface the anterior abdominal wall. Along each lateral border of the blad the peritoneum is reflected over the corresponding lateral wall of pelvis. In passing from the rectum to the upper part of the base the bladder the peritoneum forms the **recto-vesical pouch.** The bott of this pouch is, as a rule, fully 1 inch distant from the base of prostate gland, thus leaving the part of the base of the bladder, cal the external trigone, quite free from peritoneum. The peritoneum, it passes to and from the bladder, forms certain folds, which constitu the **false ligaments** of the viscus. These are five in number as follov

posterior, which represent the laterally-disposed lips of the mouth :he recto-vesical pouch; *two lateral*, right and left, which represent reflection of peritoneum from each lateral border of the bladder the corresponding lateral wall of the pelvis; and *superior*, which :he reflection of the peritoneum from the apex of the bladder to posterior surface of the anterior abdominal wall along the median bilical ligament. The parts of the bladder which are left uncovered peritoneum are (1) the inferior surface, and (2) the external trigone.

The pelvic peritoneum on either side of the bladder and rectum presents recesses when these viscera are moderately distended, which are named, n before backwards, *paravesical* and *pararectal*.

Retro-pubic Cellular Tissue.—This is a collection of areolar and pose tissues which lies between the posterior aspect of the bodies :he pubic bones, the bladder, and medial pubo-prostatic ligaments.

Pelvic Fascia.—This fascia clothes the inner wall of the pelvis, and nishes inward expansions, which have an intricate connection with,

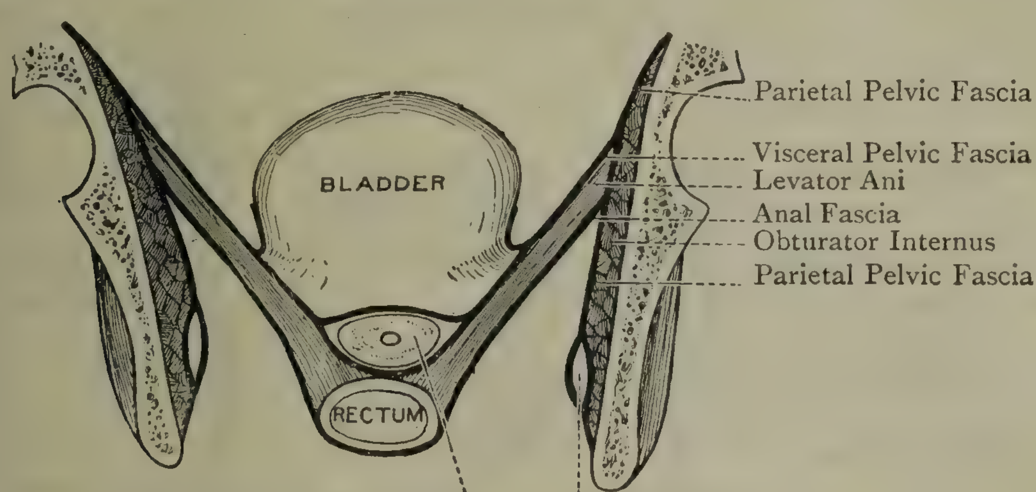


FIG. 541.—THE PELVIC FASCIA (ANTERIOR VIEW).

l serve to support, the contained viscera. It is divisible into two tions—parietal and visceral.

Parietal Portion.—Over the posterior wall of the pelvic cavity parietal portion of the pelvic fascia, which is here very thin, covers intrapelvic portion of each pyriformis muscle and the corresponding ral plexus, this portion being known as the *fascia of the pyriformis.* er the lateral wall the fascia attains considerable strength, and is ached superiorly to the back part of the iliac portion of the pectineal for a short distance, where it becomes continuous with the iliac cia. In front of this the fascia falls short of the pectineal line, and ixed to the lateral wall of the pelvis a little below the line, its attachnt being oblique, and accurately following the upper border of the turator internus muscle. When it arrives at the upper part of the turator foramen there is a break in the osseous attachment of the cia, which here joins the upper border of the obturator membrane er the upper border of the obturator internus, and so converts the turator groove into a canal for the passage of the obturator vessels

and nerve. At the upper and inner part of the obturator foramen fascia resumes its osseous attachment, but falls more and more sh of the pelvic margin, its connection with the back of the body of os pubis being in a direction downwards and inwards till it reac a point just below the lower part of the symphysis pubis. The fas descends from the foregoing line of attachment, closely covering obturator internus, to be attached as follows from before backwar (1) to the pelvic aspect of the ischio-pubic ramus near the pubic ar medial to the obturator internus; (2) to the inner margin of the falcifo process of the sacro-tuberous ligament at the lower part of the iscl ramus, and also to the sacro-tuberous ligament itself, where that attached to the inner margin of the ischial tuberosity; and (3) to portion of the sacro-tuberous ligament near its ischial attachment, a to the anterior margin of the greater sciatic notch The lateral port of the parietal pelvic fascia, from its relation to the obturator intern

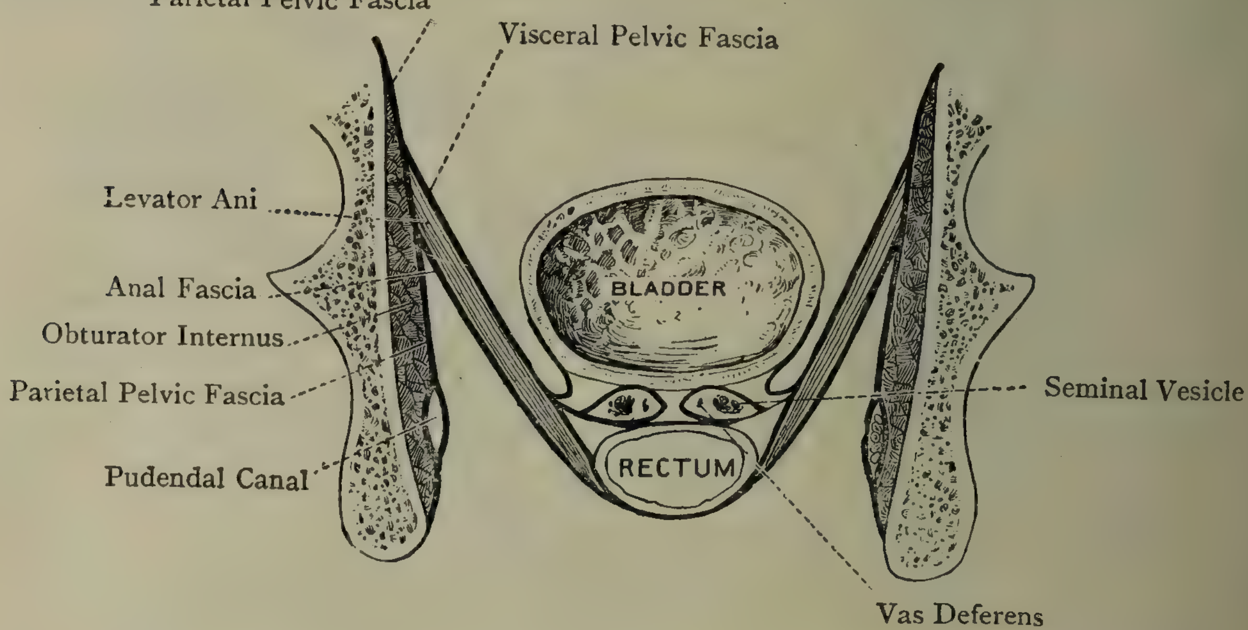


FIG. 542.—DIAGRAM OF THE PELVIC FASCIA FROM BEHIND.

muscle, is sometimes called the *obturator fascia.* From its lower attac ment the fascia is continued backwards and inwards over the great sciatic foramen, pyriformis, and sacral plexus to the sacrum, as t fascia of the pyriformis. As it covers the foramen it is perforated the superior and inferior gluteal, and internal pudendal vessels, and in consequence indistinct.

At the anterior part of the pelvic cavity the fascia, after takin attachment to the pelvic surface of the ischio-pubic ramus near t pubic arch, is continued inwards over that arch, where it lies behin the sphincter urethræ muscle, and forms one half of the superior lay of the perineal membrane, the other half being formed by the corr sponding portion of the fascia of the opposite side. When it arrives the urethra it changes its course, and passes backwards over the anteri border of the levator ani to blend with that portion of the visceral pelv fascia which ensheathes the prostate gland.

In the direction of a line passing from the inner aspect of the ischial ine to the back of the body of the os pubis, near its lower end and close the symphysis, the lateral pelvic fascia is strengthened by fibres iich impart to it a white colour. This part is called the **arcus ten-ıeus** (*white line*), and it serves to divide the fascia into two portions—per or pelvic proper, and lower or perineal. The *pelvic portion* oks into the pelvic cavity, and covers the upper part of the obturator ernus, whilst it is itself covered by the peritoneum. The *perineal rtion* covers the lower part of the obturator internus, and lies on the ter wall of the ischio-rectal fossa, where it constructs the pudendal nal. The under aspect of the arcus tendineus affords extensive igin to the levator ani muscle.

Visceral Portion of the Pelvic Fascia.—The visceral portion is stined to support the lower part of the bladder, seminal vesicles, minal portions of the vasa deferentia, prostate gland, and rectum. is a laminar offshoot of the parietal portion, from which it springs ong the arcus tendineus. Though, however, this is its principal urce, it has an independent origin anteriorly on either side of the ddle line from the posterior aspect of the body of the os pubis near e lower part of the symphysis. In this latter situation it lies a little ove the attachment of the parietal portion, the anterior fibres of the rator ani taking origin from the portion of bone between the two sciæ. Though the visceral portion forms one continuous sheet along pelvic attachment, its ultimate disposition is so intricate that it is nvenient to consider its arrangement under three divisions.

1. *Opposite the bladder, seminal vesicle, and rectum.* In this region e visceral portion of the fascia passes inwards as far as the outer rder of the seminal vesicle. In doing so it covers the upper surfaces of e levator ani and coccgyeus, and is in turn covered by the peritoneum. the outer border of the seminal vesicle it divides into three laminæ—per, middle, and lower. The **upper** or **vesical lamina** ascends upon e lateral aspect of the bladder for a short distance, and ultimately ses itself in the muscular tissue of the vesical wall. This portion at ch side forms the lateral pubo-prostatic ligament of the bladder. The **ddle** or **recto-vesical lamina** passes inwards between the base of the adder and the rectum, and is continuous with the corresponding mina of the opposite side. As it passes inwards it furnishes a sheath the seminal vesicle and adjacent portion of the vas deferens, closely apping these structures to the base of the bladder. The **lower** or **ctal lamina** descends upon the side of the rectum, and passes to its sterior surface, where it is continuous with the rectal lamina of the posite side.

2. *Opposite the lateral aspect of the prostate gland.* In this situa-n the visceral portion of the fascia also divides into three laminæ upper, middle, and lower. The **upper** or **prostatic lamina** passes wards over the anterior surface of the prostate gland, and is con-uous with the prostatic lamina of the opposite side. The **middle** **recto-prostatic lamina** passes inwards between the posterior surface

of the prostate gland and the rectum, and is continuous with corresponding lamina of the opposite side. The **lower** or **rectal lam** is unaltered in its disposition. The upper or prostatic and middle recto-prostatic laminæ furnish a stout sheath to the prostate gland.

3. *Between the pubic bodies and the anterior aspect of the pros gland.* The portion of the visceral fascia in this region represe the upper lamina in the other regions, and may be called the **pu prostatic lamina.** It is arranged in the form of two stout cords, wh are known as the *medial pubo-prostatic ligaments* or the *anterior t ligaments* of the bladder. Each is attached anteriorly to the poste aspect of the body of the os pubis, near the lower part of the symphy and a little above the attachment of the parietal portion of the pel fascia in this region, the anterior fibres of the levator ani taking ori from the portion of bone between the two fasciæ. As the cord-l fascial bands pass backwards they are connected by a portion of visceral fascia which covers the dorsal vein of the penis and lies deep thus giving rise to a small pouch, which is capable of admitting point of a finger. This pouch is filled with fat, which is continuous w the retro-pubic pad of fat. The anterior portion of the visceral fas lies upon the anterior surface of the prostate gland, and on reach the bladder it passes forwards on its inferior surface, where it sc disappears in the muscular tissue of the vesical wall. The mec pubo-prostatic ligaments are largely composed of plain muscular tiss which is derived from the longitudinal fibres on the inferior surface the bladder as they pass to take attachment to the back of the bod of the pubic bones on either side of the middle line. These fib constitute the so-called *pubo-vesical muscles.*

Anal Fascia.—This very thin sheet of fascia is an offshoot fr the parietal pelvic fascia just below the white line and the origin the levator ani. It closely covers the ischio-rectal surface of th muscle and of the coccygeus, upon which it descends to the region the anus, where it blends with the aponeurotic investment of t sphincter ani externus.

Sympathetic Plexuses in the Pelvis.—These are derived from t **hypogastric plexus,** which is formed by the fusion of the two late strands of the aortic plexus after they have crossed the common ili arteries. It is reinforced by branches from the ganglia of the lumb sympathetic trunks, and is situated in front of the body of the fif lumbar vertebra between the common iliac vessels. It is a larg flattened plexus, measuring about $1\frac{1}{2}$ inches in breadth, and breaks into two divisions, which form the **right** and **left pelvic plexuses.** Ea of these enters the pelvis on the inner side of the internal iliac arte and takes up a position on the side of the rectum. The pelvic plex of each side is reinforced by branches from the upper one or two gangl of the pelvic sympathetic trunk, and by spinal fibres from the anteri primary divisions of the third and fourth sacral nerves (sometimes al the second), there being very small ganglia at the places of junctio From each plexus the following secondary plexuses are given off, whic

ccompany the corresponding branches of the internal iliac artery: æmorrhoidal, vesical, and prostatic, the latter being replaced in the male by the vaginal and uterine plexuses.

Internal Iliac Artery.—This vessel arises from the common iliac pposite the sacro-iliac joint at the level of the lumbo-sacral joint, nd terminates opposite the upper border of the greater sciatic notch y dividing into an anterior and a posterior division. The length of e vessel is about $1\frac{1}{2}$ inches, and its direction is downwards and ackwards.

Relations—*Anterior.*—The artery is covered by the peritoneum, nd the ureter descends over it. In front of the ureter are the ovary nd the fimbriated extremity of the uterine tube. The terminal part f the ileum forms an anterior relation of the right vessel, whilst the elvic colon is similarly related to the left. *Posterior.*—The vessel ests chiefly upon its own vein, but near its origin it is placed over the ommencement of the common iliac vein. Behind the veins there are e lumbo-sacral trunk and sacro-iliac joint. *Lateral.*—The psoas ajor, with the intervention of the external iliac vein, and subsequently e lateral wall of the pelvis, with the intervention of the obturator erve. *Medial.*—The peritoneum.

Varieties.—The chief variety affects the length of the vessel. It may be orter or longer than usual, according as the common iliac is longer or shorter an normal, or according to the height at which the internal iliac ends in its vo divisions.

Fœtal Condition.—During fœtal life the internal iliac is represented by the **mbilical artery,** the size of which greatly exceeds that of the external iliac. The nction of this artery is to carry the impure blood from the fœtus to the placenta the mother. The umbilical artery passes forwards to the posterior surface of e anterior wall of the abdomen, being crossed by the vas deferens. It then scends to the lower part of the umbilicus, where it leaves the abdomen with its llow. The two umbilical arteries, together with the umbilical vein, form the mbilical cord, in which the arteries describe spiral coils around the vein. The teries convey the impure blood to the placenta, where it is purified, after which is returned to the abdomen of the fœtus by the umbilical vein. After birth, ere being no further use for the placental circulation, the umbilical cord is tied, nd the child separated from the mother. The umbilical arteries become imperious, and each is converted into a fibrous cord. The obliteration, however, does ot involve the first $1\frac{1}{2}$ inches of the vessel, which persists as the internal iliac tery of the adult. Moreover, the proximal end of the fibrous cord representing e obliterated umbilical remains pervious also, and being connected with the nterior division of the internal iliac, it furnishes the superior vesical artery or teries. This pervious portion lies along the side of the pelvis beneath the eritoneum, where it is crossed by the vas deferens in the male and the ligaentum teres of the uterus in the female. The fœtal umbilical artery gives off e inferior gluteal, which is the primitive main artery of the lower limb, until e external iliac, which becomes the femoral, is developed.

Branches.—These are subject to much variation. In normal ases they arise from the two terminal divisions, anterior and posterior, ome of them being parietal in their distribution, which will be indicated y the letter P, whilst others are visceral, which will be indicated by he letter V. The branches are as follows:

Anterior Division.		Posterior Division
Visceral.	*Parietal.*	*Parietal.*
Umbilical (which gives off superior vesical).	Obturator.	Ilio-lumbar.
Inferior vesical.	Internal pudendal.	Lateral sacral.
Middle rectal.	Inferior gluteal.	Superior gluteal.

In the female the inferior vesical artery may be replaced by t vaginal, or the vaginal may be an independent branch; the uteri artery is always a special branch.

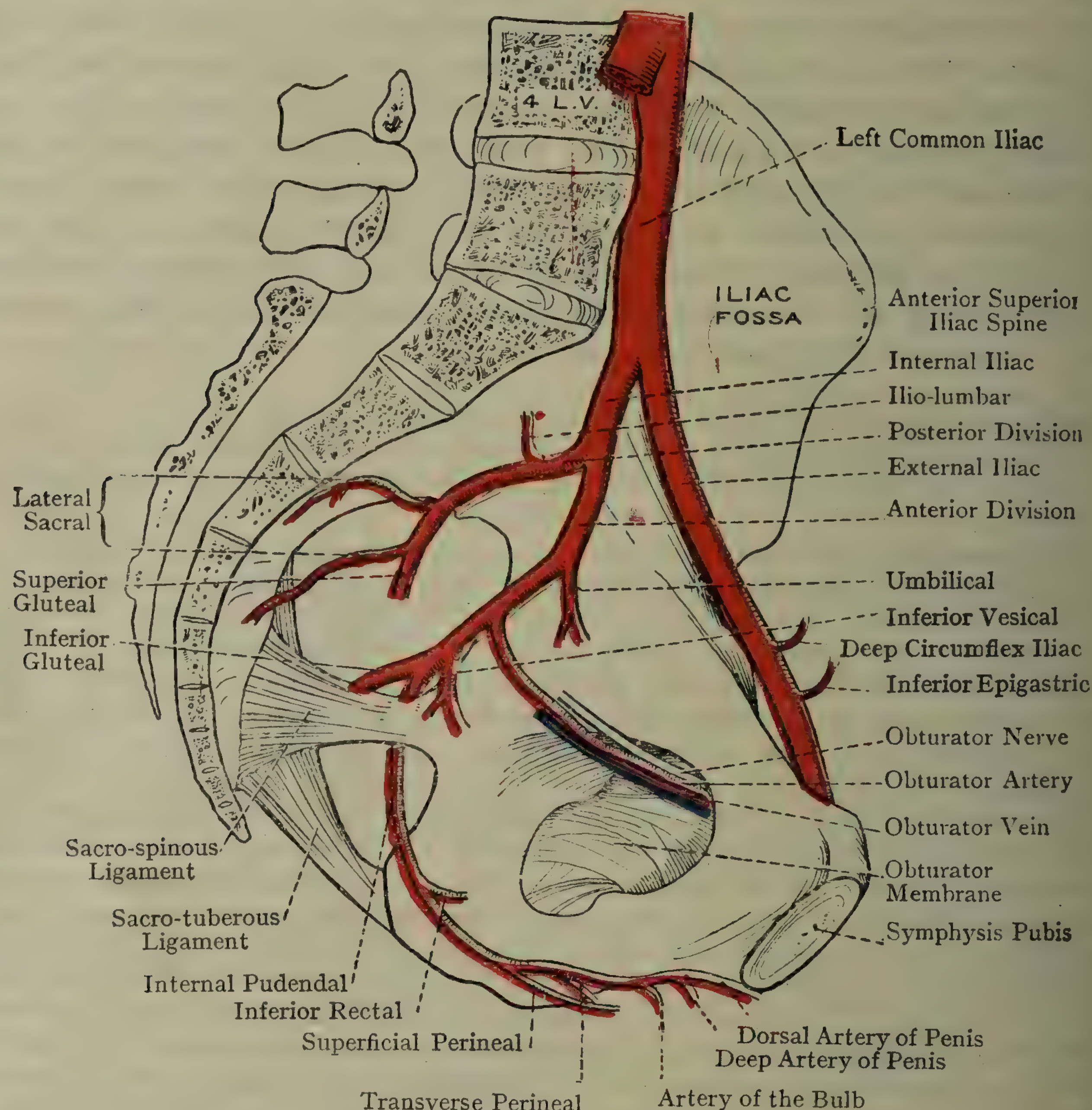


FIG. 543.—THE LEFT INTERNAL ILIAC ARTERY AND ITS BRANCHES.

Anterior Division.—The **superior vesical artery** (V) arises from th pervious portion of the fibrous cord which represents the fœtal umbilica artery, and at once breaks up into several twigs which frequently hav independent origins. They are distributed to the upper portion of th bladder, and anastomose with the vesical of the obturator, and th inferior vesical of the same side, and with the superior vesical of th opposite side. The superior vesical furnishes the following branches *urachal* to the medial umbilical ligament; *ureteric* to the lower end c

e ureter; and *deferential* (as a rule) to the vas deferens, though this anch may arise from the inferior vesical. The *artery to the vas deferens,* hich is usually of small size, divides into a descending and an ascend- g branch. The descending branch passes downwards to supply the npulla of the vas deferens and the seminal vesicle. The ascending anch accompanies the vas deferens through the deep inguinal ring id inguinal canal into the scrotum, supplying the vas deferens, and ving a few twigs to the tail of the epididymis, in which latter situation anastomoses with the epididymal branch of the testicular artery. i the spermatic cord it also anastomoses with the cremasteric branch the inferior epigastric. The artery to the vas is sometimes of large ze, and then takes the place of the testicular artery if that vessel iould be absent. One of the branches of the superior vesical artery is metimes spoken of as the middle vesical.

The **inferior vesical artery** (V) takes an inward course to the lower rtion of the bladder, which it supplies, giving branches to the seminal esicle, ampulla of the vas deferens, and prostate gland, and in the male to the vagina. It sometimes gives off the artery to the vas eferens, and it may give origin to an accessory pudendal. It anasto- oses with the superior vesical and middle rectal of its own side, and ith its fellow of the opposite side.

The **middle rectal artery (middle hæmorrhoidal artery)** (V) often ises in common with the inferior vesical. It is distributed to the ctum, and gives branches to the seminal vesicle, ampulla of the vas eferens, and prostate gland. The anastomoses which it establishes e with the superior rectal of the inferior mesenteric, the inferior ctal of the internal pudendal, the inferior vesical of its own side, and s fellow of the opposite side.

The **obturator artery** (P) passes along the outer wall of the pelvic ivity on its way to the obturator canal, lying between the parietal elvic fascia and the peritoneum. It has the obturator nerve above , and its own vein below it. In entering the obturator canal, by which emerges from the pelvis, the artery does not pierce the parietal pelvic scia, but passes over its upper border, where that joins the upper part the obturator membrane. As the artery passes along the pelvic wall furnishes the following branches: *muscular* to the obturator internus; *iac* to the iliac fossa, which supplies the bone, psoas major, and iliacus, id anastomoses with the iliac branch of the ilio-lumbar; *vesical,* which aches the side of the bladder within the lateral false ligament; and *ubic* to the back of the body of the os pubis, where it anastomoses with ie pubic branch of the inferior epigastric from the external iliac, and s fellow of the opposite side.

For the distribution of the obturator artery outside the pelvis, ee p. 589.

The obturator artery sometimes arises from the inferior epigastric ee p. 566).

The **internal pudendal artery (internal pudic artery)** (P) is one of ie terminal branches of the anterior division. It descends with the

inferior gluteal artery upon the pyriformis and sacral nerves, a emerges from the pelvis through the lower compartment of the grea sciatic foramen, having previously pierced the parietal pelvic fasc The intrapelvic branches of the vessel are unimportant, and are c tributed to the pyriformis, coccygeus, obturator internus, and pel fascia. For the further course and distribution of the artery, see t gluteal region and the perineum, pp. 539 and 686.

The **inferior gluteal artery (sciatic artery)** (P) is the other and lar terminal branch of the anterior division. It descends, usually behi the internal pudendal, upon the pyriformis and sacral nerves, a emerges from the pelvis through the lower compartment of the grea sciatic foramen, having previously pierced the parietal pelvic fasc Within the pelvis the artery gives off branches to the pyriformis, leva ani, coccygeus, rectum, bladder, seminal vesicle, and prostate glar Although very variable in their origin and course, the inferior glut artery as it runs backwards frequently passes between the anter primary divisions of the first and second sacral nerves and the inter pudendal between those of the second and third sacral nerves.

For the extrapelvic course and distribution of the vessel, see p. 5

Posterior Division.—The **ilio-lumbar artery** (P) passes upwards a outwards in front of the sacro-iliac articulation, between the lumb sacral trunk and obturator nerve. In its course it passes behind t external iliac, or, it may be, the common iliac, vessels, and also behi the psoas major and iliacus. On reaching the back part of the ili fossa it divides into two branches, iliac and lumbar. The *iliac bran* passing transversely, ramifies in the iliacus and ilium, and anastomo with the iliac branch of the obturator and branches of the deep circu flex iliac from the external iliac. The *lumbar branch* ascends benea the psoas major on to the quadratus lumborum, where it anastomos with the terminal part of the deep circumflex iliac, and the last lumb of the abdominal aorta. In its course it furnishes a spinal branch, whi enters the vertebral canal through the intervertebral foramen betwe the fifth lumbar and first sacral vertebræ, to be distributed in a mann similar to the other spinal arteries.

The **lateral sacral arteries** (P) are usually two in number, superi and inferior. They course downwards and inwards to the front the lateral mass of the sacrum, passing in front of the pyriformis a sacral nerves. Upon the sacrum both arteries lie lateral to the anteri sacral foramina, the superior being confined to the region of the fir two foramina, whilst the inferior descends as low as the coccyx, whe it anastomoses with the median sacral artery. They are distribut to the pyriformis and sacral nerves, and furnish spinal branches, whic enter the anterior sacral foramina, and so reach the sacral canal, whe they supply its contents. Each spinal branch, before entering t sacral canal, gives off a posterior branch, which emerges through t posterior sacral foramen, and anastomoses with branches of the superi and inferior gluteal and internal pudendal. The lateral sacral arteri anastomose with each other and with the median sacral.

The **superior gluteal artery** (P) is a large vessel, which is the con-
uation of the posterior division. It is destined for the supply of the
iteal region, and lies within the pelvis for a very short distance. Its
ection is backwards through the parietal pelvic fascia, and between
e lumbo-sacral trunk and the anterior primary division of the first
cral nerve, its escape from the pelvis being through the upper com-
rtment of the greater sciatic foramen. The branches of the artery
thin the pelvis are unimportant.

For the extrapelvic course and distribution of the vessel, see p. 536.

The branches of the internal iliac, with one exception, have to
erce the pelvic fascia. The exception is the **obturator artery,** which,
stated, passes over the upper border of the parietal pelvic fascia at
e obturator canal.

Internal Iliac Vein.—This vessel results from the union of tributaries
iich correspond, for the most part, with branches of the internal
ac artery. The ilio-lumbar vein, however, is an exception, inasmuch
it is a tributary of the common iliac vein. Moreover, during fœtal
e the umbilical vein, which corresponds to the umbilical artery, passes
the liver after entering the abdomen of the fœtus. The internal iliac
in extends from the upper part of the greater sciatic notch to the
cro-iliac articulation on a level with the pelvic brim, where it joins
e external iliac, and so the common iliac vein is formed. In its course
lies behind the corresponding artery. There are no valves in the vein
elf, but its branches are freely provided with them.

The internal iliac vein is developed from the lower part of the cardinal
in.

Internal Iliac Lymphatic Glands.—These glands are about *ten* in
mber, and are associated with the origins of the branches of the
ternal iliac artery. They are arranged in a curve, which usually
gins in front in a gland situated between the obliterated umbilical
d obturator arteries, and then is formed in succession by uterine
prostatic, inferior gluteal and internal pudendal, middle rectal,
perior gluteal and sacral glands. They are situated immediately
ider the peritoneum, between it and the parietal layer of pelvic fascia,
though occasionally some of them may be formed lateral to this
scia.

The *afferent* vessels of the internal iliac glands return lymph from
e parts supplied by the branches of the internal iliac artery. Thus,
ey receive *afferent* vessels from the following parts:

1. The anal canal, but not the anal margin.
2. Lower part of the rectum.
3. Bladder.
4. Seminal vesicle and vas deferens.
5. Prostate gland.
6. Prostatic, membranous, and bulbar portions of the urethra,
part.
7. Uterus (cervix).
8. Vagina.

9. Deep structures of gluteal region, supplied by superior glu
artery.
10. Deep structures of upper part of back of thigh, supplied
inferior gluteal artery.
11. Obturator region.
12. Deep structures of perineum.

The *efferent* vessels of the internal iliac glands pass to the mic
group of common iliac glands.

Anterior Primary Divisions of the Sacral and Coccygeal Ner —There are five sacral nerves and one coccygeal nerve on either s The anterior primary divisions of the first four sacral nerves enter pelvis through the anterior sa foramina, and that of the fifth sa passes between the inferior lat angle of the sacrum and the tra verse process of the first coc geal vertebra, through the coccyg muscle. The anterior primary d sion of the coccygeal nerve ent the pelvis below the transverse p cess of the first coccygeal verte through the coccygeus muscle. first and second sacral nerves of large size, and their course obliquely downwards and outwar Beyond the second they dimin rapidly in size, and pass more ho zontally. They receive grey ra communicantes from the adjac ganglia of the pelvic sympathe trunk, and the third and four nerves (sometimes also the secon furnish white rami communican to the corresponding pelvic plex The anterior primary divisions of t first and second sacral nerves divi each into an anterior or ventral and a posterior or dorsal bran The anterior primary division of the third sacral nerve divides in an upper and a lower branch and is known as the *nervus bigemin* The anterior primary division of the fourth sacral nerve also divid into an upper and a lower branch, and it is known as a *nervus furcal* The lumbo-sacral trunk in two divisions, ventral and dorsal, the anteri primary divisions of the first two sacral nerves, the upper and low branches of the third sacral, and the small upper branch of the four sacral form the sacral plexus, whilst the large lower branch of the four sacral, the fifth sacral, and the coccygeal form the coccygeal plexus.

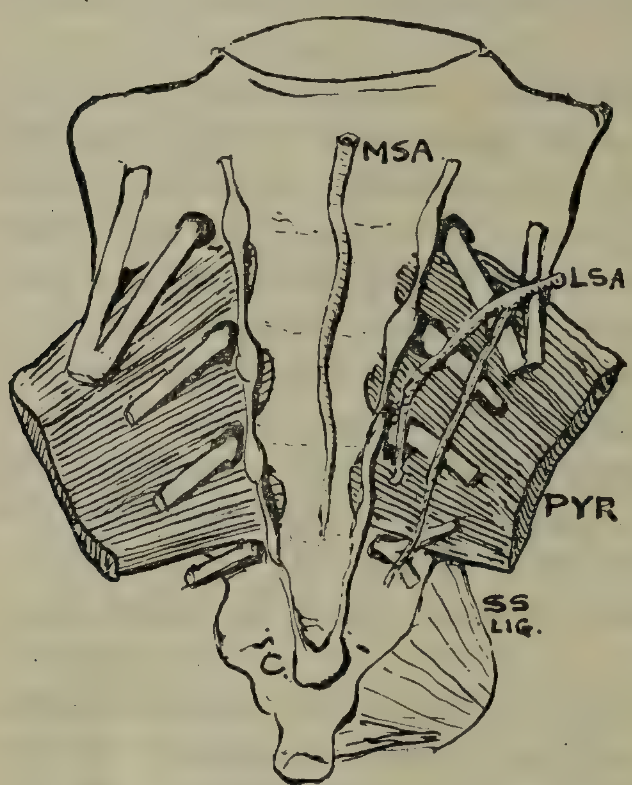


Fig. 544.—Plan of Position of Structures lying on the Front of the Sacrum.

LSA, lateral sacral arteries; MSA, middle sacral arteries; C, coccygeal ganglion; SS lig., sacrospinous ligament.

Sacral Plexus.—This plexus, formed as stated, is a large flatten mass, lying upon the pyriformis muscle, and behind the parietal pelv

cia, which separates it from the inferior gluteal and pudendal vessels. e mass ultimately forms two bands, upper and lower. The **upper sciatic band,** which is the larger of the two, receives the lumbo-sacral nk, first sacral, larger portion of the second sacral, and upper branch the third sacral nerves. It is flat and somewhat triangular, and is tinued into the sciatic nerve, which leaves the pelvis through the er part of the greater sciatic foramen below the pyriformis without rcing the parietal pelvic fascia. The upper band and its contributory ves are sometimes spoken of as the *sciatic plexus.* The **lower** or

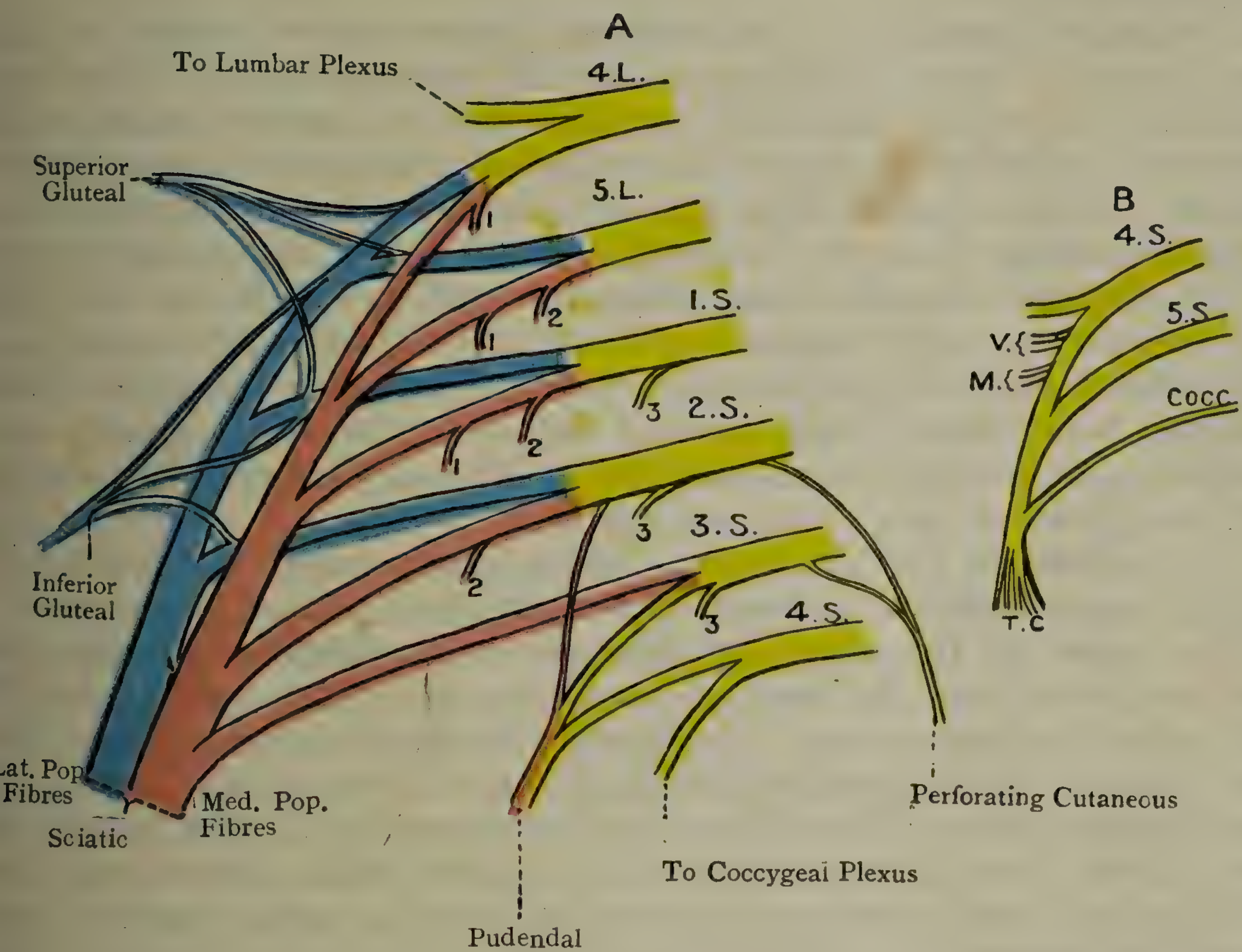


FIG. 545.—**A**, THE SACRAL PLEXUS; **B**, THE SACRO-COCCYGEAL PLEXUS.

A

1, 1, 1. Nerve to Quadratus Femoris
2, 2, 2. Nerve to Obturator Internus
3, 3, 3. Posterior Cutaneous Nerve of Thigh

B

4.S. Fourth Sacral, giving a Branch to Sacral Plexus
V. Visceral Branches
M. Muscular Branches
T.C. Terminal Cutaneous Branches

endal band, the smaller of the two, receives fibres from the second er branch of the third, and upper branch of the fourth sacral nerves, l is continued into the pudendal nerve, which leaves the pelvis, like the tic, through the lower compartment of the greater sciatic foramen hout piercing the parietal pelvic fascia. The lower band and its tributory nerves are sometimes spoken of as the *pudendal plexus.* e sciatic and pudendal nerves are thus the terminal branches of the ral plexus. The reason of the name *nervus bigeminus*, as applied to third sacral nerve, is because it enters into the sciatic band by its er branch, and into the pudendal band by its lower branch.

Branches.—The branches of the sacral plexus are arranged in groups—collateral and terminal.

Collateral Group.—The branches of this group form three set visceral, muscular, and cutaneous.

Visceral Branches.—These are derived from the third sacral that part of the fourth which enters into the sacral plexus (someti also from the second). They are white rami communicantes, wh reinforce the pelvic plexus of the sympathetic, a few of them be traceable independently to the pelvic viscera. They are known as **pelvic splanchnics.**

Muscular Branches.—The **superior gluteal nerve** arises by th roots from the dorsal divisions of the descending branch of the fou lumbar, fifth lumbar, and first sacral nerves. It passes outwards backwards, and leaves the pelvis with the superior gluteal artery thro the upper compartment of the greater sciatic foramen, to be distribu to the gluteus medius, gluteus minimus, and tensor fasciæ latæ musc

The **inferior gluteal nerve** arises by three roots from the do divisions of the fifth lumbar and first and second sacral nerves. leaves the pelvis through the lower compartment of the greater sci foramen, below the pyriformis and dorsal to the sciatic nerve, to distributed to the gluteus maximus. It is usually intimately associa with the posterior cutaneous nerve of thigh.

The **nerves to the pyriformis,** which are usually two in num spring from the dorsal divisions of the first and second sacral nerve

The **nerve to the obturator internus and gemellus superior** ar by three roots from the ventral divisions of the fifth lumbar and f and second sacral nerves. It leaves the pelvis through the lo compartment of the greater sciatic foramen, crosses the back of ischial spine, where it lies lateral to the internal pudendal vessels, then passes through the lesser sciatic foramen to the outer wall of ischio-rectal fossa, where it enters the inner or pelvic surface of obturator internus. In the gluteal region it gives a branch to gemellus superior when that muscle is present.

The **nerve to the quadratus femoris and gemellus inferior** arises three roots from the ventral divisions of the descending branch the fourth lumbar, fifth lumbar, and first sacral nerves. It leaves pelvis through the lower compartment of the greater sciatic foram and then lies between the ischium and the sciatic nerve. It s sequently descends over the back of the capsular ligament of the h joint, to which it usually gives a branch, and beneath the gemelli a obturator internus to the deep surface of the quadratus femoris, which it ends, having previously given a branch of the gemellus infer

Cutaneous Branches.—The **posterior cutaneous nerve of thigh** (**sm sciatic nerve**) arises by three roots from the posterior aspects of first, second, and third sacral nerves. It leaves the pelvis through lower compartment of the greater sciatic foramen, and is distribu to (1) the lower and outer part of the gluteal region by its glut cutaneous branches, (2) the skin of the scrotum by the long perin

rve, (3) the skin of the back of the thigh, and (4) the skin of the back the leg as low as about the centre of the calf.

The **perforating cutaneous nerve** arises by two roots from the sterior aspects of the second and third sacral nerves. It passes ckwards through the sacro-tuberous ligament, after which it turns und the lower border of the gluteus maximus near the coccyx to be stributed to the skin over the lower and inner part of that muscle.

Terminal Group.—This group is comprised of two nerves—namely, e sciatic and the pudendal.

The **sciatic nerve** is the continuation of the upper or sciatic band of e sacral plexus. In reality it is made up of the two divisions in which ultimately ends—namely, the lateral and medial popliteal—which lie ose together within the same sheath. Sometimes, however, these two visions arise separately from the sacral plexus, in which cases the eral popliteal nerve may pass through the pyriformis. Again, ough the sciatic nerve may be apparently single, a careful dissection it, after the removal of its sheath, will reveal the lateral and medial pliteal nerves, which can be shown to have independent origins. The **eral popliteal nerve** derives its fibres from the *dorsal* divisions of the scending branch of the fourth lumbar, fifth lumbar, and first and cond sacral nerves; and the **medial popliteal nerve** derives its fibres om the *ventral* divisions of the foregoing nerves, and in addition from e upper branch of the third sacral.

The sciatic nerve leaves the pelvis through the lower compartment the greater sciatic foramen below the pyriformis.

The **pudendal nerve (pudic nerve)** is the continuation of the lower pudendal band of the sacral plexus. It arises by three roots from e ventral division of the second, the lower branch of the third, and e upper branch of the fourth sacral, the root from the third being e largest. The nerve leaves the pelvis through the lower compart-ent of the greater sciatic foramen, crosses the back of the ischial ine, where it lies medial to the internal pudendal vessels, passes rough the lesser sciatic foramen, and then traverses the outer wall of e ischio-rectal fossa. Having given off the inferior hæmorrhoidal rve, it divides into the perineal and dorsal nerve of penis, which th the internal pudic vessels are contained in the pudendal canal.

The sacral plexus and its branches being situated behind the parietal lvic fascia, the branches do not pierce the fascia as they leave the lvis. The branches of the internal iliac artery, on the other hand, ing placed in front of the parietal pelvic fascia, have to pierce it, th the single exception of the *obturator artery*.

Coccygeal Plexus.—The nerves which form the plexus are the wer branch of the anterior primary division of the fourth sacral, the terior primary division of the fifth sacral, and the anterior primary vision of the coccygeal nerve. The upper branch of the fourth sacral ters the pudendal band of the sacral plexus, and the fourth sacral therefore a *nervus furcalis,* inasmuch as it gives a branch to the sacral exus and one to the coccygeal plexus. Before entering the coccygeal

plexus the lower branch of the fourth sacral nerves gives off visce and muscular branches. The *visceral branches* for the most part re force the pelvic plexus of the sympathetic as white rami commu cantes, but a few of them pass independently to the pelvic visce The *muscular branches* supply the levator ani, coccygeus, and sphinc ani externus. The branch to the latter muscle reaches the perine either by piercing the coccygeus, or by passing between it and t levator ani, and besides supplying the external sphincter, it giv branches to the skin between the coccyx and the anus. The nerve known as the *perineal branch of the fourth sacral.* The lower bran of the fourth sacral nerve, having parted with the foregoing offse descends upon the coccygeus, where it joins the fifth sacral, which h just entered the pelvis through that muscle. The conjoined nerve n descends, and is soon reinforced by the coccygeal nerve, which a enters the pelvis by piercing the coccygeus. In this manner t coccygeal plexus is formed. It lies at the lower part of the posteri wall of the pelvis upon the coccygeus, and the nervous loop takes downward course. Subsequently it divides into several twigs, whi leave the pelvis by piercing the coccygeus, the sacro-spinous ligame and the adjacent portion of the gluteus maximus to be distributed the skin over the coccyx.

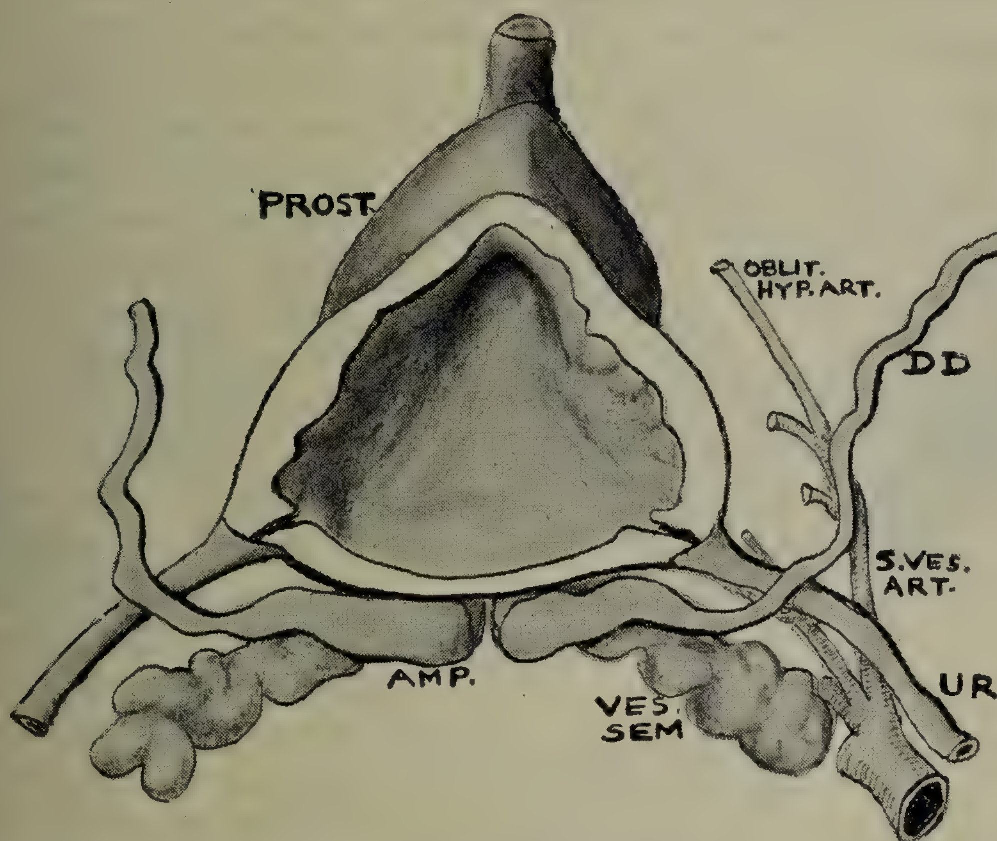
Ureters.—The ureter of each side, having crossed the terminati of the common iliac, or the commencement of the external iliac arte enters the pelvis. It then passes downwards, describing a curve wi its convexity backwards and outwards, lying in front of the intern iliac artery. It next runs along the outer wall of the pelvis, lyi beneath the peritoneum, and crossing medially the obturator vess and nerve, and the obliterated umbilical artery. It subsequent passes inwards to the bladder, being crossed medially by the vas defere Having arrived at the lateral or ureteric angle of the bladder, it pass obliquely through the vesical wall anterior to the upper free end of t seminal vesicle, being here about 2 inches distant from its fellow, a about $1\frac{1}{2}$ inches from the base of the prostate gland.

Bladder.—The bladder, when empty, or only moderately di tended, lies entirely within the cavity of the pelvis. When, howeve it is fully distended, the apical part of the viscus rises above the lev of the symphysis pubis into the hypogastric region of the abdom for at least 2 inches, and in cases of marked over-distension it may rea to the umbilicus, or even higher. The bladder, therefore, has to considered under two aspects—namely, when empty or only moderate distended, and when fully distended.

The bladder, *when empty* or *moderately distended,* is triangular, a presents the following component parts: an apex, a base, and a bod the latter presenting a superior surface, two inferior lateral surface two lateral borders, a posterior border, an antero-median border, a two lateral angles.

The *apex* is directed forwards, and lies behind the upper part of t symphysis pubis. It has connected with it the median umbilic

;ament representing the *urachus*, which ascends on the posterior rface of the anterior abdominal wall to the lower part of the umlicus. The *base* or *fundus* is directed backwards and downwards wards the rectum, from which it is separated by the seminal vesicles id terminal portions of the vasa deferentia, and the recto-vesical mina of the visceral portion of the pelvic fascia. The base is separated om the superior surface by the posterior border, and from each unded inferior lateral surface by a slight elevation, which extends om the lateral or ureteric angle of either side to the urethral opening. ie *superior surface* is three-sided and slightly convex. It is usually lated to a few coils of the small intestine, and a loop or two of the lvic colon. The *inferior lateral surfaces*, which are convex, rest



;. 546.—Showing the Internal Trigone of the Bladder and the Relations of the Vas Deferens (DD), Ureter, etc., in its Neighbourhood.

on (1) the symphysis pubis and the adjacent portions of the posterior rfaces of the bodies of the pubic bones, (2) the retro-pubic pad of t, (3) the medial pubo-prostatic ligaments, (4) the fasciæ covering e upper part of the obturator internus muscle and the upper surface the levator ani, and (5) the prostate gland. The *lateral borders* start om the apex, whence they pass backwards in a diverging manner, and ch marks the separation between the superior surface and the corresonding inferior lateral surface. Posteriorly each lateral border meets e posterior border. The *posterior border* extends transversely beeen the superior surface and the base. At either end it is joined by e lateral border. The *lateral* or *ureteric angles* are situated on either le at the junction of the lateral with the posterior border. At these gles the ureters pass through the vesical wall (Fig. 546). At its

most dependent point the bladder is continuous with the ureth There is, however, no contraction of the bladder at or near this poi in other words, no neck.

The **external trigone** is the name given to a limited triangular sp upon the exterior of the base, which is bounded as follows: above, the bottom of the recto-vesical pouch of peritoneum; laterally, by ampulla of the vas deferens, lateral to which is the seminal vesic and below, by the approximation of the ejaculatory ducts at the b of the prostate gland. The length of the space from the apex bel to the base above is, as a rule, fully 1 inch, but its breadth is limi by the encroachment upon it of the ampullæ of the vasa deferen There is no peritoneum over this region.

The Bladder during Distension and when fully distended.—As bladder becomes distended very little alteration takes place in a dov ward direction. The marcations between component parts of viscus gradually disappe and it becomes ovoid. T apex appears above symphysis pubis, and the organ increases in s the apex and the super portion of the body asce into the hypogastrium such a manner as to st off the parietal peritoneu from the back of the lin alba. In this way a p tion of the original inferi lateral surface, *devoid peritoneum,* is brought in direct contact with t back of the linea all which is now also *free from peritoneal covering.* A distended bladd may therefore be punctured or opened through the linea alba abo the symphysis pubis without doing any injury to the peritoneu The bladder is now becoming spheroidal, and its long axis is direct downwards and backwards. The part which rises highest is not t original urachal apex, but that part of the superior surface which immediately adjacent to, and behind, the apex.

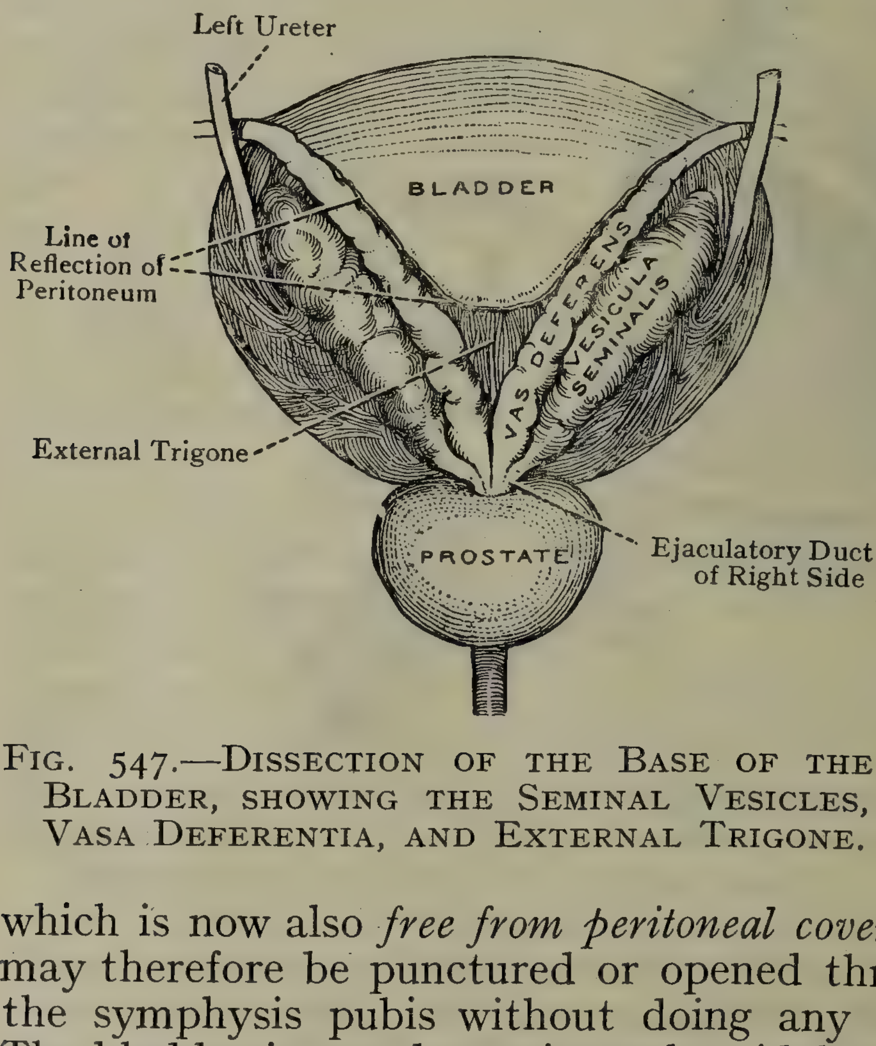


Fig. 547.—Dissection of the Base of the Bladder, showing the Seminal Vesicles, Vasa Deferentia, and External Trigone.

Peritoneal Relations.—The only part of the bladder which is cover by peritoneum is the superior surface. The peritoneum is reflect from the apex along the urachus, and at either side it leaves the org along the lateral border. When the bladder is distended the late reflection of peritoneum appears to take place along the course of t obliterated umbilical artery, but this is due to the lateral distensi and elevation of the viscus, the obliterated umbilical itself lying alo

outer wall of the pelvis. For the structure and development of bladder, see pp. 949 and 955.

Vas Deferens in the Pelvis.—The vas deferens enters the abdomen ough the deep inguinal ring, where it lies on the inner side of the er constituents of the spermatic cord. It then hooks round the er side of the inferior epigastric artery, and having crossed the ernal iliac vessels from without inwards, it dips down on the inner of the external iliac vein. In this way it enters the pelvis under er of the peritoneum. It now passes backwards and downwards on the lateral wall, crossing median to the obliterated umbilical ery, the ureter, and the obturator vessels and nerve. It is then

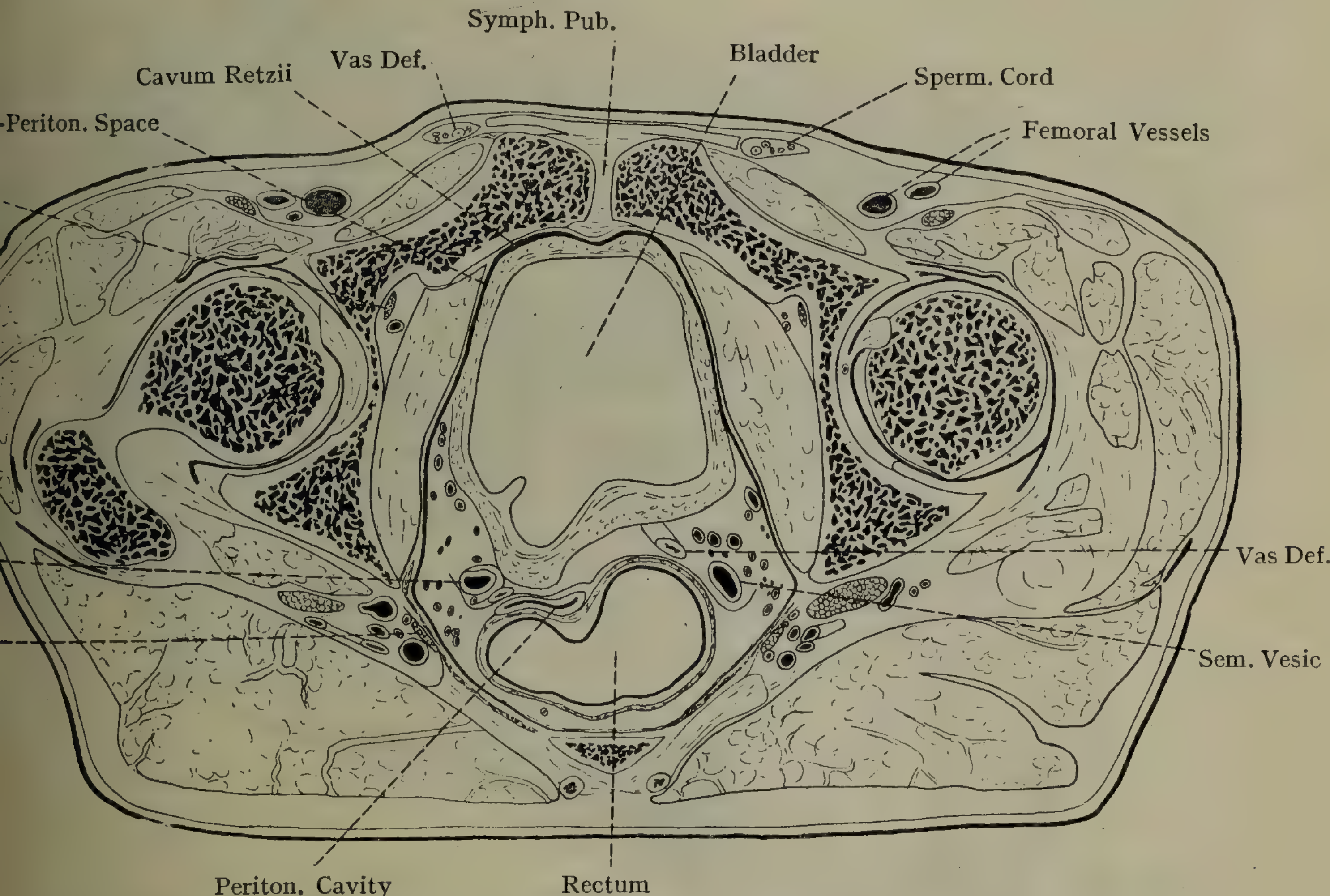


FIG. 548.—TRANSVERSE SECTION THROUGH LAST PIECE OF SACRUM (AFTER SYMINGTON).

ected inwards to the inner aspect of the upper end of the seminal sicle, whence it passes downwards, inwards, and forwards along the se of the bladder, where it lies close to the inner side of the seminal sicle. This part of the vas deferens, which comes very near its fellow, dilated and sacculated, like the adjacent seminal vesicle, and is known the **ampulla.** Close to the base of the prostate gland the saccula-ns disappear, and the duct, having become very narrow, is joined the outer side at an acute angle by the duct of the seminal vesicle, and the ejaculatory duct is formed, which will be presently described. r the structure and development of the vas deferens, see pp. 737 d 753.

Seminal Vesicles.—These are two in number, right and left, and between the base of the bladder and the rectum. They are sacculat reservoirs for the seminal fluid, and each is conical, being about 2 incl long, and about ½ inch broad at the widest part. The broad end free, and looks upwards, outwards, and backwards. It is cover posteriorly in its upper part by the peritoneum, which forms the rec vesical pouch, while anterior to it is the ureter as that is about to p through the bladder. The upper ends of the two seminal vesicles wide apart, and the bottom of the recto-vesical pouch descends betwe

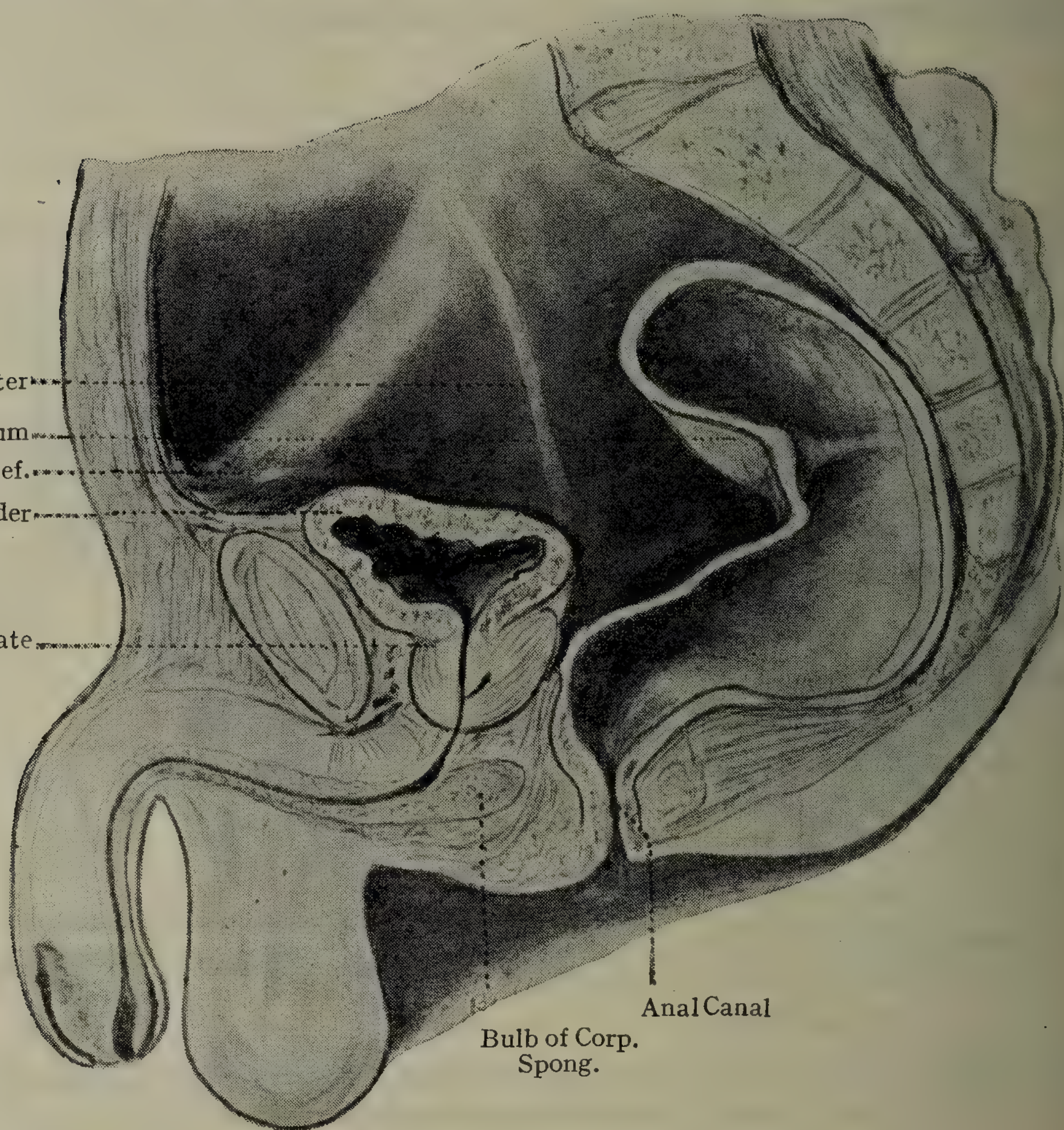


FIG. 549.—MEDIAN SAGITTAL SECTION THROUGH MALE PELVIS.

them for a short distance. The lower end of each, which is narr and free from sacculations, approaches its fellow, the vasa deferen intervening. This lower end represents the duct, which, as stat joins the vas deferens at an acute angle close to the base of the prost gland, and so gives rise to the ejaculatory duct. For the struct and development of the seminal vesicles, see p. 958.

Ejaculatory Ducts.—These are two in number, right and left. Ea is formed by the union of the duct of the seminal vesicle with the deferens close to the base of the prostate gland; it is about 1 inch

ngth. The two ducts pass downwards, forwards, and inwards through e prostate gland between the middle and lateral lobes, and each enters e lateral wall of the prostatic utricle to terminate in a minute aperture the lateral margin of the opening of the prostatic utricle. For the ructure and development of the ejaculatory ducts, see p. 955.

Prostate Gland.—This gland surrounds the first $1\frac{1}{4}$ inches of the ethra. It is firm in consistence, and in shape and colour resembles chestnut—that is to say, it is conical and of a reddish-brown colour. is subject to much variety in size, but its average measurements ay be stated as follows: the transverse diameter at the base is about inches; the vertical diameter from base to apex is about $1\frac{1}{4}$ inches;

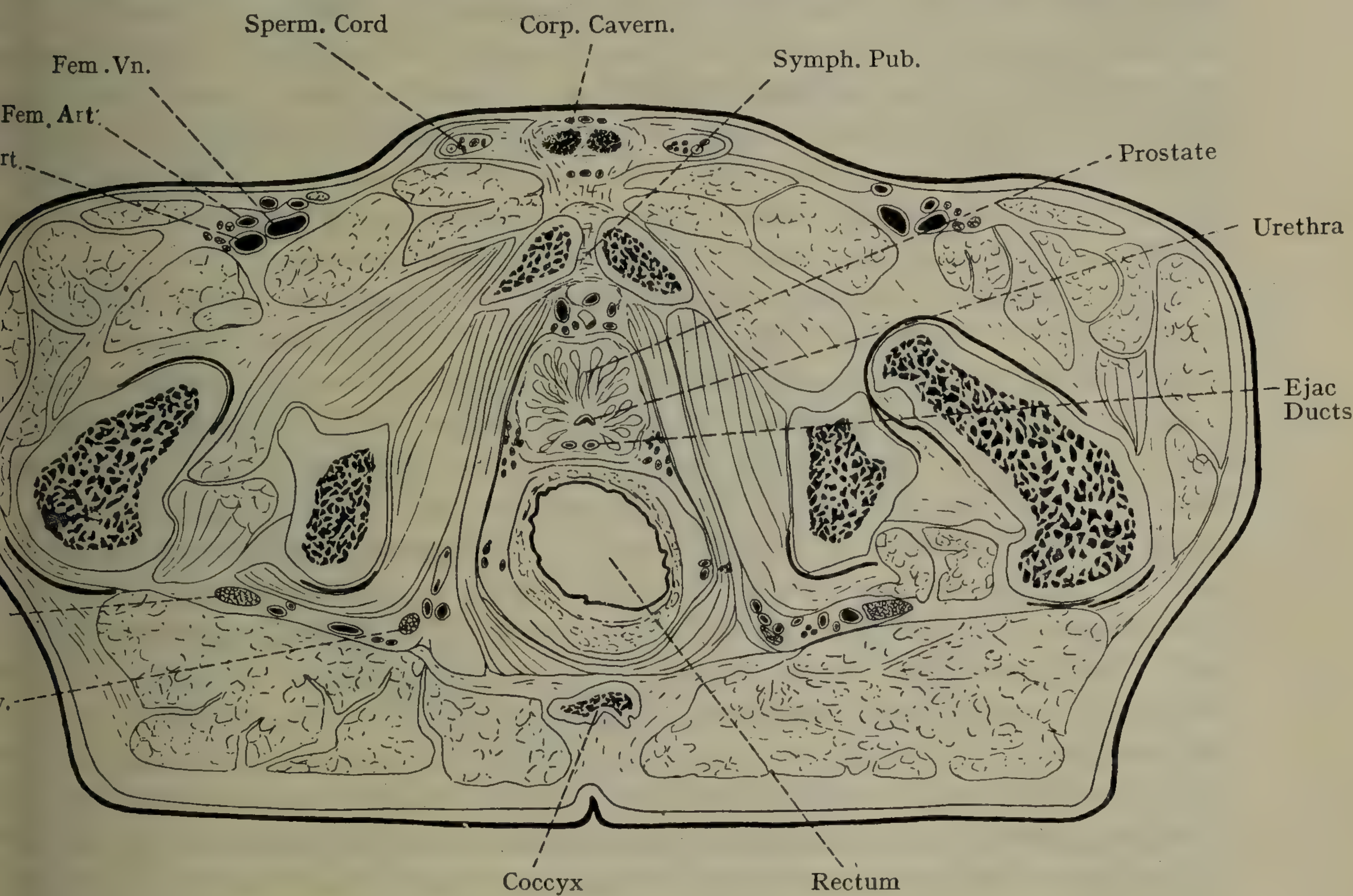


FIG. 550.—TRANSVERSE SECTION AT LEVEL OF COCCYX (AFTER SYMINGTON).

nd the antero-posterior diameter is about $\frac{3}{4}$ inch. The average weight the organ is about $4\frac{1}{2}$ drachms.

The gland is situated fully $1\frac{1}{2}$ inches from the anus, and its anterior rface is about $\frac{3}{4}$ inch below and behind the lower part of the symphysis ubis. It presents a base, an apex, a posterior or rectal surface, an nterior or pubic surface, and two lateral surfaces. The **base,** which directed upwards, surrounds the urethra, and is intimately connected ith the vesical wall. Notwithstanding this, however, there is a superficial line of demarcation between the two, which takes the form of an nnular groove, occupied by a portion of the prostatic venous plexus. he ejaculatory ducts enter the base close to the upper part of the osterior or rectal surface, where there is a small transverse cleft lled the *prostatic fissure.* The **apex** is directed downwards, and is

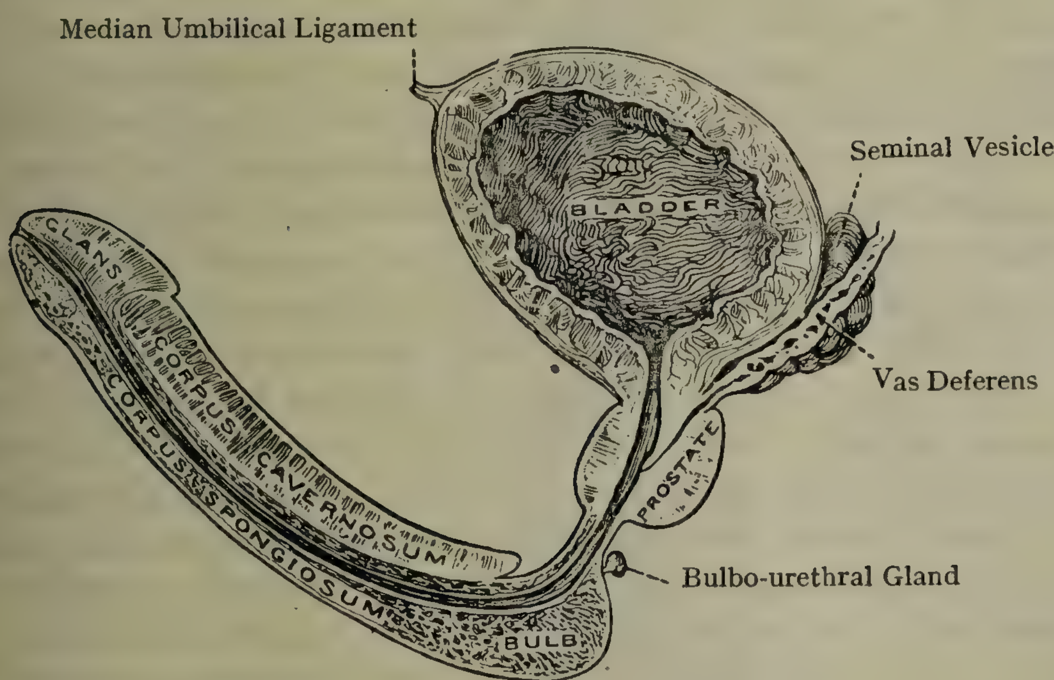
the most dependent part of the organ. It is in contact with the super layer of the perineal membrane. The **posterior** or **rectal surface** is f and triangular. It is directed backwards and slightly downwar and is set upon the anterior wall of the rectum, from which it is separat by the recto-prostatic lamina of the visceral portion of the pelvic fasc This surface is accessible to manipulation on introducing the finger in the anal canal, and carrying it up for fully $1\frac{1}{2}$ inches. The **anterior** **pubic surface,** which is convex, is so much projected as to be really anterior round border which separates the two lateral surfaces. It l about $\frac{3}{4}$ inch behind the lower part of the symphysis pubis, from wh it is separated by a portion of the prostatic venous plexus, the ret pubic pad of fat, and the medial pubo-prostatic ligaments. T anterior surface projects between the anterior borders of the levato ani muscles. The **lateral surfaces** are convex, and stand out in f relief. Each is embraced by the anterior fibres of the correspondi levator ani, which constitute the so-called levator prostatæ musc When an accessory pudendal artery is present it passes over the late surface, and might be endangered in lateral lithotomy.

The gland is usually regarded as composed of three lobes, t lateral and a middle, but, though the middle lobe can usually demarcated without much difficulty, there is no external indicati of any separation between the lateral lobes. The **lateral lobes** fo the chief bulk of the gland, and they meet and become continuous front of and behind the prostatic portion of the urethra, forming t anterior and posterior commissures. The **middle lobe** represents th part of the basal portion of the gland which is wedged in between t ejaculatory ducts and prostatic utricle behind and the urethra in fro and which lies just below the apex of the trigonum vesicæ. It is i portant to note that the middle lobe lies *behind* the commencement the urethra. It is liable to become hypertrophied in old age, and m then produce undue elevation of the uvula vesicæ in the interior of t bladder, which is a natural product of it. In this manner, by blocki the internal orifice of urethra, it may not only give rise to difficulty micturition, but may also obstruct catheterization.

The prostate gland is traversed by the first $1\frac{1}{4}$ inches of the ureth The ejaculatory ducts are also contained within the gland, in which th pass downwards and inwards between the middle and lateral lob For the structure and development of the prostate gland, see pp. 9 and 960.

Urethra.—The male urethra commences at the internal orifice urethra of the bladder, and terminates at the extremity of the gla penis in a vertical fissure, called the **external orifice of urethra.** It about 8 inches in length, and is divided into three portions, whic from the bladder outwards, are called prostatic, membranous, a spongy. The prostatic and membranous portions constitute t *non-penile part* of the canal, and the spongy portion, being contain within the corpus spongiosum of the penis, represents the *pen* *part.*

[T]he **prostatic portion of the urethra** is the part of the canal which ontained within the prostate gland. It is $1\frac{1}{4}$ inches in length, its course is almost vertical, there being a slight curve with the :avity directed forwards. It is spindle-shaped, being wider at the :re than at either end, and at its upper or vesical end it is rather er than at the lower end. Its diameter at the centre, which is the est part of the entire canal, is rather more than $\frac{1}{3}$ inch; at the upper esical end it is rather less than this, and at the lower end it is still . This portion of the urethra, though surrounded by the prostate id, is the most dilatable part of the whole canal. Close to the lder, however, it usually offers some resistance to the passage of an rument. Its walls are anterior and posterior, the latter being often ken of as the *floor*. These walls are in contact with each other, ept during the passage of fluid, and the mucous membrane is thrown longitudinal folds. The **posterior wall** presents along the middle



[F]IG. 551.—SECTION OF THE BLADDER AND PENIS TO SHOW THE URETHRA.

a prominent narrow elevation of the mucous membrane, called the **thral crest (verumontanum).** It is about $\frac{3}{4}$ inch long, and comnces either a little below the urethral orifice of the bladder or at the er end of the uvula vesicæ. As it descends it gradually becomes re prominent, assuming a height of about $\frac{1}{8}$ inch, and then rapidly sides. It is due to a thickening of the submucous tissue, which ises an elevation of the mucous membrane. On account of this protion a transverse section of this portion of the urethra is curved or scentic, with the convexity directed forwards. On either side of the st there is a longitudinal groove, called the **prostatic sinus,** into which majority of the prostatic ducts open. A few of these ducts, hower, from the middle lobe open in the median line above the crest, or, he crest commences at the lower end of the uvula vesicæ, upon its per part. Immediately below the most prominent part of the crest re is the opening of a small blind recess, called the **prostatic utricle**

(sinus pocularis). Its direction is upwards and backwards behind t middle lobe of the prostate, and it is from $\frac{1}{4}$ to $\frac{1}{2}$ inch in length. It somewhat flask-shaped, being narrow at its urethral orifice, but e panded at its deep cæcal end. It may extend beyond the prostate a is sometimes bifid. Upon the lateral margins of its orifice are the minu openings of the ejaculatory ducts. The utricle represents the uter and vagina in the female, being developed from the fusion of the posteri or caudal ends of the para-mesonephric ducts.

When the middle lobe of the prostate becomes hypertrophied blocks the urethral orifice of the bladder, as has been stated, by pressi the uvula vesicæ over it from behind, and so gives rise to difficulty micturition, and obstructs catheterization. When both lateral lob become uniformly hypertrophied, the prostatic portion of the ureth undergoes increase in length. When only one lateral lobe is involv in the hypertrophy it presses against the urethra, and, producing d tortion of the canal, gives rise to difficulty in micturition, and oft considerable obstruction in catheterization.

Structure.—The mucous membrane of the prostatic urethra surrounded externally by the inner circular muscular fibres of t prostate, and is covered internally by *transitional epithelium.*

The **membranous portion of the urethra** succeeds to the prosta portion, and extends from the apex of the prostate gland to the co mencement of the spongy portion. It is contained, for the most pa between the two layers of the perineal membrane, but it also exten for a short distance ($\frac{1}{4}$ inch) beyond the inferior layer of that structu It is the shortest and narrowest part of the canal, with the excepti of the external orifice of urethra. Its length is $\frac{3}{4}$ inch along the anteri wall, and $\frac{1}{2}$ inch along the posterior, the difference being due to t fact that the membranous urethra passes into the spongy part in slanting manner at a point $\frac{1}{4}$ inch in front of the posterior extremi of the bulb. The back part of the bulb projects backwards for $\frac{1}{4}$ in over the posterior wall of the membranous urethra, and is here lyi in front of the inferior layer of the perineal membrane. It is in t situation where a false passage is liable to be made in catheterizati partly because the walls are here very thin, and partly by reason the backward extension of the posterior extremity of the bulb. T diameter of the membranous urethra is $\frac{1}{5}$ inch. It lies about 1 in behind and below the inferior ligament of symphysis pubis, and direction is downwards and slightly forwards. It describes a gen curve, the concavity of which looks forwards and upwards towards t lower part of the symphysis pubis. As the membranous urethra pass through the superior layer of the perineal membrane, which is form by the parietal pelvic fascia, the fascia is prolonged upwards to fo part of the capsule of the prostate gland. Moreover, as it pierces t inferior layer of the perineal membrane about 1 inch below the sy physis pubis, it carries with it a prolongation from the margins of t urethral opening, which forms a fascial investment for the bulb. B tween the two layers of the perineal membrane the membranous ureth

ırrounded by the fibres of the sphincter urethræ muscle, and the o-urethral glands lie behind it, one on either side of the middle

Structure.—External to the mucous membrane there is a layer of tile tissue, and outside this there is a layer of circularly-disposed ı muscular fibres, ;h are continuous /e with the circular cular fibres of the tate around the pro- ic urethra. External this, again, there are sphincter fibres of sphincter urethræ. mucous membrane is ered by *columnar epi-um.* The membran- portion of the urethra ransverse section pre- s the appearance of ircular opening, the ıen of which is ıched, this being due the longitudinal folds which the mucous nbrane is thrown.

The **spongy portion of urethra** succeeds to membranous portion. is contained within corpus spongiosum of penis, and extends n a point $\frac{1}{4}$ inch in ıt of the posterior ex- nity of the bulb and the inferior layer of perineal membrane the external orifice of thra on the extremity the glans penis. It is ut 6 inches in length, l its calibre is unequal oughout. It presents

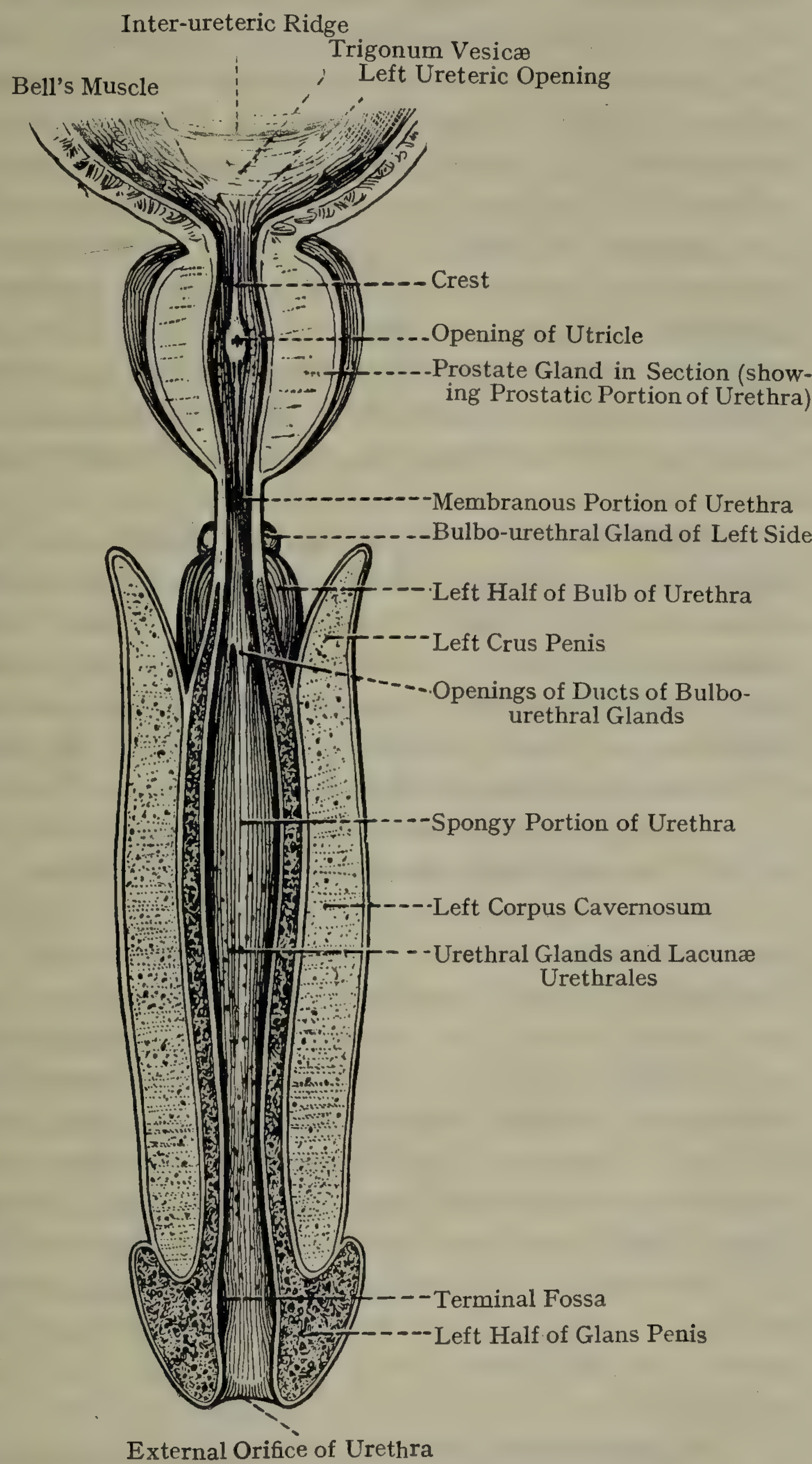


FIG. 552.—THE INTERIOR OF THE MALE URETHRA.

› dilatations, one situated in the **bulb,** the **intrabulbar fossa** (which resents about the first $1\frac{1}{2}$ inches of the corpus spongiosum), and other in the glans penis, the latter being called the **terminal sa (fossa navicularis).** The intrabulbar fossa is about $1\frac{1}{4}$ inches in gth, whilst the terminal fossa is about $\frac{1}{2}$ inch long. The diameter

of that part of the spongy urethra which intervenes between the in bulbar fossa and the terminal fossa is about $\frac{1}{4}$ inch. At the exte orifice of urethra the calibre of the canal is diminished, this being narrowest part of the entire canal. The spongy portion at its c mencement is directed forwards for a short distance, and then be downwards. It thus describes a curve, which is situated about 2 inc from its commencement, the concavity being directed downwa This curve is fixed, and corresponds with the **angle** of the penis, the sit tion of which is immediately in front of the penile attachment of suspensory ligament, where drooping of the organ takes place. walls of the spongy part of the urethra are in contact, except du the passage of fluid. A transverse section of it, except in the gl presents a transverse slit with anterior and posterior lips. In the gl however, the slit is vertical with its lips laterally disposed. At upper end of the terminal fossa—that is, the end most remote from external orifice of urethra—the vertical slit is modified by the addi of a short transverse slit, and so presents the shape of an inverted as follows, ⊥.

Structure.—The mucous membrane of the spongy portion is vided with elastic tissue, and is very vascular. It is covered *columnar epithelium,* except in the glans, where it is of the *strati squamous* variety. Outside the mucous membrane is the submuc coat, which contains two layers of plain muscular tissue—inner lo tudinal and outer circular. External to the submucous coat ther a plexus of veins, which forms part of the corpus spongiosum. mucous membrane contains both simple and compound mucous glar called the **urethral glands (glands of Littré),** the openings of the du of which are studded over the surface. In addition to these there other openings, which lead into small blind recesses, called the **lac urethrales,** these openings being directed forwards. One lacuna, large size, called the *lacuna magna,* is situated on the roof of the fo navicularis about 1 inch from the meatus urinarius. The muc membrane which surrounds this lacuna is known as the *valvule Guérin.* Besides the foregoing openings, the ducts of the bul urethral glands open upon the floor of the bulbous portion of the uret about 1 inch in front of the inferior layer of the perineal membrane.

There is sometimes a congenital deficiency in the floor of the spo urethra, constituting the condition known as hypospadias. In ot cases the deficiency may be on the roof, and it is then known epispadias.

Lymphatics of the Male Urethra—Spongy Portion.—The lymph vessels of the spongy portion communicate with those of the glans with the deep lymphatics of the penis, and in part through this conn tion drain to the *deep inguinal* and *external iliac glands.* Much of lymph, however, from this region drains into vessels which, acc panying first the vessels of the bulb and later the internal pudic vess finally pass to the gland or glands of the *internal iliac chain,* which situated near the origin of the internal pudendal artery.

ulbar and Membranous Portions.—The lymphatics of these portions to (1) the *internal iliac glands,* and (2) the *inner chain of the external glands.*

rostatic Portion.—The lymphatics of this portion join those of the :ance of the prostate gland, and pass to (1) the *middle chain of xternal iliac glands,* (2) the *internal iliac glands,* (3) the *lateral l glands,* and (4) the *inner group of the common iliac glands.*

elvic Colon.—The pelvic colon succeeds to the iliac colon. It nences at the inner border of the left psoas major just anterior to ɜft sacro-iliac articulation, and terminates in front of the third sacral ɜbra, where it becomes continuous with the rectum. It is very ıble in length, but measures on an average about 15 inches, and lly lies in the pelvic cavity, resting upon the bladder and rectum, ɜscending on either side of these viscera. It is surrounded by periɪm, which forms behind it an expanded wavy mesentery, called the **c meso-colon,** which contains between its two layers the branches ıe lower left colic arteries and the superior rectal artery, with the ɜsponding veins. The root of this mesentery is composed of two s, which become continuous at an acute angle. One limb takes an ırd course along the inner border of the psoas major, and the other ɜs downwards over the sacral promontory to be attached to the rior surfaces of the first three sacral vertebræ. At its extremities, h are near each other, the mesentery is short, and the extremities of pelvic colon are necessarily fixed. The intervening portion, how-, is long, and so allows of considerable mobility on the part of the ter portion of the attached gut. A very common course for the ic colon to take is to pass from the left wall to the right wall of the is, resting upon the bladder or uterus, then to pass backwards wing the posterior wall of the pelvic cavity until it arrives at the lle line, when it turns vertically downwards. A portion of it is ɜtimes met with in the abdominal cavity.

tructure.—The chief difference in the structure of the pelvic colon, ɔmpared with the other divisions of the colon, affects the arrange-t of the longitudinal muscular fibres. Though arranged at first ıree tæniæ, these gradually become disposed as two broad tæniæ, rior and posterior. When this has taken place, the longitudinal s almost surround the gut, except along the sides, in which situa- the usual sacculations are formed. Appendices epiploicæ are met over the pelvic colon.

lood-supply.—The pelvic colon receives its **arteries** from the lower colic arteries, which are branches of the inferior mesenteric. The s pass to the inferior mesenteric vein, and ultimately into the al vein.

he **lymphatics** pass to the *left lower pre-aortic glands.*

he **nerves** are derived from the inferior mesenteric sympathetic us.

ectum.—The rectum succeeds to the pelvic colon, and extends the front of the third sacral vertebra to a point $1\frac{1}{2}$ inches in front of

and below the tip of the coccyx, where it pierces the pelvic diaphra and terminates in the anal canal. Its direction is at first downwa and slightly backwards, then vertically downwards, and finally do wards and forwards. It is fully 5 inches in length, and its diameter the most part is about $1\frac{1}{2}$ inches in the empty state, but it becor enlarged above the anal canal, this dilated part being called the **amp recti.** When empty, its anterior and posterior walls are in contact, in transverse section it appears as a transverse slit. The rectun destitute of a mesentery. The peritoneum covers the upper th *laterally* and *anteriorly*, but not posteriorly, the middle third be covered by peritoneum *only anteriorly*, whilst the lower third is f from serous covering. The level at which the peritoneum leaves anterior surface of the rectum is usually about 3 inches above the an opposite the body of the fifth sacral vertebra.

The rectum, so far from being straight in man, presents both ante posterior and lateral curvatures. The **antero-posterior flexures** two in number, upper and lower. The *upper* curve extends from third sacral vertebra to the posterior or rectal surface of the prost gland, and its concavity is directed forwards. The *lower* curve, wh is abrupt, corresponds with the rectal surface of the prostate, its c cavity looking backwards, and containing the ano-coccygeal body. **lateral flexures** are of importance, because they tend to obstruct passage of instruments by giving rise to the rectal valves (Housto These flexures are usually three in number—upper, middle, and low The *upper* and *lower* flexures have their convexities directed towa the right, whilst the *middle* flexure has its convexity directed towa the left. In the concavities of these flexures the rectal wall becon inflected, and so gives rise to more or less prominent shelves of muc membrane, which are known as the rectal valves. The lateral infl tions and resultant valves are associated with the erect posture of m which posture throws considerable pressure upon the anal aperture a its sphincter muscles. They are best marked in the distended rectu and the lateral flexures are brought about in the following manner: T longitudinal muscular fibres of the rectum are rather shorter than t gut to which they are applied. Moreover, they are principally dispos in two stout broad sheets, one on the anterior and the other on t posterior wall, there being very few longitudinal fibres along the late walls. The shortness of these longitudinal fibres therefore throws t rectum into lateral flexures on account of the sparseness of the lon tudinal fibres at the sides. These lateral flexures may be taken representing the sacculations of the other parts of the colon.

Relations—*Anterior.*—The recto-vesical pouch of peritoneum f a short distance, usually containing coils of small intestine or of pelv colon; the base of the bladder, seminal vesicles, and vasa deferentia, wi the intervention of the recto-vesical lamina of the visceral pelvic fasci and the posterior or rectal surface of the prostate gland, with the inte vention of the recto-prostatic lamina of the visceral pelvic fascia. the female the anterior relations are (1) the recto-uterine pouch

ritoneum (pouch of Douglas), with a few coils of small intestine or lvic colon, in front of which are the posterior surface of the body of e uterus and the upper part of the posterior wall of the vagina; and) the greater portion of the posterior wall of the vagina. *Posterior.*—ie lower three sacral vertebræ, coccyx, levatores ani, and ano-coccygeal dy; the median and lateral sacral vessels, sacral lymphatic glands, cral nerves, and sacral sympathetic trunk. Behind the rectum there a large amount of areolar tissue. *Lateral.*—The pelvic sympathetic exuses, levatores ani, and coccygei muscles, the lateral divisions of e superior rectal artery, and the corresponding veins.

Anal Canal.—This is the terminal portion of the large intestine. extends from the lower end of the rectum, where that has pierced e pelvic diaphragm at a point corre-onding to the apex of the prostate and, to the anus, and it is the part nich is surrounded by the sphincter uscles. It is about $1\frac{1}{2}$ inches in igth, and its lateral walls are in ntact, so that in transverse section appears as an antero-posterior slit, which respect it differs from the ctum proper. Its direction is down-ards and backwards, and its antero-sterior diameter is from $\frac{1}{2}$ to $\frac{3}{4}$ inch.

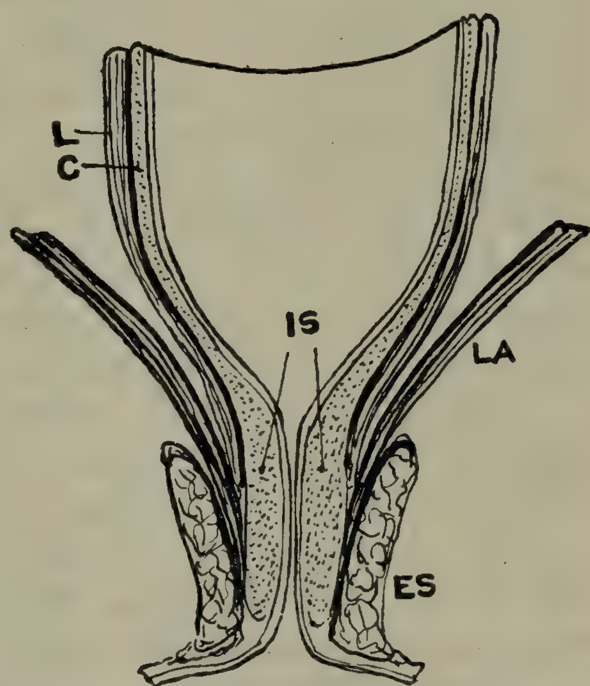


Fig. 553.—Diagram of Structure of Rectum and Anal Canal.

L, C, longitudinal and circular fibres of wall; the circular fibres thicken below to form the internal sphincter (IS); ES, external sphincter; LA, levator ani.

Relations.—*Anterior.*—The bulb of e penis, the base of the perineal embrane, and the membranous part the urethra. In the female the rineal body is anterior to it, and parates it from the lower end of e vagina. *Posterior.*—The ano-coccy-al body. *Lateral.*—The fat of the hio-rectal fossæ. The anal canal is sely guarded by muscles in the fol-wing manner and to the following tent: most internally is the sphincter i internus continuous with the circular muscular fibres of the rest the gut; outside this are the longitudinal muscular fibres markedly inforced by the fibres of the levator ani, which here run longi-dinally; and most externally is the sphincter ani externus. For e structure and development of the rectum and anal canal, see 960.

Parts felt per Rectum in Catheterization.—A catheter having been passed to the bladder, the following parts, in order from before backwards, may be t through the anterior wall of the bowel on the introduction of the index ger: (1) the membranous portion of the urethra; (2) the posterior or rectal rface of the prostate gland; and (3) the apical part of the external trigone of e bladder, destitute of peritoneum, with a vas deferens on either side, and very

near each other—indeed, almost touching. During this examination the fin may come in contact with the lower left, and perhaps the right horizontal folc rectum.

Median Sacral Artery.—This vessel arises from the posterior asp of the abdominal aorta just above the bifurcation. Its course downwards in the middle line, behind the left common iliac vein a the hypogastric sympathetic plexus, and it rests in succession up the following parts: the lower half of the body of the fourth luml vertebra and the disc between it and the fifth, the body of the fi lumbar and the disc between it and the first sacral vertebra, and t pelvic surfaces of the sacrum and coccyx. In the pelvis it lies witl the root of the pelvic meso-colon, being covered by a portion of t pelvic colon, as low as the third sacral vertebra, and beyond that i placed behind the rectum. On reaching the tip of the coccyx terminates in the coccygeal body. The branches of the artery are follows: *anterior* or *rectal* to the posterior wall of the rectum, where th anastomose with the superior and middle rectal arteries; *lateral* to t front of the sacrum and coccyx, which anastomose with the late sacral arteries; and *terminal* to the coccygeal gland. The vessel usua furnishes a fifth pair of lumbar arteries, which wind round the sides the body of the fifth lumbar vertebra.

The median sacral artery represents the caudal aorta of anima and its lateral branches are serially homologous with the lumb branches of the abdominal aorta.

The **median sacral vein** is at first arranged as two venæ comit but these subsequently unite to form a single vessel, which usua terminates in the left common iliac vein.

Glomus Coccygeum.—This so-called gland is situated in front of t tip of the coccyx. It is about the size of a small pea, and is compos of a few nodules which are held together and invested by connecti tissue. It receives the terminal twigs of the median sacral artery. structure it consists of groups of polyhedral cells united by connecti tissue, and permeated by blood-capillaries and sympathetic nerv filaments. It is in some respects similar to the *carotid body*, whi is situated behind the common carotid artery of each side close its bifurcation, but differs from it in not containing chromapl cells.

Sacral Glands.—This group comprises a few lymphatic glands whi lie in front of the sacrum to the inner side of the second and third sacı foramina. They receive their afferent vessels from the various pelv viscera, as well as from the posterior wall of the pelvis; their effere vessels pass to the middle chain of common *iliac glands*.

Sacral Sympathetic Trunk.—This is situated close to the inner si of the anterior sacral foramina. The two trunks, right and left, co verge as they descend, and in front of the coccyx they are connect by a loop which sometimes presents a single median ganglion, called tl *ganglion impar* or *coccygeal ganglion*. The number of ganglia on eac trunk is usually four.

3ranches.—(1) **Grey rami communicantes,** which spring from the glia and pass to the anterior primary divisions of the sacral and ygeal nerves. These rami are very short. (2) **Visceral branches** nall size which pass from the upper part of the pelvic sympathetic l. (3) **Parietal branches,** which are distributed over the front of sacrum, and which communicate with those of the opposite side, s to form a plexus upon the median sacral artery. From the terminal and ganglion impar (when present) branches proceed to the front he coccyx and glomus coccygeum. The ganglia of the sacral trunk not receive any white rami communicantes from the sacral nerves, se, under the name of the *pelvic splanchnics,* going directly to the ic plexus.

Levator Ani—*Origin.*—(1) The posterior surface of the body of the is in its lower part, below the attachment of the medial pubo-static or anterior true ligaments of the bladder, and above the chment of the parietal pelvic fascia; (2) the internal surface of the ietal pelvic fascia along the **arcus tendineus (white line)**; and (3) the ic surface of the spine of the ischium in its lower part, below the cygeus.

Insertion.—(1) The side of the lower part of the coccyx; (2) the -coccygeal raphé, where it meets its fellow of the opposite side; the wall of the anal canal, where the fibres blend with the longi-inal fibres of the gut, and ultimately pass with them between the ernal and internal sphincter muscles to be attached to the skin und the anus; and (4) the anal raphé and the perineal body, where muscle again meets its fellow of the opposite side.

The levator ani is a broad, flat, and thin fleshy muscle, the direc-of which is downwards, inwards, and backwards; with its fellow he opposite side it forms an incomplete muscular floor to the pelvic ity. It is covered on its pelvic aspect by the visceral portion of the ic fascia, and on its perineal aspect by the anal fascia, and in this ner a separation is formed between one half of the pelvic cavity and ischio-rectal fossa of the same side.

The anterior border is free close to the body of the pubis, but a little her back it passes downwards upon the side of the prostate gland he male, or vagina in the female; farther back still it meets its fellow he opposite side, between the prostate gland and the commencement he membranous part of the urethra on the one hand and the rectum the other, or between the vagina in the female and the rectum, the eting taking place in the anal raphé. Between the anterior borders he two muscles the membranous part of the urethra in the male, l the vagina and urethra in the female, leaves the pelvic cavity. The erior or pubo-prostatic fibres are sometimes spoken of as the **levator statæ.** The posterior border adjoins the coccygeus muscle.

The muscle is often divided on morphological grounds into two ts, the pubo-coccygeus and the ilio-coccygeus, the coccygeus muscle lf constituting the ischio-coccygeus. The anterior fibres of the o-coccygeus descend on the sides of the prostate gland and vagina,

supporting these, and in strong contraction compressing them; posterior fibres of this part pass almost directly backwards, lying on superior surface of the ilio-coccygeus muscle; but not all of these fib reach the coccyx, some ending immediately behind the anal canal joining the corresponding fibres of the opposite side to form the so-cal pubo-analis muscle. The ilio-coccygeus arises mainly from the ar tendineus and the pelvic surface of the ischial spine, but its fibres can infrequently be traced upwards underneath the arcus, particularly front, to become continuous with the outer surface of the upper part the parietal layer of pelvic fascia.

Nerve-supply.—(1) The anterior primary divisions of the third a fourth sacral nerve on its superior surface, and (2) the perineal bran of the pudendal nerve (deep division) on its deep surface.

Action.—(1) To elevate and support the floor of the pelvis, th diminishing the vertical measurement of the abdominal cavity; (2) pull up the wall of the anal canal over the contained fæces, and so ass in their expulsion; (3) to pull the anal canal towards the symphy through the action of the pubo-analis muscle, and so straighten to so extent this portion of the alimentary canal; (4) to elevate and compr the prostate gland in the male and the vagina in the female; and (5) flex the coccyx.

Coccygeus (Ischio-coccygeus)—*Origin.*—(1) The pelvic surface the spine of the ischium, above the origin of the posterior fibres of t levator ani; and (2) slightly from the inner surface of the parietal pel fascia, above the ischial spine.

Insertion.—The side of the upper two coccygeal and lower t sacral vertebræ.

Nerve-supply.—The anterior primary divisions of the fourth a fifth sacral nerves.

Action.—To flex the coccyx.

The coccygeus is a thin, flat, triangular muscle, the fleshy fib having a large admixture of tendinous fibres. The internal or pel surface is related to the visceral pelvic fascia, coccygeal plexus a rectum, and the external surface to the sacro-spinous ligament. T superior border is adjacent to the pyriformis, with the intervention the structures which leave the pelvis below that muscle. The inferi border adjoins the posterior border of the levator ani. The muscle continuous with the sacro-spinous ligament, which is made by chang in its fibres.

The coccygeus muscle is to be regarded as a detached portion the levator ani.

The levatores ani and coccygei muscles form the *pelvic diaphrag* which presents a superior concave and an inferior convex surfac The greater part of this diaphragm is formed by the levatores ani, a this part of it gives passage in the middle line to the rectum.

Pyriformis—*Origin.*—(1) By three fleshy slips from the anteri surfaces of the second, third, and fourth sacral vertebræ, which a interposed between and lie lateral to the adjacent anterior sacr

nina; (2) the deep surface of the sacro-tuberous ligament; and he posterior border of the ilium immediately below the posterior ior spine.

nsertion.—An impression on the upper border of the greater tro-ter of the femur near its centre.

Verve-supply.—Two branches from the sacral plexus, more cularly from the dorsal divisions of the first and second sacral es.

ction.—Lateral rotator of the thigh.

'he intrapelvic portion of the muscle is covered by a prolonga- of the parietal pelvic fascia, called the fascia of the pyriformis, it supports the nerves of the sacral plexus, branches of the anterior ion of the internal iliac artery, and pelvic colon. For the extra-ic portion, see Gluteal Region.

bturator Internus.—*Origin.*—(1) The internal surface of the rator membrane; (2) the posterior surface of the body and inferior is of the pubis, and ramus of the ischium; (3) the inclined plane of ischium, extending as far back as the greater sciatic foramen, and ly as high as the iliac portion of the pectineal line; and (4) the etal pelvic fascia covering the muscle.

nsertion.—The medial surface of the greater trochanter above and ont of the trochanteric fossa.

Verve-supply.—The nerve to the obturator internus from the sacral us.

Action.—Lateral rotator of the thigh.

Relations of Intrapelvic Part—*Medial.*—As low as the arcus ten-us the internal surface of the muscle is covered by the parietal ic fascia and peritoneum with the extra-peritoneal areolar tissue, is directed towards the pelvic cavity. The obturator vessels and e here lie between the extra-peritoneal areolar tissue and the etal pelvic fascia. Below the level of the arcus tendineus the lial surface is still covered by the parietal pelvic fascia, which con-cts the pudendal canal. This portion of the muscle lies upon the ral wall of the ischio-rectal fossa. *Lateral.*—The internal surface the obturator membrane, and the surrounding bone. For the a-pelvic part of the muscle, see p. 535.

Structure of the Viscera of the Male Pelvis.

The Bladder.

The wall of the bladder is composed of four coats—serous, muscular, mucous, and mucous.

The **serous coat** is formed by the peritoneum, and is confined to superior surface and upper part of the base. It forms the false ments of the viscus.

The **muscular coat** consists of plain muscular tissue, which is anged in three layers—external longitudinal, middle circular, and ernal longitudinal.

The *external longitudinal fibres* are most apparent on the supe and inferior surfaces. Laterally they are scarce, and are dispo in an interlacing manner. They have an independent bony atta ment to the posterior aspects of the bodies of the pubic bones n the lower part of the symphysis, where they constitute the so-cal *pubo-vesical muscles.* They then pass within the medial pubo-prost ligaments to the prostate gland. Having covered the infero-late surfaces of the bladder as far forwards as the apex, some of them there prolonged along the median umbilical ligament for a short tance, whilst others turn to the superior surface, over which they p to the base. Having descended upon the base, they enter the prost gland, where they blend with its muscular tissue. The longitudi stratum has been called the **detrusor urinæ muscle** from its suppo function in expelling the urine from the bladder.

The *middle circular fibres* are somewhat indistinct, and more less reticular over the greater part of the viscus. In the region wh the fundus and infero-lateral surfaces meet they become more distin and near the spot where the urethral opening is situated they form tolerably well-marked annular bundle, known as the **sphincter vesi** beyond which they are continuous with the muscular tissue of prostate gland.

The *internal longitudinal fibres* are somewhat indefinite, and chiefly recognizable on the inferior surface.

When portions of the mucous membrane project between scattered muscular bundles, the bladder is said to be *sacculated.* Wh on the other hand, the muscular bundles become hypertrophied fr any cause, such as enlarged prostate or stricture, they give rise inward projections of the mucous coat, which are arranged in a coars reticular manner, a condition known as the *fasciculated bladder.*

The **submucous coat** is situated between the muscular and muco coats, which it connects in a loose manner for the most part, and composed of areolar tissue with an admixture of elastic tissue. serves as a bed in which the arteries and nerves subdivide bef entering the mucous coat.

The **mucous coat** is soft in consistence, and of a pinkish colour health. It is continuous with the mucous membrane of the uret and urethra, and over the greater part of the empty bladder is thro into folds, which, however, disappear as the viscus becomes distend This rugose condition is explained by the loose connection which exi between the mucous and muscular coats through means of the su mucous coat. Over the internal trigonum vesicæ, however, to presently described, the mucous membrane is quite smooth, and al very sensitive. The mucous coat is covered by stratified transitio epithelium, similar to that of the ureters. In the most superficial lay the cells are cubical, and they present depressions on their deep su faces, which receive the round ends of the pyriform cells of the lay beneath. In the second layer the cells are pyriform, the round en being capped by the cubical cells of the first layer, and the narrow en

deeply placed amongst the deeper cells. In the third and fourth ; the cells are round or oval.

)rifices of the Bladder.—These are three in number—namely, ral, and two ureteric. The **internal orifice of urethra** is the ng by which the urine leaves the bladder, and it is situated at osterior extremity of the infero-lateral surfaces, where they meet ase. This is the most dependent part of the viscus, and is surled by the base of the prostate gland. Immediately above the ral orifice the mucous membrane presents a short median vertical , which projects forwards over the orifice. This ridge is called the *vesicæ.* It is produced by the middle lobe of the prostate gland, s much more conspicuous when that lobe is enlarged. The **ureteric ngs** assume the form of small, slit-like, somewhat elliptical aper-, which are about $1\frac{1}{4}$ inches apart, and an equal distance from the ıral orifice, their direction being obliquely downwards and inwards. ureters, before so terminating, have pierced the vesical wall uely, lying in it for about $\frac{3}{4}$ inch, and in this manner reflux of is prevented.

rigonum Vesicæ.—This is situated at the lower part of the basal ce, and the mucous membrane over it is so closely connected to the ular coat that it is always smooth, and so presents a marked ast to the rugose condition of the mucous membrane over the of the empty bladder. The trigone (Fig. 546) assumes the form ı equilateral triangle, the angles of which correspond with the ıral and ureteric openings, whilst the sides are constructed by s connecting these openings. The interureteric ridge, called *ier's bar,* is produced by a bundle of muscular fibres, and is slightly ex, with the convexity directed downwards towards the urethral e. The fibres constituting the ridge, on reaching the ureteric es, run for some distance within Waldeyer's sheath along and erior to the ureter, with the longitudinal fibres of which they are ıately continuous. When the fibres contract they pull the ureters ıwards and inwards, increasing their obliquity, and thus diminish-any tendency to regurgitation of urine when contraction of the der occurs; they moreover bring the duct more definitely within the ɔ of the arched muscular fibres which surround the intraparietal ion of its course, and so still further diminish any such tendency. urethro-ureteric ridge on either side is also produced by a bundle of cular fibres, which are, however, very often indistinct, these bundles g known as the *muscles of Bell.* The uvula vesicæ is situated at lower part of the trigone in the middle line above the urethral ce.

umen of the Empty Bladder.—This is very small, and is composed wo limbs, anterior and posterior. The *anterior limb,* which is , lies almost horizontally in front of the urethral orifice, and is ed by the juxtaposition of the superior and inferior walls. The *rior limb,* which is short, is directed upwards and backwards, and rmed by the juxtaposition of the back part of the superior wall

and the base. The anterior and posterior limbs join each other at t urethral orifice, and are there continued onwards into the lumen the prostatic urethra. A triradiate appearance is thus impart to the lumen of the empty bladder and of the prostatic urethra, t three rays diverging from a central point—namely, the internal orifi of urethra—one ray being urethral and two vesical, of which latter o is the anterior limb of the vesical lumen and the other the posteri limb.

The Infantile Bladder.—The bladder in early life is pyriform. T narrow end is directed downwards, and is on a level with the upp border of the symphysis pubis, from which point it gradually descen as age advances. The broad end is directed upwards, and lies in t hypogastric region of the abdomen. The base is absent at this perio and the anterior surface of the viscus, devoid of peritoneum, is in co tact with the posterior surface of the anterior wall of the abdome which is likewise destitute of peritoneum. There being no base, t bottom of the recto-vesical pouch of peritoneum lies close to the ba of the prostate gland.

Ligaments of the Bladder.—These are classified as false and tr ligaments. The **false ligaments** are formed by the peritoneum, a are five in number as follows: *two posterior,* which represent the laterall disposed lips of the mouth of the recto-vesical pouch; *two lateral,* rig and left, which represent the reflection of the peritoneum from eac lateral border of the bladder to the corresponding lateral wall of t pelvis; and *superior,* which is the reflection of the peritoneum from t apex of the bladder to the posterior surface of the anterior abdomin wall along the median umbilical ligament. The **true ligaments** a also five in number as follows: *two lateral pubo-prostatic,* right and le which are formed by the vesical layers of the visceral portion of t pelvic fascia on the sides of the bladder; *two medial pubo-prostat* which are the reflections of the visceral pelvic fascia from the back the bodies of the pubic bones near the lower part of the symphysis the neck of the bladder, and which pass in their course over the anteri surface of the prostate gland; and *superior,* which is the median um bilical ligament. Each medial pubo-prostatic ligament contains som of the external or longitudinal muscular fibres of the bladder.

Blood-supply—Arteries.—These are as follows: (1) superior vesica from the umbilical artery; (2) inferior vesical, from the anterior divisio of the internal iliac; (3) vesical, from the intrapelvic portion of t obturator; (4) vesical, from the intrapelvic portion of the inferior glutea and (5) branches from the uterine and vaginal arteries in the female.

Veins.—These are very copious, and are arranged in two plexuses- vesical and prostatic. The **vesical plexus** is situated over the fund and sides of the bladder, and its blood is conveyed into the prostat plexus. The **prostatic plexus** is composed of two parts continuous wit each other. Its blood is conveyed by one or more veins into the intern iliac vein.

Lymphatics.—These pass to the *external* and *internal iliac glands.*

erves.—Each half of the bladder receives sympathetic and spinal s from the following sources: (1) the pelvic plexus of the sym-etic, which contains spinal fibres from the third and fourth sacral es (sometimes also from the second), these being known as the *pelvic ichnics*; and (2) special twigs from the pelvic splanchnics, which e traced independently to the bladder. It is to be noted that the der also receives spinal fibres from the upper two or three lumbar es through (*a*) the ganglia of the lumbar sympathetic trunk, (*b*) the c plexus, (*c*) the hypogastric plexus, and (*d*) the pelvic plexus.

Structure of the Penis.

orpora Cavernosa.—Each corpus cavernosum has a strong capsule, d the **tunica albuginea.** This tunic is composed of fibrous, plain cular, and elastic tissues. It is disposed in two laminæ—external internal. The fibres of the external lamina are arranged longi-ally, and are common to both corpora cavernosa. The fibres of nternal lamina run circularly round each corpus cavernosum, and e middle line those of each side meet and are prolonged inwards septum, which is imperfect except near the roots of the penis, g traversed by vertical clefts. This partition is called the **septum.** n the inner surface of the tunica albuginea strong trabeculæ are n off, which penetrate into the interior of the corpus cavernosum. se trabeculæ, which are fibro-muscular and elastic in character, are nged in a reticular manner, and enclose the cavernous spaces of the tile tissue. The deep artery of penis lies in the centre, and, in tion to this chief vessel, several other arteries, derived from the al artery of the penis, enter it from the surface. The branches of e arteries run in the trabeculæ, and terminate in capillaries, which their blood directly into the cavernous or intertrabecular spaces. e of the small arteries in the trabeculæ are thrown into spiral loops, h project into the intertrabecular spaces. Such vessels are called *helicine* (spiral) *arteries* (Müller). From the intertrabecular spaces radicle veins proceed, and by them the blood is returned from the n.

orpus Spongiosum.—This differs from the corpora cavernosa in g destitute of any bony attachments. Its length is about 6 inches, it is expanded at either end. It is divided into a bulb, body, and s. The glans has been already described (see p. 713 *et seq.*) The **bulb** esents about the first $1\frac{1}{2}$ inches of the corpus spongiosum, and at widest part it measures $\frac{3}{4}$ inch. It is surrounded by the bulbo-giosus muscles, and its enlarged posterior extremity rests upon the t of the inferior layer of the perineal membrane, where it is about ch in front of the anus. The **body** is cylindrical. It has a capsule unica albuginea, but this is very thin. Within the capsule there is erectile tissue, which resembles that of the corpora cavernosa, gh of a finer texture and not so well developed; in the centre is the gy portion of the urethra. The corpus spongiosum is traversed

by the arteries of the bulb, right and left, which are branches of t internal pudendal arteries. They are situated underneath the ureth canal, one on either side of the middle line.

The venous blood of the corpora cavernosa and corpus spongiosu is returned by the dorsal vein of the penis, and by the internal pudend venæ comites.

For the structure of the different parts of the urethra, see p. 940.

The glans penis and corpora cavernosa are developed from the genital e nence, and the corpus spongiosum is developed from the genital folds.

Development of the Bladder and Urethra—The Allantois (see pp. 31, 32, a 45).—The intra-embryonic part of the allantois is at first directly continu

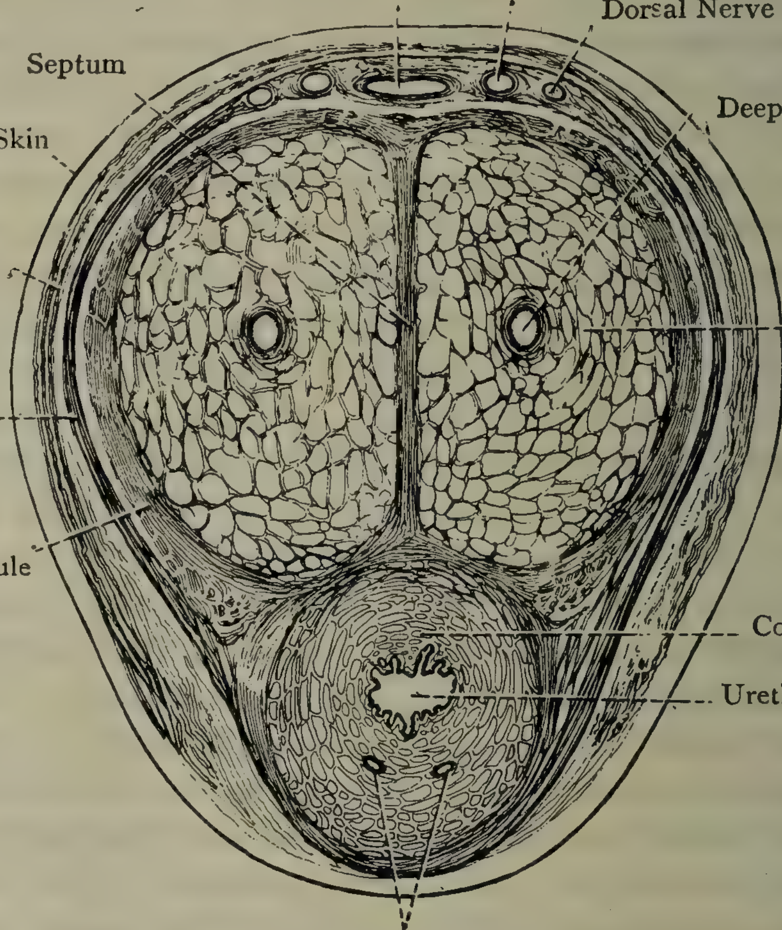


FIG. 554.—TRANSVERSE SECTION OF THE PENIS OF A CHILD AS SEEN UNDER A LOW POWER.

with the upper part of the bladder, but in the course of the second month lumen usually disappears, and then this portion is transformed into a fibro cord, which is called the **urachus.** It is, however, to be noted that the lum of the intra-embryonic part of the allantois may remain persistent for son time, thus giving rise to the condition which is known after birth as an umbilic urinary fistula.

The **cloaca,** which is the common terminal chamber of the hind-gut an allantois (Fig. 555), is divided by the **cloacal septum** into ventral and dors parts. These changes are illustrated in the figure, where the dividing ' septum is seen to deepen from above. The *dorsal* compartment gives rise to the **rectu** The *ventral* compartment constitutes the **uro-genital sinus,** so termed becau the excretory ducts and subsequently the genital ducts open into it.

These ducts are indicated in Fig. 555. The *mesonephric* (or Wolffian) duc reach the lateral walls of the cloaca, and when the septum extends down behi

m they are left opening into the dorso-lateral aspect of the ventral compart-nt. Later, as will be shown in the next paragraph, the ureteric outgrowth m the duct comes to open into the cavity, and the ultimate opening of the duct t a lower level. The *para-mesonephric* (or Müllerian) ducts now reach this lower el by passing along the mesonephric ducts, and thus reach the uro-genital sinus ow the dilatation which forms the bladder.

In the meantime the cloacal derivatives are changing their form rapidly. e **cloacal membrane** (shown as a black line in the first two stages in Fig. 555) es cranially at first, but is quickly swung round so that it comes to face in opposite direction. This is brought about by rapid mesodermal formation *ween the base of the body-stalk* (*BS*) *and the membrane,* along the sides of which xtends for some distance; in this way the **genital tubercle** (G) comes into dence, and the mesodermal growth beside the membrane makes the **genital ls** continuous with the tubercle. Thus not only is the area of the membrane ing round on its non-growing caudal extremity, but the whole mesodermal

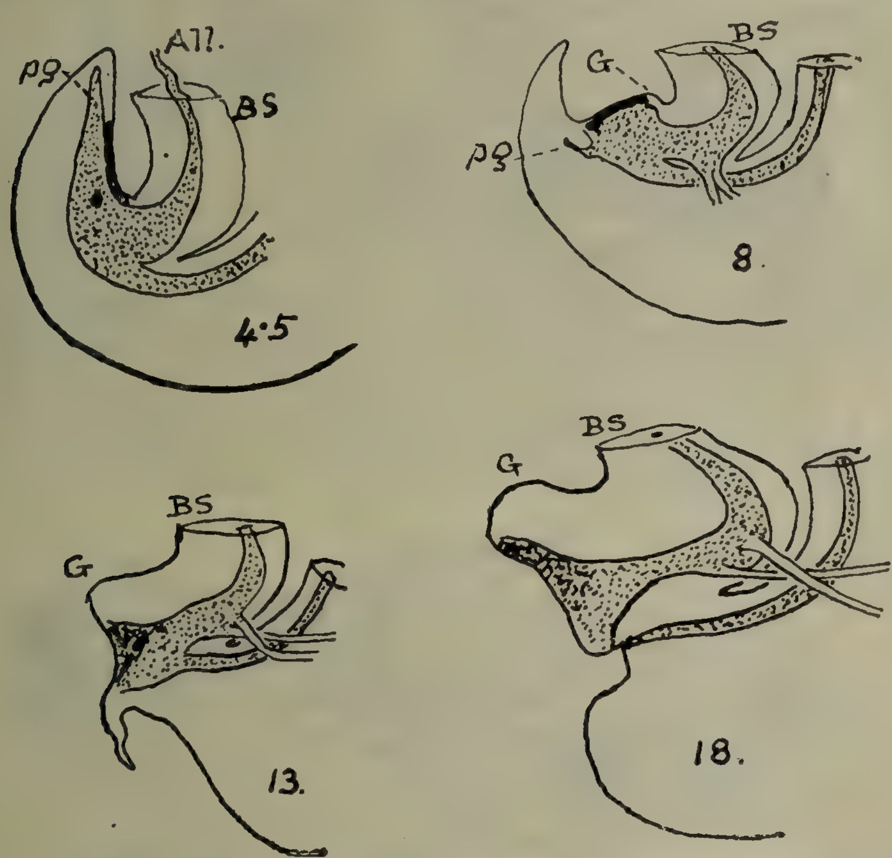


FIG. 555.—OUTLINES TO SHOW CLOACA AT DIFFERENT STAGES.
Observe rotation of plane of cloacal membrane and division of the cavity.

wth encloses a new cavity which is added to the length of the uro-genital sinus; s can be appreciated from Fig. 556.

The **urinary bladder** is developed from the *cephalic part* of this elongated -genital sinus. In the first section in Fig. 556 the mesonephric duct (W) ches a dilated part of the sinus above the lower end of the septum (S). In the ond section the duct is not shown, but the marked elongation of the sinus, in ping with the great external growth, is well shown, and the dilatation of the dder is much more evident. Each duct had a metanephric bud (ureter) ning into it at first some distance from the sinus. The upper part of the sinus, held by the lower thickenings of mesoderm, begins to expand, *extending ng the mesonephric duct* in doing so; this expansion (Fig. 557) goes on round duct, the end of which is thus passively invaginated or intussuscepted into the dder cavity, where it rapidly atrophies, breaks up and disappears. This process s on until the expanding bladder *reaches the ureteric opening,* which is affected the same way, at its *extreme end only,* when the expansion ceases. Thus the ter comes to open into the bladder apart from the duct, and to its lateral side l above it.

About this time the infra-umbilical portion of the belly-wall, hardly exist up to now, begins to grow, and the upper part of the sinus is gradually dra up with it; the lower part is, of course, fixed in the mesodermal condensatio Thus the bladder, carrying the ureter with it, is elongated in an upward directi The mesonephric duct, however, embedded in the topmost part of the cond sation, is held in position here. Thus its terminal piece, held below but dra up at its upper end, is embedded in and fused with the lining cells of the cor sponding wall of the sinus. This is indicated schematically in Fig. 558, wh the first diagram shows the dorsal wall of the sinus here including the end-piece the duct (W), still visible almost as far as the level of the entrance of the ureter (The next diagram shows how, by the breaking down of the (dotted line) vent wall of this included duct, its ultimate opening is left at the low level, while ureteric opening is moving up. In this way *the ejaculatory ducts come to op below the level of the bladder.*

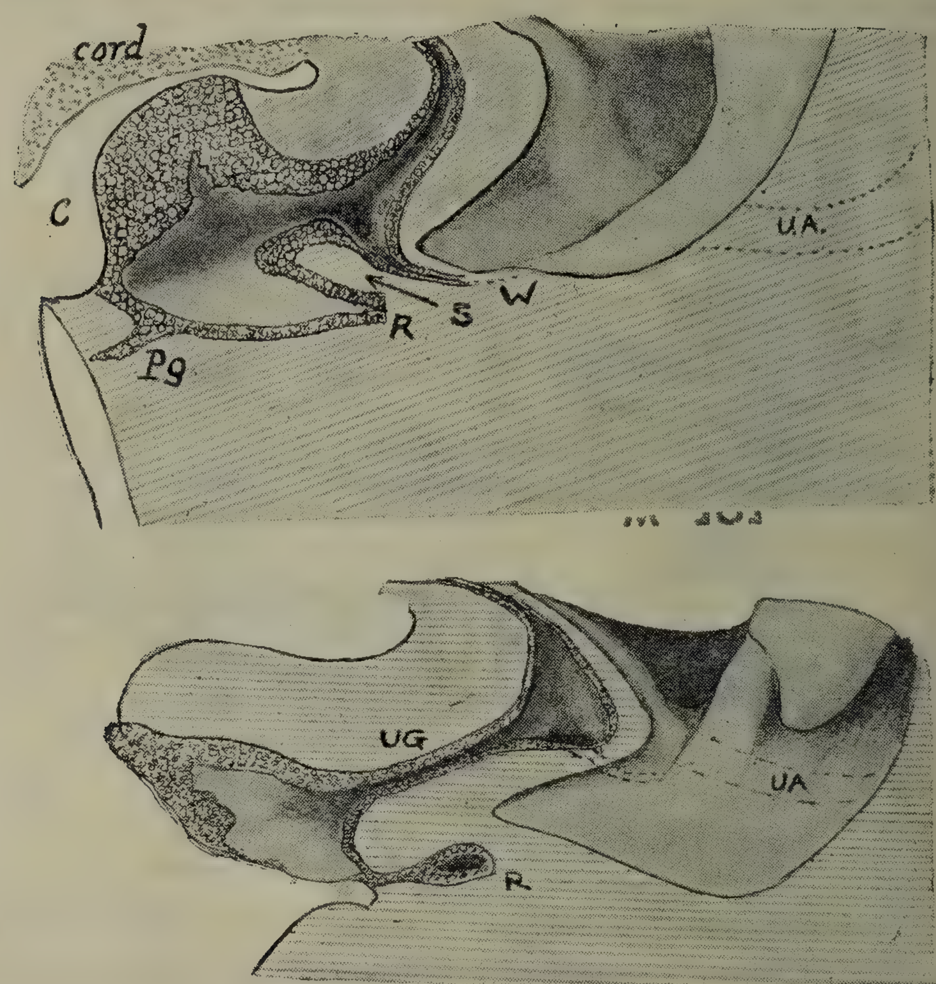


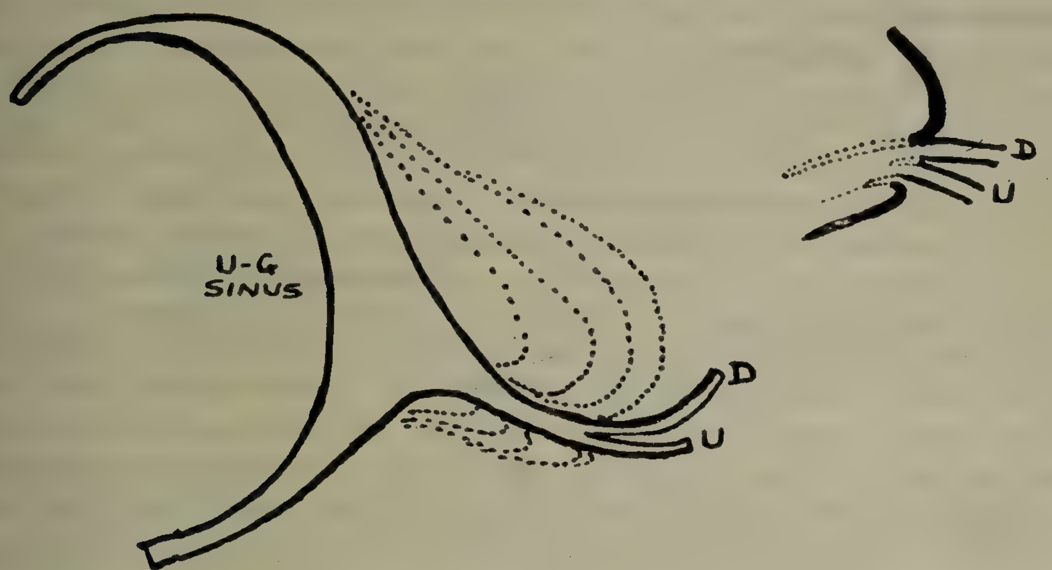
FIG. 556.—ENTODERMAL CLOACÆ OF EMBRYOS OF 8·5 AND 16 MM., SOMEWH SCHEMATIZED.

This part of the uro-genital sinus, in which the openings of the duct are l becomes the **prostatic urethra** or, in women, the whole urethra.

Membranous Urethra.—The membranous portion of the urethra is develop from the *caudal part* of the uro-genital sinus.

Spongy Portion of Urethra.—The **cloaca,** the cavity (p. 45) common to allantoic and intestinal terminations, is shut off from the exterior by the **cloa membrane,** consisting of entoderm and ectoderm, with a certain amount mesodermal cells between these layers. It extends at first *from the tail pro nence to the body-stalk,* and corresponds with the situation of the *primitive stre* later it is more restricted in extent, being separated from the body-stalk mesodermal thickenings which make the *genital eminence* and the *lower part the belly-wall,* and from the tail prominence by a much smaller mesoderm growth which makes the *ano-coccygeal region.* The restricted area of cloa membrane, limited in this way, lies at the bottom of an **external cloacal depress**

fossa, or **ectodermal cloaca;** this is the cavity included between the external sodermal growths already mentioned. The internal or entodermal cloaca livided into rectal and uro-genital compartments in the course of the second



. 557.—SCHEMES TO SHOW HOW THE TERMINAL PIECE OF THE MESONEPHRIC (WOLFFIAN) DUCT BECOMES INVAGINATED WITHIN THE BLADDER AS A RESULT OF THE EXPANSION OF THIS STRUCTURE.

expansion finally involves the extreme end of the ureter, so that, when the invaginated parts disappear, the ureter and duct open separately into the cavity of the bladder.

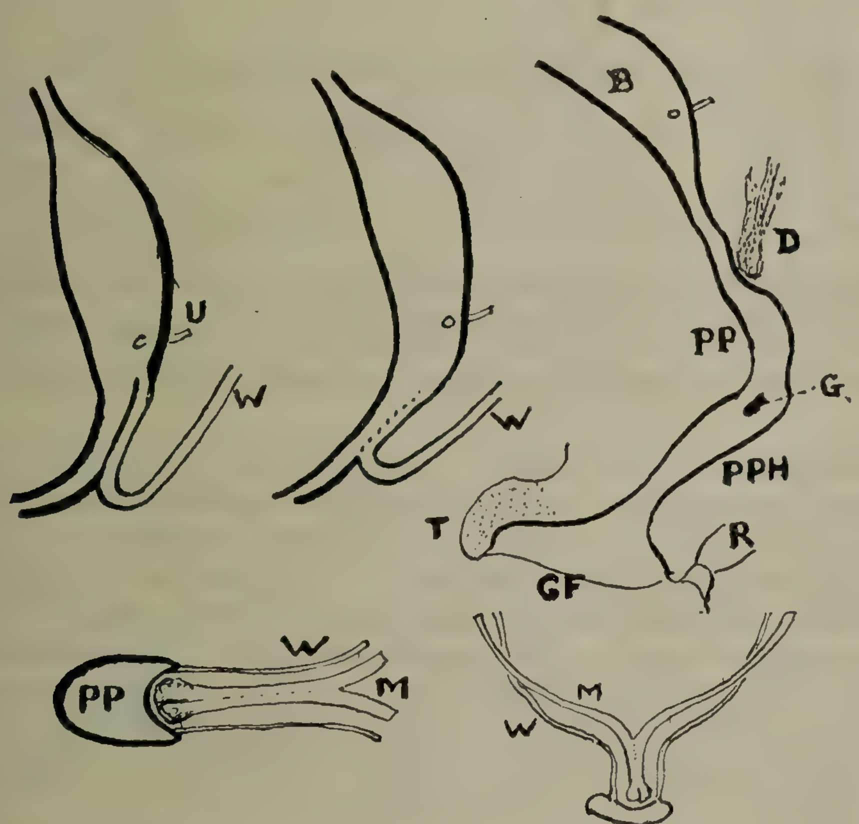


FIG. 558.—DIAGRAMS TO ILLUSTRATE DESCRIPTIONS IN THE TEXT.

first two figures show the way in which the low level of insertion of mesonephric duct is gained. The third shows the curved uro-genital sinus, comprising the *bladder* dilatation (B); a *pars pelvina* (PP), into which the ducts (D) open; and a *pars phallica* (PPH), opening externally and prolonged on to the genital tubercle (T).

th, and as this takes place a corresponding division of the external fossa omes apparent, due to a transverse mesodermal thickening—the **perineal** —coinciding in position with the transversely disposed internal septum

(which has divided the internal cloaca) as this completes its growth. The and outer transverse septa thus become continuous as the division of the is completed.

The part of the cloacal fossa behind the perineal fold forms the **anal de sion** or **proctodæum,** and the portion of the cloacal membrane which for is called the **anal membrane.** When the anal membrane disappears (the third month) the anus becomes formed, and the rectal compartment cloaca now opens into the back part of the cloacal fossa. The uro-genital opens into the cloacal fossa in front of the perineal fold by means of a n vertical cleft, called the **uro-genital cleft.** Leading backwards from the g eminence there is a furrow, which ends at the uro-genital cleft. The g eminence is continuous at the sides with the **labio-scrotal folds,** which, exte backwards, enclose the cloacal fossa and the cloacal membrane. The pos surface of the genital eminence presents a groove, which is continuous wit uro-genital furrow. The lips of this groove, by their subsequent meeting fusion, form a canal, which represents the part of the spongy urethra cont in the glans penis. Posterior to this the lips of the uro-genital furrow together and unite as far back as the uro-genital cleft, and thus convert the part of the cloacal fossa into a canal, which represents the spongy part c

FIG. 559.—FOUR SIMPLE OUTLINES TO SHOW CLOSURE OF URETHRA DEVELOPMENT OF EXTERNAL MALE CHARACTERS.

R, raphe formed by fusion of genital folds (GF).

urethra *behind the glans.* The spongy part is thus to be regarded as a for extension of the uro-genital sinus, which opens at the uro-genital cleft. V the lips of the uro-genital furrow fail to meet and unite at any part, the co tion known as hypospadias is produced, in which the spongy urethra o externally on the under surface of the body of the penis. It is to be n that, whilst the *prostatic* and *membranous portions* of the urethra are devel from the ventral or uro-genital compartment of the entodermal cloaca, the *sp portion* is developed from the anterior part of the ectodermal cloacal fossa, posterior part of that fossa giving rise to the anus and anal canal.

Structure of the Seminal Vesicles.

Each seminal vesicle consists of a tube which is thrown int number of coils, these being held together by fibrous tissue. W these coils are undone, and the tube straightened out, it meas from 5 to 6 inches in length. Its upper end is closed, and along course several diverticula are met. Each seminal vesicle in its nat sacculated condition is surrounded by a sheath, which is derived f the recto-vesical lamina of the visceral portion of the pelvic fas

n this sheath the tube has a fibrous wall composed of delicate is tissue, and within this there is a muscular coat, which is formed ain muscular tissue arranged in two layers—outer longitudinal nner circular. Within the muscular coat is the mucous coat, ı presents a number of reticular ridges with intervening alveoli. us bears a resemblance to honeycomb, in which respect it corre-ls with the mucous membrane of the ampulla of the vas deferens of the gall-bladder, the last named having coarser meshes. The elium which covers the mucous membrane is of the columnar non-ed variety.

ood-supply—Arteries.—These are derived from the inferior vesical, iddle rectal, the descending branch of the artery to the vas, and ntrapelvic portion of the inferior gluteal.

he **veins** are fairly large and numerous, and are disposed in a form manner. They communicate with the prostatic plexus.

ymphatics.—These go to the *internal iliac glands.*

erves.—These are derived from the pelvic plexus.

velopment.—Each seminal vesicle is developed early in the fourth month liverticulum from the posterior or caudal part of the mesonephric duct, which the vas deferens originates. It begins to show dilatations at the e of this month.

Structure of the Ejaculatory Ducts.

he wall of each duct is composed of three layers as follows: an **fibrous layer,** which is very delicate; a middle **muscular layer,** osed of an *outer circular* and *inner longitudinal* stratum; and an **mucous layer,** lined by columnar non-ciliated epithelium.

velopment.—Each duct is developed from the caudal part of the meso-ic duct. The level of its opening is gained as described on p. 956 (Fig. 558).

Structure of the Prostate Gland.

he prostate gland is encased in a strong capsule, which is formed y by the visceral portion of the pelvic fascia, and partly by the tal pelvic fascia, in the following manner: the anterior wall of apsule is formed by the prostatic lamina, and the posterior wall ne recto-prostatic lamina, of the visceral portion of the pelvic a; and on either side the capsule is joined by the corresponding of the superior layer of the perineal membrane (which is formed he parietal pelvic fascia) after it has passed backwards over the rior border of the corresponding levator ani muscle. The capsule material influence in fixing the prostate gland in its position. The ule is formed of concentric layers of fibrous tissue, within and een which lies the prostatic plexus of veins. The substance of the l is composed of two elements—muscular and glandular. The **ular tissue,** which is of the plain variety, is arranged as (1) an nal, partly longitudinal and partly transverse layer, which lies

beneath the fibrous capsule; and (2) an internal circular layer, wl surrounds the prostatic urethra, being continuous above with fibres of the sphincter vesicæ, and below with those around the m branous portion of the urethra. Between these two layers the musc fibres pervade the gland in a decussating manner, so as to constru muscular reticulum, the meshes of which contain the glandular tis The chief part of the gland in front of the urethra is compose muscular tissue. The **glandular element** consists of branched tub alveoli or acini, the walls of which are formed by a basement memb covered internally by columnar epithelium. The tubular alveoli into the prostatic ducts, the structure of which is similar to that o gland-tubes. The ducts average twenty in number, ten on either and they open by independent orifices upon the posterior wall of prostatic portion of the urethra, for the most part into the prost sinus on either side of the crest. The outer portion of the gl consists mainly of muscular tissue, and has received the name of *cc* to distinguish it from the inner glandular portion—the *medulla.*

Blood-supply—Arteries.—These are derived from the inferior ves the middle rectal, and the intrapelvic portion of the inferior glute

The **veins** form a copious **prostatic plexus,** which is most plen over the anterior and lateral surfaces. It receives in front the d vein of the penis in two divisions, and discharges its blood by on more veins into the internal iliac vein. The prostatic plexus is li to become much enlarged in old age.

Lymphatics.—These pass to the *external iliac, internal iliac, sa* and *common iliac glands.*

Nerves.—These are derived from the pelvic sympathetic plexu

Development.—The glandular part of the prostate is developed from epithelium of the uro-genital sinus. The epithelial cells in the course o third month send out ramifying branches, which are at first solid, but s quently become tubular, and so form the glandular part. The outgro arise above and below the entrance of the mesonephric ducts, and from the of the urethra, and a small inconstant group may arise from its front The muscular tissue develops during the fourth month from the surrou mesoderm.

Structure of the Rectum.

The wall of the **rectum** is composed of five coats—serous, fas muscular, submucous, and mucous.

The **serous coat** is formed by the peritoneum, and, as has stated, is imperfect.

The **fascial coat** represents a sheath which is derived from visceral pelvic fascia. In front of the rectum it is composed of recto-vesical and recto-prostatic laminæ, whilst posteriorly it is for by the rectal lamina of that fascia. It is best marked over the l third of the rectum, where the peritoneum is absent. Elsewhere comparatively thin, and over the peritoneal area it merges into subperitoneal areolar tissue.

The **muscular coat** is well developed, and is composed of p

cular tissue, arranged as an external longitudinal and internal ılar layer. The *longitudinal layer* is present all round the gut, attains its greatest development along the anterior and posterior s, where it forms two broad stout laminæ. Along the sides it is ewhat sparse. The *circular fibres* form a continuous covering for rectum, and inferiorly they become increased in amount around anal canal, and so give rise to the *sphincter ani internus.*

Γhe **submucous coat** is composed of areolar tissue, and connects muscular and mucous coats in a very loose manner, so that the er is thrown into a number of temporary folds in the empty con- on of the gut. The internal hæmorrhoidal plexus of veins is edded in this coat.

Γhe **mucous coat** is characterized by great thickness and vascularity. ealth, therefore, it has a reddish colour, and is capable of free move- t upon the muscular coat. The mucous membrane is covered by mnar epithelium, and is provided with crypts of Lieberkühn and phoid nodules. It is thrown into a number of folds in the empty e, but the majority of these are temporary, and become effaced n the gut is distended. There are, however, at least three permanent s, which constitute the *horizontal folds* of rectum. The mucous ıbrane is also studded over with a number of minute tubular de- ssions, called *rectal pits,* which are surrounded at their deep ends by phoid tissue (Birmingham).

Γhe **horizontal folds of rectum** (**Houston's valves**) are *horizontal* ldings of the wall of the rectum in certain situations. Each fold is centic or semilunar, and consists of (1) the rectal mucous membrane, the submucous areolar tissue, and (3) a variable amount of the *ular* muscular fibres. The folds are very variable both in number position, but are usually described as three in number. The most stant and best-developed **fold** is situated on the right wall about ches from the anus on a level with the body of the fifth sacral vertebra the bottom of the recto-vesical pouch of peritoneum. It is there- related to the fundus of the bladder. This fold is sometimes referred ıs the *plica transversalis recti,* and is occasionally annular. The al muscular fibres (circular) which it contains constitute the so- ed *sphincter ani tertius,* or *sphincter of Nélaton.* The other folds much less definite, and are usually found one about an inch above the other about the same distance below the fold just described.

The horizontal folds are probably sustentacular in function, serving support the rectal contents. They may give rise to obstruction ing the introduction of instruments.

Structure of the Anal Canal.

The wall of the anal canal is composed of three coats—muscular, mucous, and mucous. The **muscular coat** is composed of plain scular tissue, arranged as an external longitudinal and internal ular layer. The *longitudinal fibres* are continuous with those of the

rectum, and blending with them there are fibres of the levator Inferiorly they pass between the internal and external sphincter be attached to the skin round the anus. Associated with the longitudinal fibres on the posterior wall of the anal canal there are minute muscles (sometimes united into one), called the *recto-coc muscles*. These spring from the front of the coccyx and descend the posterior wall, where they blend with the longitudinal fibres.

There is nothing specially noteworthy in the submucous coat.

The **mucous coat** presents the anal columns and the anal va The **anal columns (Morgagni)** are six or more in number, and the form of permanent vertical folds, which are confined to the u two-thirds of the anal canal, where they are separated from each by longitudinal grooves. They composed of inflections of the mu membrane, which contain plain cular tissue belonging to the muscu mucosæ and small bloodvessels. stop short about $\frac{1}{2}$ inch above the The **anal valves** are situated at lower ends of the anal columns a $\frac{1}{2}$ inch above the anus. They l the lower ends of the longitu grooves, where they extend bet adjacent columns, and they be resemblance to the valves which met with in veins. They are semil folds of the mucous membrane, free margins being directed upw and above each valve there is a s recess or 'sinus.' The anal valves sinuses are best seen in the child, tend to disappear as age adva The mucous membrane of the canal is replaced in the lower t (below the anal valves) by modified and finally for the last few lines by ac skin with sebaceous glands and hair follicles; this skin in the neg pigmented like the skin covering the body, and terminates by joi the modified skin along a fine wavy line. In white races the junc is known as the **white line of Hilton.** In the upper two-thirds of canal the mucous membrane is lined by *columnar epithelium*, and in upper third it is provided with a few intestinal glands and lymp nodules. The wall of the lower third of the anal canal is lined epithelium, which gradually becomes more and more stratified as anal orifice is approached, and which is continuous at the anal ma with the epidermis. It is at the margins of the anal valves where modified epidermic epithelium gives place to the columnar epithel of the mucous membrane, and here also the modified skin of the lo

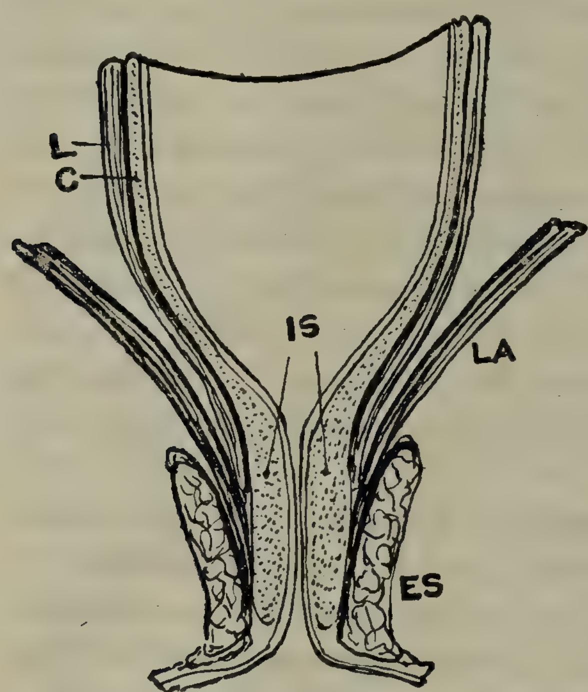


FIG. 560.—DIAGRAM OF STRUCTURE OF RECTUM AND ANAL CANAL.

L, C, longitudinal and circular fibres of wall : the circular fibres thicken below to form the internal sphincter (IS); ES, external sphincter; LA, levator ani.

l of the canal becomes continuous with the mucous membrane of ıpper two-thirds.

phincter Ani Internus.—This so-called muscle is merely a thicken- ıf the *circular* plain muscular fibres of the gut. It is confined to the ɔn of the anal canal, and viewing it as an independent muscle, or er thickening of muscular tissue, it begins very near the upper end ıe anal canal, and terminates about ½ inch above the anus. Though liary to the external sphincter, the principal action of the internal ncter is to expel the contents of the anal canal.

lood-supply of the Rectum and Anal Canal—Arteries.—The rectum and anal l receive their arterial supply from (1) the superior rectal, which is a single l; (2) the middle rectals, right and left; (3) the inferior rectals, right and left; (4) branches from the median sacral and inferior gluteal arteries.

he **superior rectal artery (superior hæmorrhoidal artery)** is of large size, and e direct continuation of the inferior mesenteric. Having crossed the left non iliac vessels, it descends within the root of the pelvic meso-colon as ıs the third sacral vertebra, where the rectum commences. Here it divides two branches, right and left, which descend upon the sides of the rectum. ı each of these divisions six or more branches are given off, which pierce ıuscular coat of the rectum about half-way down, and so enter the submucous in which they descend to lie ultimately within the anal columns. As these inal branches descend they give off twigs, which, by anastomosing with ches of the middle and inferior rectals, give rise to an arterial anastomotic ork in the submucous coat. The disposition of the two primary divisions e superior rectal artery on the sides of the rectum is to be borne in mind in ɔerformance of operations in this region.

t is important to bear in mind that while there is a free anastomosis between ower left colic arteries in the pelvic meso-colon, the anastomosis between the st branch of the lower left colic and the superior rectal is more restricted. ıses, therefore, where it is desirable in the course of an operation to render ɔelvic colon more mobile by cutting through its mesentery, care should be n not to interfere with this low anastomosis, but instead to divide and tie ɔr other of the upper branches of the lower left colic arteries.

'he **middle rectal arteries (middle hæmorrhoidal arteries)** are two in number, t and left, and are branches of the anterior divisions of the internal iliacs, ı arising in common with the inferior vesicals. Having reached the sides ıe rectum about its middle, they divide into branches, some of which supply muscular wall, whilst others enter the submucous coat to take part, along the superior and inferior rectals, in the anastomotic network.

'he **inferior rectal arteries (inferior hæmorrhoidal arteries)** are two in number, t and left, and each may be a single artery, or there may be two or three on side. In any case, they are branches of the internal pudendal, immediately : that vessel has taken up its position in the pudendal canal on the outer wall ıe ischio-rectal fossa. Having pierced the wall of the pudendal canal, and ersed the fat of the ischio-rectal fossa, they approach the wall of the anal ıl, where they break up into branches, some of which supply the muscular , including the external sphincter and adjacent fibres of the levator ani, st others pass into the submucous coat, where they take part, along with the ɛrior and middle rectals, in the anastomotic network already referred to. middle and inferior hæmorrhoidal arteries of one side anastomose with : fellows of the opposite side.

'he rectum also receives twigs from the median sacral and inferior gluteal ries.

/eins.—The veins, all of which are destitute of valves, form two rich plexuses ternal rectal, situated in the submucous coat; and external rectal, lying g the exterior of the rectum, both being confined to its lower third. The

internal rectal plexus, situated in the submucous coat, receives its radicles a set of vessels, termed *anal veins,* which commence beneath the skin of the a These anal veins ascend in the wall of the anal canal, some of them lying w the anal columns, and are reinforced by other veins from the anal wall. Ha given rise by their communications to the internal rectal plexus over the l third of the rectum, the blood is conveyed away from the plexus in two cha as follows: (1) the veins from the upper part of the plexus pierce the wall o rectum, and open into the external rectal plexus; and (2) the veins from lower part of the plexus pass through the external sphincter to end in a pl on the outer surface of that muscle, in which the inferior rectal veins origi The **external rectal plexus** is situated on the outer wall of the rectum ove lower third, and is continuous below with the plexus on the outer surface o external sphincter. It is from this external rectal plexus that the rectal v which correspond with the rectal arteries, arise. The **superior rectal vein (sup hæmorrhoidal vein)** leaves the plexus in two divisions, right and left, w ultimately join to form one vessel, the *inferior mesenteric vein.* It is there an indirect tributary of the vena portal vein. The **middle rectal veins (mi hæmorrhoidal veins),** right and left, terminate in the *internal iliac veins.* **inferior rectal veins (inferior hæmorrhoidal veins),** right and left, pass to *internal pudic veins.* Through means of the external rectal plexus a free c munication is established between the systemic and portal venous channels, there being no valves, when the portal circulation is obstructed the condi known as hæmorrhoids frequently results.

Lymphatic Vessels of Rectum, Anal Canal, and Anus—(1) **Rectum** The lymphatics of the rectum can be divided into two groups, an up and a lower; the upper accompany the superior rectal vessels, after passing through small *pararectal glands,* which to the numbe four to seven lie directly on the muscular coat of the rectum underne its fascial covering, enter the glands in the pelvic meso-colon; the lo accompany the middle rectal vessels, and pass to a gland situated r the origin of the middle rectal artery.

(2) **Anal Canal.**—The lymphatics of the anal canal mainly acc pany the inferior rectal vessels, coursing therefore below the leva ani, and draining into one of the internal iliac glands near the or of the internal pudendal artery; certain of them, however, upwards in the anal columns and join the lymphatics from rectum.

(3) **Anus.**—The lymphatic vessels of the anus pass to the superfi inguinal glands.

Nerves.—These are partly sympathetic and partly spinal. superior rectal artery conducts to the rectum and anal canal superior hæmorrhoidal sympathetic plexus, which is an offshoot f the inferior mesenteric plexus, that in turn coming from the ao plexus. The middle rectal arteries conduct the middle hæmorrho sympathetic plexuses, which are offshoots from the pelvic plexu The spinal fibres are derived from the third and fourth sacral ne (sometimes also the second), and they belong to the pelvic splanchn They are further derived from the upper two or three lumbar ner all in the manner described in connection with the innervation of bladder. The fibres from the *pelvic splanchnics* carry motor impu to the longitudinal muscular fibres of the rectum and inhibitory pulses to the circular fibres; whilst the *sympathetic fibres* are moto

ards the circular fibres, and inhibitory as regards the longitudinal res. The anal canal, close to the external sphincter, receives twigs m the inferior hæmorrhoidal branch of the pudendal nerve.

Development of the Rectum, Anal Canal, and Anus.

In man the cloaca becomes partitioned off into *two tubular compartments* by ld, called the cloacal or **uro-rectal septum.** The two compartments or canals dorsal and ventral respectively. The *dorsal canal* gives rise to (1) the rectum, l (2) the upper two-thirds of the anal canal, or the part above the anal valves. e *ventral canal* leads caudalwards from the opening of the allantoic diverticulum, l is called the **uro-genital sinus** or **canal.** The allantoic diverticulum and uro-genital ducts open into it.

The recto-anal and uro-genital canals are directed towards the cloacal mem-ne, which closes both of them ventrally and caudalwards. The uro-rectal tum is connected inferiorly with the cloacal membrane, and this membrane livided into two parts—namely, dorsal or *anal*, known as the **anal membrane,** l ventral or *uro-genital.*

The anal and uro-genital parts of the cloacal membrane are separated extern-y by a transverse fold, known as the **perineal fold.** This fold undergoes con-erable thickening, and gives rise to the *perineal body.*

The **anal membrane** is soon sunk below the surface, producing thereby the **l depression** or **proctodæum.** The depression consists of *invaginated ectoderm* ich meets the *intestinal entoderm,* and the two layers construct the **anal mem-ne,** or anal part of the cloacal membrane. The condition of matters may be npared to the invagination of ectoderm, which forms the primitive oral cavity stomodæum, and which, meeting with the entoderm of the pharyngeal part the fore-gut, forms the bucco-pharyngeal membrane.

The rupture of the anal part of the cloacal membrane gives rise to an aperture led the **anus,** through which the hind-gut and proctodæum become continuous. e lower one-third of the anal canal—that is to say, the limited portion *below* anal valves—is formed by the ectoderm of the anal fossa or proctodæum. e time of disappearance of the anal membrane varies somewhat, but seems to usually in the third month.

In some cases the anal membrane—namely, that part of the cloacal mem-ne which separates the hind-gut from the anal fossa or proctodæum—is sistent. Such a condition is known as *atresia ani* or **imperforate anus.**

The uro-genital part of the cloacal membrane becomes depressed, and so es rise to the *uro-genital fossa.* When this part of the membrane ruptures, **uro-genital opening** or **cleft** is formed, by which the uro-genital compartment the cloaca—namely, the uro-genital sinus or canal—communicates with the terior.

THE FEMALE PELVIS.

The female pelvis contains the pelvic colon and rectum, with a few ils of the small intestine; the bladder and urethra; the uterus and gina; and the uterine appendages connected with the broad liga-ents—namely, the uterine tubes, the ovaries, with the epoöphoron d paroöphoron (the latter in early life); and the ligamenta teres of the erus. The arteries are the same as in the male, with the addition of rtions of the ovarian arteries and the uterine arteries, and the sub-tution of the vaginal arteries for the inferior vesical arteries in the ale. The venous plexuses are rectal, vesical, pudendal, ovarian, erine, and vaginal. The nerve-plexuses peculiar to the female are e uterine, ovarian, and vaginal.

General Position of the Viscera.—The pelvic colon and rectum situated as in the male pelvis. The bladder lies anteriorly, b situated immediately behind the bodies of the pubic bones, and urethra is very closely related to the anterior wall of the vagina. virgin uterus lies upon the superior surface of the bladder, and the br ligaments extend from either side of it to the lateral wall of the pe The vagina leads from the lower end of the uterus, and in its outv course lies between the base of the bladder and the rectum.

Peritoneum.—The peritoneum is related to the pelvic colon rectum as in the male. On leaving the rectum at a point fully 3 in above the anus it passes to the posterior wall of the vagina, whic covers for about its upper fourth. It then mounts upwards over posterior surface of the supravaginal portion of the cervix uteri and

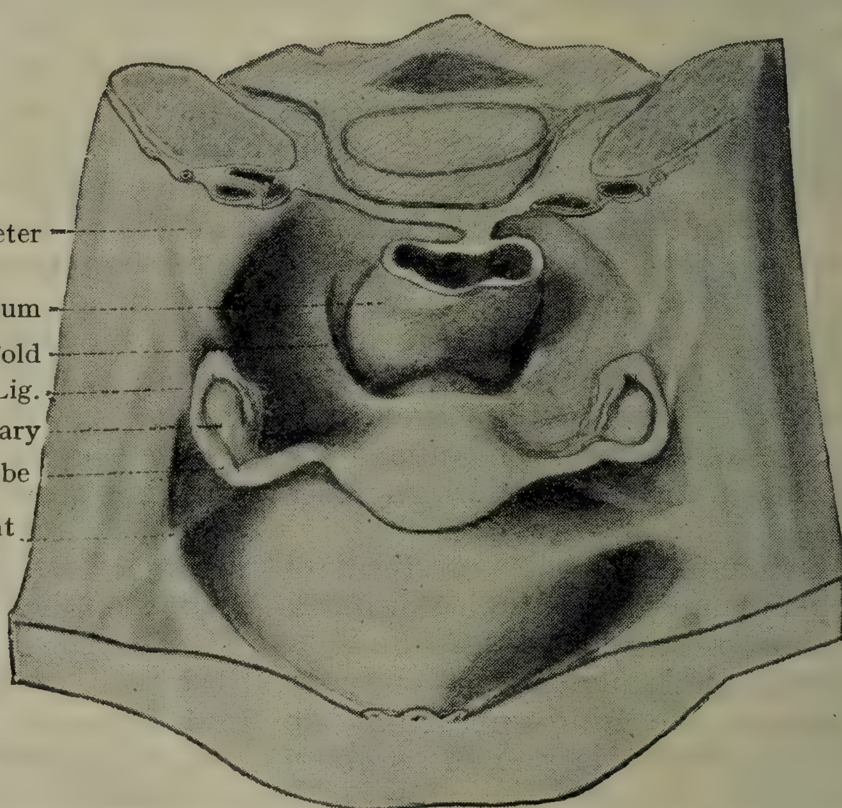


FIG. 561.—FEMALE PELVIC VISCERA SEEN FROM ABOVE.

body of the uterus. On reaching the fundus it turns round to anterior surface, which it invests as low as the junction of the b and cervix. On leaving the viscus it passes to the upper part of the l of the bladder, whence it extends forwards over the superior surf which it covers as far as the apex. Its later course is as in the m Along each lateral border of the bladder the peritoneum is refle on to the lateral wall of the pelvis. Along either side of the uteru is reflected on to the lateral wall of the pelvis, and in this manner broad ligaments are formed. Between the rectum and the upper tion of the posterior wall of the vagina and supravaginal portion of cervix uteri the peritoneum forms a recess, called the **recto-uterine po (pouch of Douglas)**, which corresponds to the recto-vesical pouch in male. The mouth of this pouch is bounded on either side by a semilu peritoneal fold, which extends from the front of the sacrum over the

the rectum to the cervix uteri. These folds are known as the **recto-**
rine folds (folds of Douglas). Each fold contains a collection of fibrous
l plain muscular tissues, connected on the one hand with the fibrous
uctures in front of the lower part of the sacrum, and on the other
h the cervix uteri. They become continuous with each other over
back of the isthmus uteri (junction of body and cervix), and there
y give rise to a transverse ridge, called the **torus uterinus.** The
to-uterine pouch is bounded in front by the upper part of the posterior

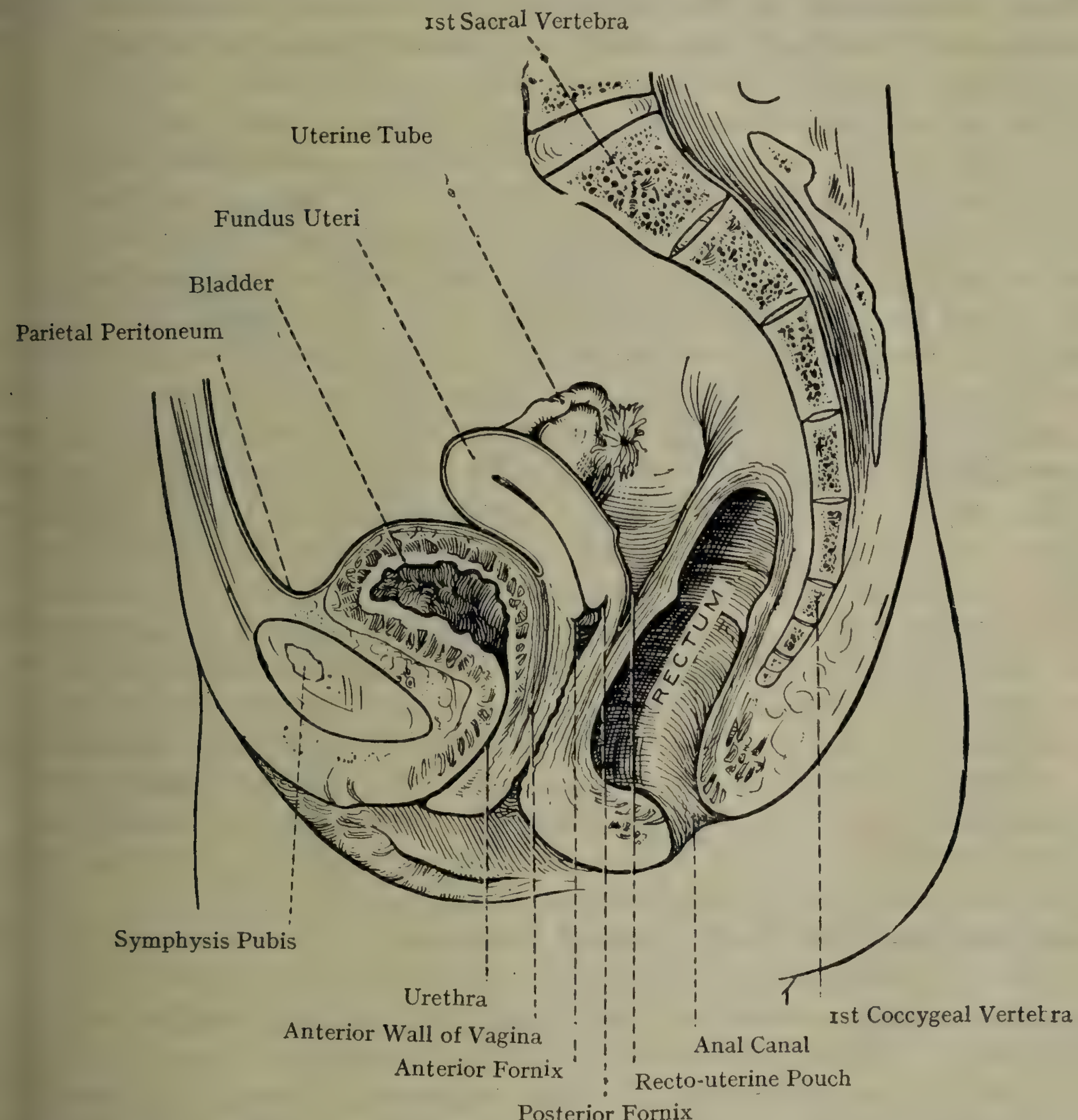


FIG. 562.—VERTICAL SAGITTAL SECTION OF THE FEMALE PELVIS.

ll of the vagina and the supravaginal portion of the cervix uteri, and
hind by the rectum. In front of the uterus the peritoneum gives
e to a small recess, called the **vesico-uterine pouch,** the entrance to
hich is bounded laterally by two folds, called the **vesico-uterine folds.**
s regards the bladder, the peritoneum forms for it false ligaments as
the male—namely, one superior, two lateral, and two posterior.
he latter are simply the vesico-uterine folds, and may be regarded not
ly as posterior ligaments of the bladder, but also as anterior ligaments
the uterus.

Pelvic Fascia.—The parietal pelvic fascia in the female is sim to the corresponding fascia in the male. The visceral pelvic fas however, is complicated by the interpolation of the vagina. On eit side of the pelvic viscera it divides into four laminæ as follows: *vesi* which forms on either side the lateral pubo-prostatic ligament of bladder; *vesico-vaginal,* which passes between the bladder and vagina; *recto-vaginal,* which passes between the vagina and the rectu and *rectal,* which passes over the sides and posterior wall of the rectu

Broad Ligaments of the Uterus.—These are also called the *vespertilionis,* from their supposed resemblance to a bat's wings. Ea is an extensive fold of peritoneum composed of two layers, anterior a posterior, which pass between the side of the uterus and the late wall of the pelvis. The broad ligament has associated with it following important structures: (1) the uterine tube or oviduct, wh lies within the superior border of the ligament; (2) the ovary and ligament, which lie within a backward extension of the posterior la of the broad ligament at a lower level than the uterine tube; (3) ligamentum teres of the uterus, which lies within a forward project of the anterior layer of the broad ligament, also at a lower level th the uterine tube; (4) the epoöphoron, which lies within the ligam between the ovary and the uterine tube; and (5) the paroöphoron early life), which also lies within the ligament, medial to the epoöpho and near the uterus. The double fold of peritoneum attaching anterior border of the ovary over its whole length to the back of broad ligament forms a short mesentery for it, called the **mesovariu** which contains between its two layers the bloodvessels and nerves the ovary. The portion of the broad ligament which lies between uterine tube and the ovary with its ligament is called the **meso-salpi** It is somewhat falciform, and is narrow medially but broad lateral It is bounded above by the uterine tube, below by the ovary and ligament, medially by the uterus, and laterally by the ovarian fimb and the suspensory ligament of the ovary.

Ligamentum Tere Uteri (Round Ligament).—This is a narrow, f band, about 5 inches long, which is attached to the upper part of side of the uterus in front of, and a little below, the medial end of uterine tube. It is composed of fibrous connective tissue, which ne the uterus has an admixture of plain muscular fibres continuous w those of the uterus. It lies within the anterior layer of the bro ligament, where it gives rise to a slight prominence. Its direction outwards, upwards, and forwards over the obliterated umbilical arte and pelvic brim to the deep inguinal ring, close to which it hooks rou the outer side of the inferior epigastric artery, and crosses the exter iliac vessels from within outwards. Escaping by the deep inguin ring, it traverses the inguinal canal, and, emerging through the sup ficial inguinal ring, ends in the subcutaneous tissue of the labium maj For a short distance after entering the inguinal canal it is covered by process of the peritoneum, which represents the processus vaginalis the male fœtus. This process is at first tubular, and receives the na

the **vestige of processus vaginalis (canal of Nuck).** It is usually, vever, obliterated in the adult, though it may remain pervious, ler which circumstances the condition known as hydrocele of the mentum teres may occur. A few muscular fibres may be found in it of the ligamentum teres in the inguinal canal, which are conious with the lower fibres of the internal oblique, and represent the master in the male.

The ligamentum teres is supplied by two arteries as follows: the mentous branch of the ovarian artery, which supplies it as far as inguinal canal; and the ligamentous branch of the inferior epigastric,

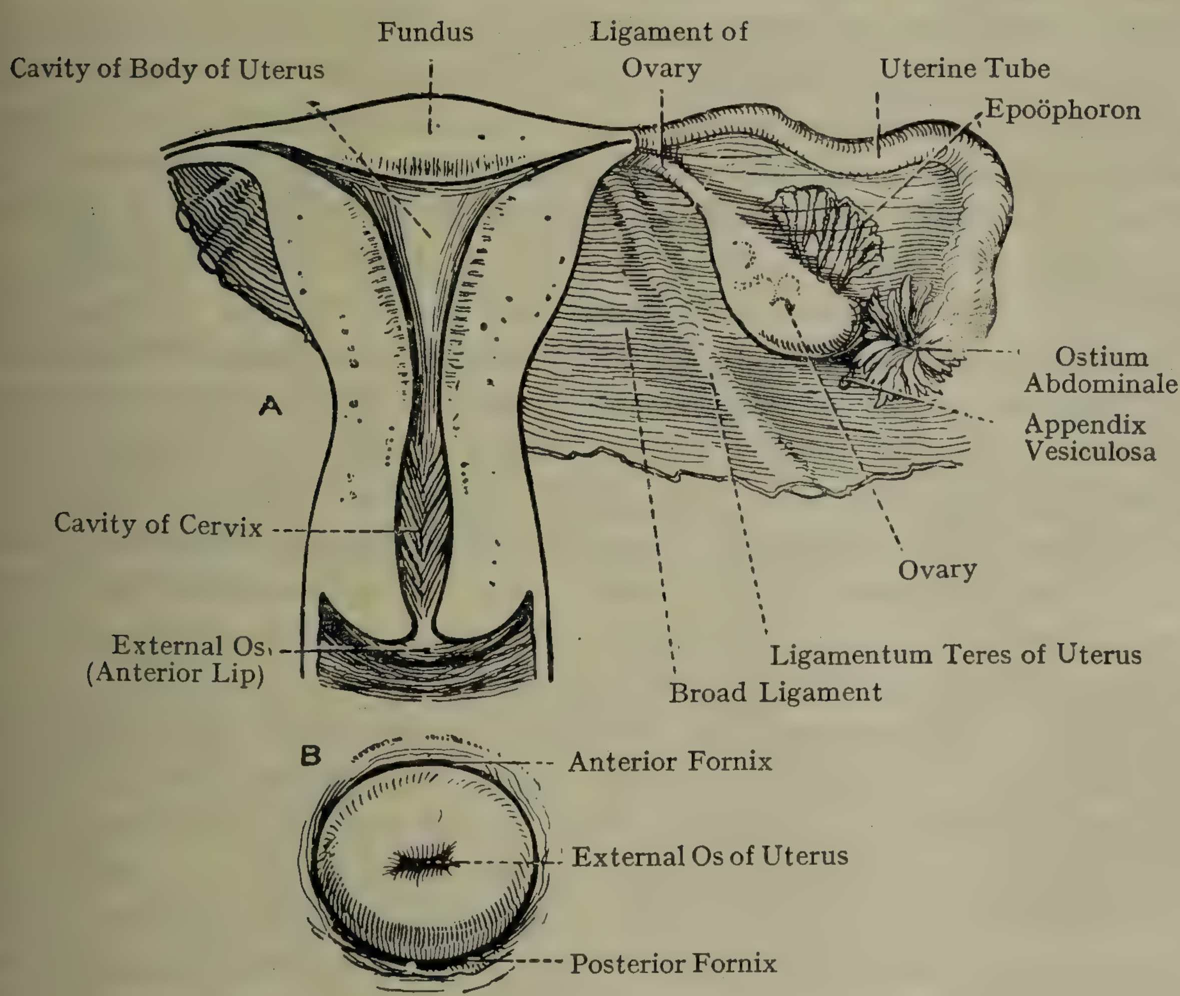


FIG. 563.—THE UTERUS AND ITS APPENDAGES.

A, the uterus opened, and the right broad ligament (posterior view); B, the os uteri externum.

ich supplies it beyond the deep inguinal ring, and corresponds to cremasteric artery in the male. The principal venous blood is urned by a ligamentous vein, which is a tributary of the ovarian xus.

The ligamentum teres uteri represents the gubernaculum testis in male.

Ovaries.—The ovaries are two small flattened bodies, each of which within a backward extension of the posterior layer of the broad ment, with which it is connected by the mesovarium. The ovary aterally compressed, and usually lies with its long axis almost vertical, inclining a little downwards and backwards, against the lateral

wall of the pelvis in a peritoneal depression called the *ovarian fo* It may, however, lie obliquely, and may even be shifted near to uterus. In size it may be likened to the half of a small walnut average length being from 1 inch to $1\frac{1}{2}$ inches, its breadth about $\frac{3}{4}$ i and its thickness (from side to side) from $\frac{1}{4}$ to $\frac{1}{2}$ inch. Its ave weight is about 2 drachms. It presents two surfaces, two borders, two extremities.

The **surfaces** are laterally disposed, and are called *medial*, rel to the uterine tube, and *lateral*, related to the ovarian fossa. **borders** are anterior and posterior. The *anterior* or *mesovarian bo* is straight. Along it are attached the two layers of the mesovar and between these it presents a hilum for the passage of the bl vessels, nerves, and lymphatics. The *posterior* or *free border* is con and lies in close relation to the ureter. The extremities are na **ends (poles)**, superior and inferior respectively. The *superior* is na the *tubal end*, because the ovarian fimbria is attached to it or nea Connected with it there is also a fold of peritoneum, which pa upwards to join the peritoneum over the psoas major near the u part of the external iliac vessels. This fold, which is termed the *pensory ligament of the ovary*, or the ovario-pelvic ligament, is tinuous with the outer part of the broad ligament, and contains ovarian vessels and nerves. The *inferior end* is known as the *ute end*, and is connected with the superior angle of the uterus by a ro cord, called the *ligament of the ovary*, or the ovario-uterine ligam The attachment of this ligament to the uterus is behind and a l below the medial end of the uterine tube.

The surface of the ovary is covered by modified peritoneum, tinuous with the mesovarium, the only exception being along anterior border, where the hilum exists. The connective-tissue elen of this peritoneum is inseparably blended with the so-called tu albuginea of the ovary, and it is covered by an epithelium the cell which present a striking contrast to those of the endothelial cove elsewhere. It is composed of *short columnar cells*, and imparts a so what dull appearance to the surface, which contrasts with the polis appearance elsewhere. The ovarian epithelium is the remains of germinal epithelium, from which the ovary is developed, and at circumference of the organ it passes abruptly into the endothelial of the adjacent peritoneum. Prior to puberty the surface of the ov is smooth, but after that period it gradually assumes a pitted scarred appearance, which is due to the periodical escape of the from the vesicular ovarian follicles.

Descent of the Ovary.—The ovary, like the testis, originally lies in the lun region of the body-cavity by the side of the vertebral column. At this pe the inguinal fold, as stated, extends from the caudal end of the ovary to inguinal region, where it traverses the inguinal canal, and terminates within labium majus. As the ligament descends it becomes connected, as stated, the para-mesonephric duct at the level where this duct fuses with its fello form the uterus; the portion above the point of fusion becomes the ligamen the ovary, the portion below the ligamentum teres. About the *third mont*

a-uterine life the ovary begins to descend towards the brim of the pelvis. ing arrived at the pelvic brim, it remains there for some time, and is still hat level at the period of birth. At a later period it descends into the pelvic ty as a rule, and assumes its normal position within a backward extension of broad ligament of the uterus.

Two factors are probably concerned in the descent of the ovary—namely, he shortening of that part of the inguinal fold which extends from the ovary he side of the uterus close to the medial end of the uterine tube; and (2) the tion exercised by the fusion of the two para-mesonephric ducts to form the us and vagina.

As each ovary descends, its mesovarium is taken along with it. This meso-um is intimately connected with the uro-genital fold, which contains the onephric and para-mesonephric ducts; and the uro-genital fold in turn is bined with the mesonephric ' mesentery ' or ligament. The vestigial portions he mesonephros in the female are therefore carried down along with the cending ovary, these vestigial portions representing (1) the so-called duct of epoöphoron or duct of Gärtner, (2) the epoöphoron, and (3) the paroöpho- The combined mesovarium, uro-genital fold, and mesonephric ' mesentery ' igament of each side become continuous medianly, and form one continuous et. Within this sheet the uterus is formed by the fusion of the two para-onephric ducts; each lateral part of the sheet constitutes the **broad ligament he uterus.**

Abnormal Positions of the Ovary.—(1) The ovary, in its original descent, y pass into the inguinal canal, and even into the labium majus; (2) it may s through the femoral ring into the femoral canal, and lie over the saphenous ning, where it may simulate a femoral hernia; (3) an ovary, when enlarged, y become prolapsed, and pass downwards and inwards behind the uterus the recto-uterine pouch, where it may be palpated through the posterior nix of the vagina.

For the structure and development of the ovary, see p. 980 *et seq.*

Epoöphoron.—The epoöphoron is situated in that portion of the so-salpinx which lies between the ovary and the uterine tube. It is nposed of a number of small blind tubules, lined with epithelium, ich converge towards the ovary, but do not meet. Their tubal ends united by a longitudinal tube, which lies parallel with and a little ow the uterine tube, the duct of the epoöphoron.

Paroöphoron.—The paroöphoron is situated in that part of the so-salpinx which lies between the ligament of the ovary and the rine tube, where it is placed near the uterus. It is composed of a y minute blind tortuous tubules, which usually become shortly after th invisible to the naked eye.

For the development of the epoöphoron and paroöphoron, see 987.

Uterine Tubes (Fallopian Tubes).—The uterine tubes, right and left, ve to convey the ova, after their escape from the vesicular ovarian licles, into the cavity of the uterus. They are, therefore, functionally ducts of the ovaries, and are hence spoken of as the *oviducts*. Each be is contained within the superior border of the broad ligament, except its extreme inner end, where the tube is embedded in the uterine wall. is fully 4 inches in length. Proceeding from the uterus, it passes at st horizontally outwards for about 1 inch towards the lower or uterine d of the ovary. It then ascends vertically for a short distance upon lateral wall of the pelvis, where it lies medial to the anterior or

attached border of the ovary. Having arrived at the upper or t end, it arches backwards and descends along the posterior convex bo and adjacent portion of the medial surface of the ovary. Each ute tube is divided into the following parts: pars uterina, isthmus, amp neck, and corpus fimbriatum; and each has two openings, ost uterinum and ostium abdominale.

The *pars uterina* is the limited portion which is contained wi the uterine wall at the superior angle, and it presents the *ost uterinum,* which is about 1 millimetre in diameter. The *isth* succeeds to the pars uterina, and represents about one-third of tube. It is straight, round, and firm to the touch, due to the dominance of circular muscular fibres in this portion. Its diam is about $2\frac{1}{2}$ millimetres. The *ampulla* succeeds to the isthmus, forms rather more than half of the tube. It is larger than the isthr less resistant (being chiefly mucous in structure), and tortuous. diameter gradually increases in the distal direction, the average b about 7 millimetres. The ampulla at its outer end becomes constri to form the *neck,* which presents the *ostium abdominale,* opening the pelvic cavity, its diameter being about 2 millimetres. It is in situation where the general cavity of the peritoneum in the fema continuous with the lumen of the uterine tube, and through it with cavity of the uterus and vagina. Beyond the neck the tube expa in the form of a funnel, called the *infundibulum,* near the centr which the ostium abdominale is situated. The circumference of infundibulum is broken up into a number of irregular fringes, ca *fimbriæ,* and the outer end of the tube is hence called the *corpus fimb tum.* The larger fimbriæ are broken up into smaller filiform proce The outer surfaces of the fimbriæ, which look into the pelvic cavity, covered by peritoneum, but the inner surfaces, which look into infundibulum, are covered by mucous membrane continuous with of the uterine tube. At the free margins of the fimbriæ the peritone with its endothelial cells, becomes continuous with the mucous m brane, which is covered by ciliated columnar epithelium. One of fimbriæ, which is larger and longer than the others, is called the *ova fimbria,* and is either directly connected with the upper or tubal of the ovary, or indirectly by means of a delicate fibrous band deri from and continuous with the broad ligament. This fimbria pres a longitudinal furrow, which serves as a channel of communica between the ostium abdominale and the ovary.

For the structure and development of the uterine tubes, see p.

Uterus.—The uterus is a hollow muscular organ, which receive its superior angles the uterine tubes, and opens below through the up part of the anterior wall of the vagina. Through the uterine tube receives the ova at periodical intervals, and when an ovum beco impregnated the uterus retains it during development, and therea expels the fœtus through the vagina. The virgin uterus lies upon superior surface of the bladder, and is usually inclined to the righ the middle line. Above it there are a portion of the pelvic colon

sually a few coils of the ileum. At its lower end is the vagina, and ie broad ligament stretches from either side. It is somewhat pyriform, ie wide end being directed upwards and forwards, and is flattened om before backwards. It is m and resistant to the touch 1 account of its very thick uscular walls. Its average ngth is 3 inches, the breadth the upper part being 2 inches, id the thickness 1 inch. The gan is divided into a fundus, dy, and cervix.

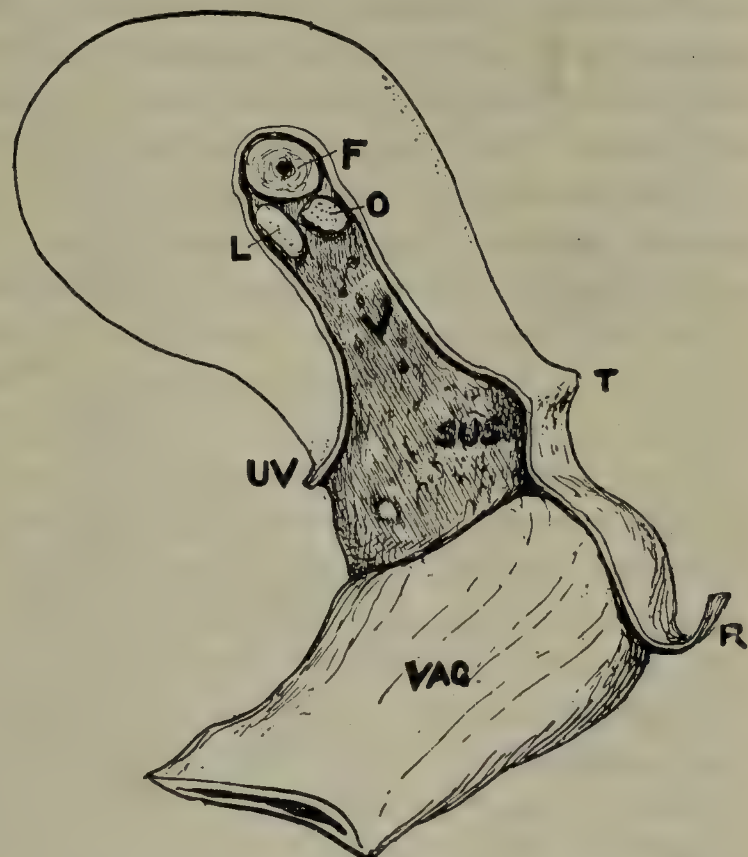


Fig. 564.—Side View of Uterus and Upper Part of Vagina, to show Reflections of Peritoneum.

F, uterine end of tube; O, L, ovarian and round ligament; V, between the reflections of layers of broad ligament, marks region where branches of uterine artery enter the organ; SUS, suspensory ligament (Mackenrodt); UV, utero-vesical fold; R, rectal fold; T, torus uterinus.

The **fundus** is that portion hich lies above the level of a ie connecting the superior igles, where the uterine tubes iss through the uterine wall. is convex from side to side, d also from before backwards. ie lateral borders of the erus are sloped downwards d inwards, and at the junction the upper two-thirds and wer third of the organ there a slight constriction or con-vity, called the *isthmus*, which also present in front and hind, and is most conspicuous early life. The part between e fundus and the isthmus is e body, and the part below e isthmus is the cervix.

The **body,** which is 2 inches long, is triangular and presents two ooth surfaces, anterior and posterior, and two lateral borders. The *terior* or *vesical surface*, which has an inclination downwards, is flat slightly convex. The *posterior* or *rectal surface*, which has an in-ıation upwards, is very markedly convex. This difference in the ıtour of the two surfaces permits of their easy identification. Each *eral border* extends from the superior angle to the isthmus, and sloped downwards and inwards. The *superior angles* are situated the point of entrance of the uterine tubes, and correspond with portions of the uterus which are elongated into cornua in some mals.

The **cervix,** which measures 1 inch in length, is cylindrical, and rower than the body. It is received into the upper part of the erior wall of the vagina, the walls of which are attached to it in h a manner as to divide it into two portions—supravaginal and ravaginal. The posterior wall of the vagina extends higher upon the

cervix behind than the anterior wall does in front. The anter surface of the supravaginal portion, which is about $\frac{1}{2}$ inch in exte is related to the base of the bladder, with the intervention of so loose cellular tissue. The posterior surface of the supravaginal porti which is about $\frac{1}{4}$ inch in extent, forms a part of the anterior wall the recto-uterine pouch, and is crossed transversely by the to uterinus. At the lower end of the intravaginal portion, where cervix is slightly protuberant, there is an opening, called the **exter os of uterus,** through which the cavity of the cervix communica with that of the vagina. This opening is also known as the *os tincæ*, cause it is supposed to resemble the mouth of the tench fish, on acco of its lips being of unequal size. In early life this opening is circu but later, in the virgin, it assumes the form of a transverse slit ab $\frac{1}{12}$ inch long. It is bounded by two lips, anterior and posterior, wh in the virgin are smooth, but in multiparæ they are often more or l fissured, especially the posterior lip. The *anterior lip* is thick, rou and short, whilst the *posterior* is thin, sharp, and long. The anter lip descends lower into the vagina than the posterior, by reason of oblique manner in which the cervix uteri passes into the canal. I the anterior lip which first meets the finger in making vaginal exami tions. The greater length of the posterior lip is due to the fact that posterior wall of the vagina extends higher on the back of the cer than the anterior wall does in front. The external os is directed do wards and backwards, towards the posterior wall of the vagina, t being due to the oblique position of the cervix.

Surrounding the vaginal portion of the cervix there is a vaul recess, which is divided into anterior, posterior, and lateral **forni** In the region of the lateral fornix the ureter is situated $\frac{3}{5}$ inch from cervix.

General Relations of the Uterus.—The anterior surface of the bo rests upon the superior surface of the bladder, and the anterior surf of the supravaginal portion of the cervix is related to the base of bladder. The lateral relations are the uterine tubes, ligamenta te ligaments of the ovaries, broad ligaments, and a certain amount adipose tissue, containing large bloodvessels, which lies upon either s of the cervix, and extends upwards over the lateral border between layers of the broad ligament. This collection is known as the **pa metrium.** The posterior surface of the body is related to the rectu and the posterior surface of the supravaginal portion of the cer forms a part of the anterior boundary of the recto-uterine pouch.

Peritoneal Relations.—The following parts of the uterus are cove by peritoneum: the supravaginal portion of the cervix posterio the posterior surface of the body, the fundus, and the anterior surf of the body as low as the front of the cervix. The following parts free from peritoneal covering: the intravaginal portion of the cerv the supravaginal portion of the cervix anteriorly, and a narrow st along each lateral border where the two layers of peritoneum pass to form the broad ligament. The uterine peritoneal folds are as follo

ɔ utero-vesical, sometimes called the anterior uterine ligaments, but ey may also be regarded as the posterior false ligaments of the bladder; e recto-uterine folds, with the torus uterinus; the ligaments of the ary, the ligamentum teres on each side, and the broad ligaments.

Position of the Uterus.—The virgin uterus occupies a position of eflexion and anteversion, assuming the bladder and rectum to be pty. In speaking of the uterus as being *anteflexed* it is to be under- od that the body of the organ is bent forwards at the isthmus in h a manner that it forms with the cervix an angle which is open eriorly. This is brought about in the following manner: the cervix

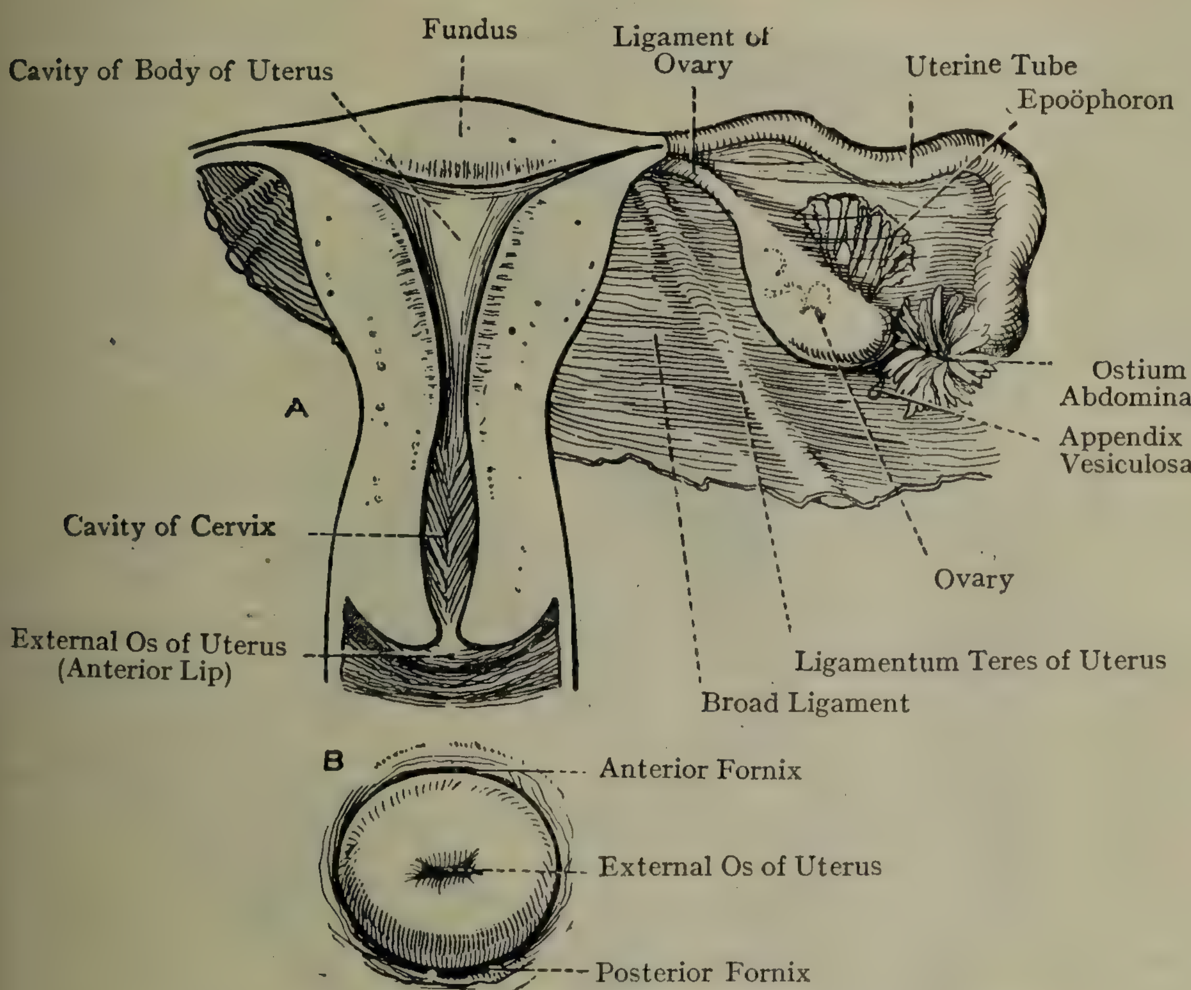


FIG. 565.—THE UTERUS AND ITS APPENDAGES.
A, the uterus opened, and the right broad ligament (posterior view); B, the external os of uterus.

ri is more fixed than the body, from its connection with the vaginal lls and base of the bladder; and the cervix is less yielding than the ly. In speaking of *anteversion* of the uterus it is to be understood ıt the entire uterus is inclined forwards, so that its long axis forms angle with the longitudinal axis of the trunk. The anterior surface s therefore a downward inclination towards the superior surface of e bladder, and the posterior surface has an upward inclination, and supports a portion of the pelvic colon and a few coils of the ileum. ıen the bladder is distended, the position of the uterus becomes ered. The organ is raised along with the distended bladder, the eflexion and anteversion become less, and the uterus may even

assume a vertical position. Any coils of the ileum lying in con
with its posterior surface, as well as the pelvic colon, would be displa
and the organ would come to be closely related to the rectum.

Interior of the Uterus.—The interior is divided into two portior
the cavity of the body and the cervical canal. The *cavity of the l*
is very small compared with the thickness of the uterine walls, an
triangular, with the base directed upwards towards the fundus.
three sides are convex towards the cavity, and its anterior and poste
walls are in contact. In the vicinity of each superior angle it narro
and gradually tapers to the medial end of the uterine tube, with

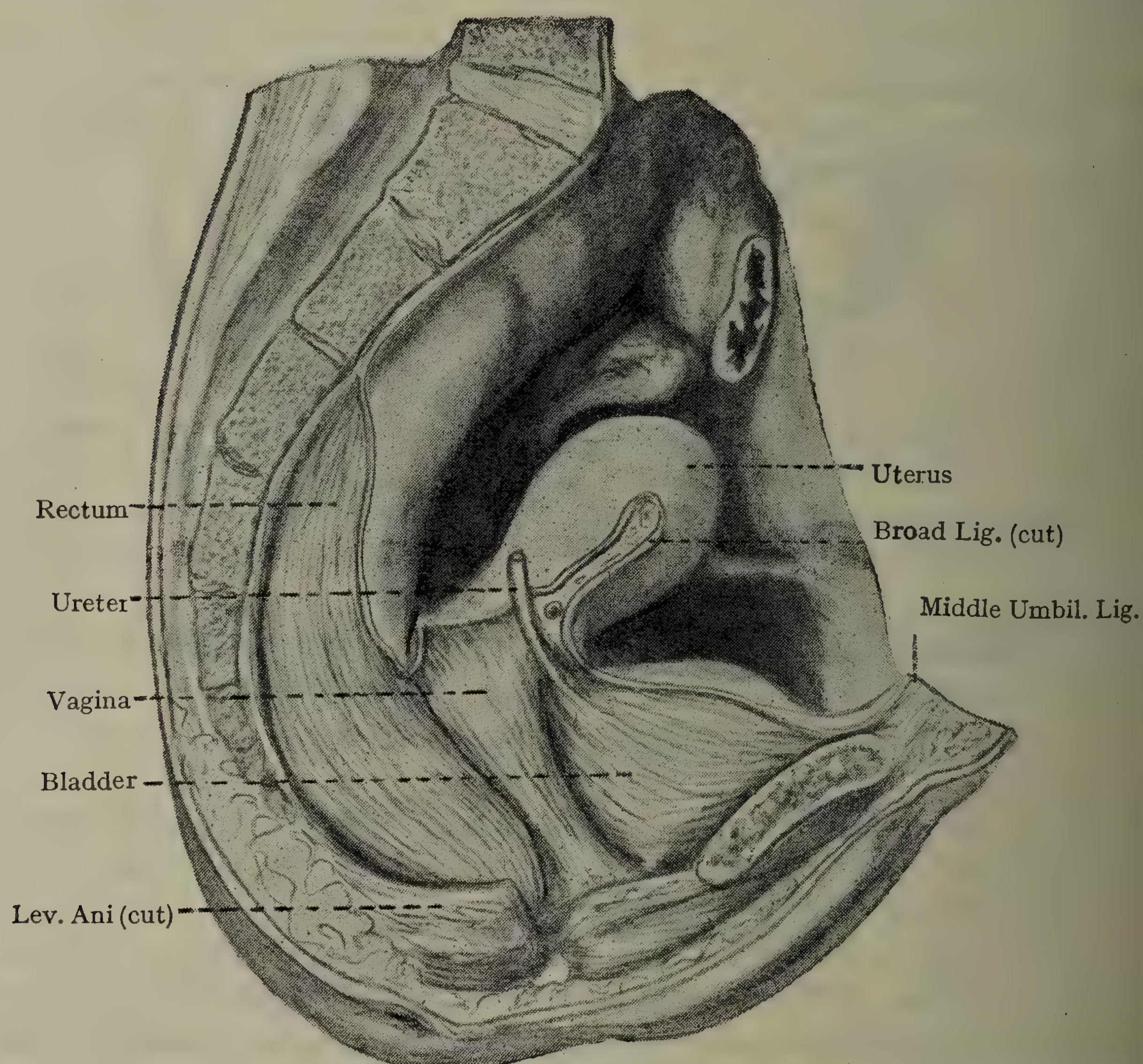


FIG. 566.—BLADDER, VAGINA, AND RECTUM, EXPOSED FROM THE RIGHT,
SHOW PERITONEAL REFLECTIONS AND VISCERAL RELATIONS.

lumen of which it is continuous. Inferiorly the cavity also becor
narrow, and at the junction of the body and cervix it ends in a circu
opening, called the **internal os of uterus,** which is smaller than
external os. Through this opening it becomes continuous with
cavity of the cervix. The *canal of cervix* is spindle-shaped, being wi
at the centre than at either end. It is somewhat flattened from bef
backwards, and is continuous above with the cavity of the bo
through the internal os, and below with the cavity of the vagina throu
the external os. Its mucous membrane presents two longitudi
ridges, anterior and posterior, from each of which a number of ru

ıd in an upward and outward direction, the appearance thus pro-
d being known as the *arbor vitæ.* The length of the cavity of the ıs is $2\frac{1}{2}$ inches, the difference between its length and that of the ıs, as measured externally, being due to the thickness of the fundus to the fact that the external os lies at the centre of a depression.

'terus at Birth.—At birth the neck of the uterus is larger than ɔody, and there is no fundus. At each superior angle it tapers much, and resembles somewhat a uterus bicornis. The arbor extends all along the interior.

arieties.—These are as follows: (1) uterus bicornis; (2) uterus unicornis; 3) double uterus. These variations are due to the partial or complete per- ıce of fœtal conditions.

'or the structure and development of the uterus, see pp. 983 7.

'agina.—This is a musculo-membranous passage which extends ı the cervix uteri to the vulva. It is from 3 to $3\frac{1}{2}$ inches long, g 3 inches along the anterior wall and $3\frac{1}{2}$ inches along the posterior. ; slightly curved, and its direction is downwards and forwards. ıxis forms an obtuse angle with that of the uterus (100° to 110°). ıe erect posture it forms with the horizontal an angle of about 60°. ɛriorly it is closely connected with the cervix uteri, the posterior rising higher than the anterior. It is rather narrower at either than at the centre, the lower end being the narrowest part of the age. The walls are anterior and posterior, and they are in contact. ransverse section the vagina appears as an H-shaped fissure at its r end, as a transverse fissure at the centre, while at its upper end it ents a lumen which is almost circular.

ɩelations—*Anterior.*—The base of the bladder and the urethra. *erior.*—From above downwards there are the recto-vaginal pouch ı short distance, the rectum, with the intervention of the recto- nal lamina of the visceral pelvic fascia, and the anal canal, from ɔh it is separated by the perineal body. The posterior wall is ɛred by peritoneum over about its upper fourth. *Lateral.*—The er at the upper end for a short distance, and the levatores ani cles.

The vagina passes through the perineal membrane, and its lower has a bulb of the vestibule on either side, with the bulbo-spongiosus ounding the external orifice. When the finger is passed into the terior fornix, which is the recess between the posterior lip of the ɛrnal os of uterus and the posterior wall of the vagina, the recto- inal pouch can be palpated and a few coils of the ileum, or a pro- sed ovary, may be felt in it. The base of the bladder may be pal- ed through the anterior fornix, and the urethra through the interior l of the vagina lower down. In the lateral fornices the ureters y be felt.

For the structure and development of the vagina, see p. 986.

Bladder.—The base is directed backwards, and is related to the ıt of the supravaginal portion of the cervix uteri and a portion of the

anterior wall of the vagina, the vesico-uterine pouch of the peritone intervening. The superior surface is in contact with the ante surface of the body of the uterus. The false ligaments formed by peritoneum are at least three in number—namely, one superior two lateral. The peritoneal folds on either side of the vesico-ute pouch are usually regarded as the anterior uterine ligaments, but t may also be looked upon as the posterior false ligaments of the blad The true ligaments are similar in both sexes.

Ureters.—Each ureter lies for a short distance on the side of cervix uteri and upper part of the wall of the vagina, being cros antero-superiorly near the vix from without inwards the uterine artery.

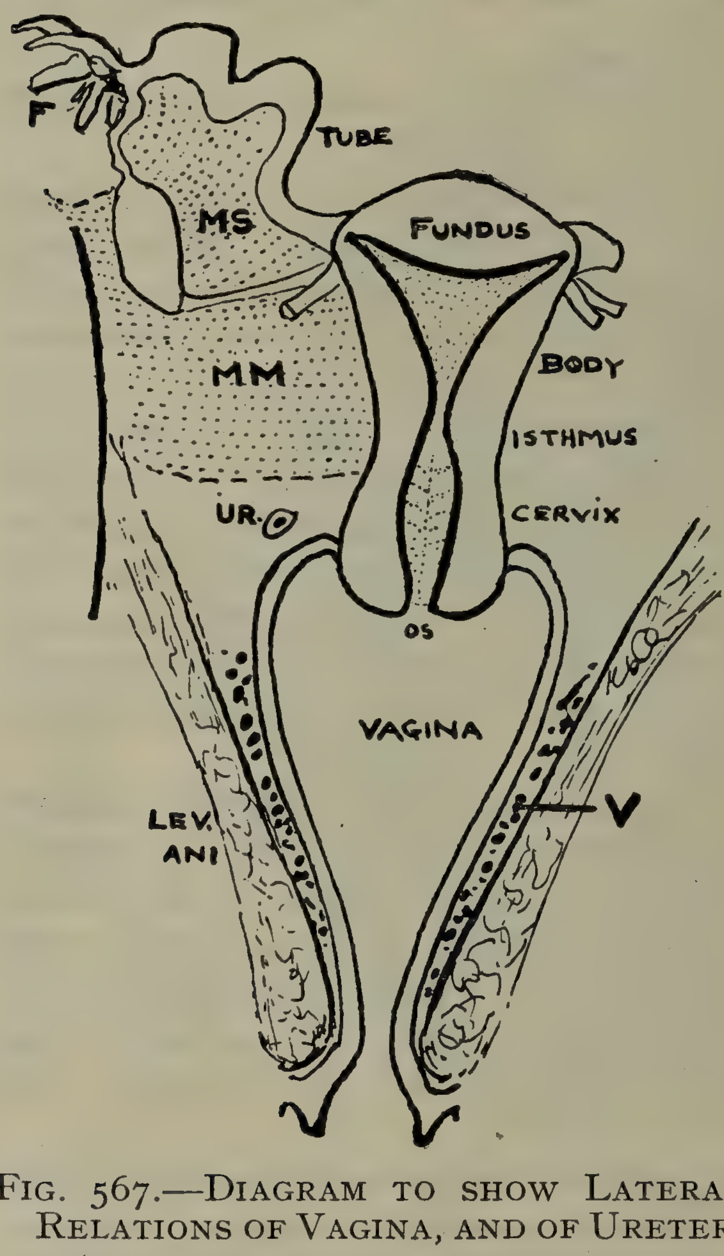


FIG. 567.—DIAGRAM TO SHOW LATERAL RELATIONS OF VAGINA, AND OF URETER, ETC.

Urethra.—The urethra very closely related to the terior wall of the vagina. length is $1\frac{1}{2}$ inches, and transverse diameter is ab $\frac{1}{4}$ inch, the narrowest part be at the external orifice. direction of the canal is do wards and forwards, and walls are anterior and poster these being in contact exc during micturition. In course it passes between two layers of the perineal m brane, where it is embraced the sphincter urethræ mus The canal is capable of c siderable distension, and m under anæsthetics, admit index finger. The *external fice of urethra* is situated in middle line immediately in fr of the external orifice of vagina, and is placed on a sli prominence, the margins which are somewhat irregul

For the structure and development of the urethra, see p. 987.

Rectum—Relations—*Anterior.*—The uterus and vagina, the rec vaginal pouch intervening for a short distance in the vicinity of cervix uteri. *Posterior.*—As in the male.

Anal Canal.—This is separated from the vagina by the perin body.

Ovarian Artery in the Pelvis.—This vessel, which arises from abdominal aorta about 1 inch below the renal artery, enters the pe by crossing the commencement of the external iliac. It then pa

in the broad ligament of the uterus, where it is very tortuous, and ranches to the ovary enter that organ through the hilum on the rior border without piercing the peritoneum. Besides supplying ovary, the vessel furnishes the following branches: *uterine* to the us, near the superior angle, where it anastomoses with branches of uterine artery from the internal iliac; *tubal* to the uterine tube; and *nentous* to the ligamentum teres of the uterus, which it accompanies ir as the inguinal canal.

The **ovarian vein** of each side originates as two vessels in the **ovarian ampiniform plexus,** which lies within the broad ligament. This us receives the veins which emerge through the hilum of the ovary,

FIG. 568.—THE OVARIAN, UTERINE, AND VAGINAL ARTERIES (POSTERIOR VIEW) (AFTER HYRTL).

vell as tributaries from the uterine tube and the ligamentum teres he uterus, and it communicates freely with the uterine plexus. two ovarian veins, having emerged from the ovarian plexus, leave pelvis, and soon join to form a single vein, that of the *right* side ning into the inferior vena cava, and that of the *left* side into the renal vein.

Uterine Artery.—This vessel is derived from the anterior division he internal iliac artery. It is directed downwards and inwards to side of the cervix uteri, near which it crosses the ureter. On reaching the cervix it turns upwards along the lateral border of the body in ery tortuous manner, lying between the two layers of the broad

ligament. As it descends it gives off tortuous branches to the front a
back of the body, and near the inner end of the uterine tube it anas
moses freely with the uterine branch of the ovarian artery. Along
side of the body it also gives offsets to the ligamentum teres ut
ligament of the ovary, and uterine tube. At the cervix the uter
artery furnishes two branches—cervical and vaginal. The *cervi*
branch supplies offsets to the cervix. One of these, called the *coron*
artery, divides into two branches, which with their fellows of the
posite side form an arterial circle around the cervix. The *vagi*
branch divides into two, anterior and posterior, which descend in
middle line of the anterior and posterior walls of the vagina, where th
anastomose with branches of the vaginal arteries.

The **uterine veins,** which are destitute of valves, form a copi
plexus within the broad ligament close to the uterus, where it is e
bedded in the parametrium. The blood from the lower part of t
plexus is conveyed away by two uterine veins, which are tributaries
the internal iliac vein. A large proportion of the blood, howev
passes from the upper part of the plexus into the ovarian plexus. T
uterine plexus communicates below with the vaginal plexus.

Vaginal Artery.—This vessel, which usually replaces the infe
vesical of the male, arises from the anterior division of the inter
iliac, occasionally in common with the uterine or the middle rec
artery. It passes downwards and inwards to the wall of the vagi
where it divides into branches which anastomose with their fello
of the opposite side, the vaginal branches of the uterine arteries, a
towards the lower end of the vagina with branches of the inter
pudendal. Along the anterior and posterior walls, in the median li
an arterial chain is constructed by the vaginal arteries and the vagi
branches of the uterine arteries, thus forming the vessels known as
azygos arteries of the vagina. The vaginal artery also furnishes branc
to the bladder, rectum, and bulb of the vestibule.

The veins of the vagina form a rich plexus in the muscular co
which is more copious towards the lower end. They communic
above with the uterine plexus, in front with the pudendal ple
around the urethra, behind with the rectal plexus, and below with
veins of the bulb of the vestibule. The **vaginal vein** leaves the up
part of the vaginal plexus and opens into the internal iliac vein.

THE STRUCTURE OF THE SPECIAL VISCERA OF THE FEMALE PEL

The Ovaries.

The ovary is covered by a layer of short columnar epithelial ce
These are the remains of the germinal epithelium from which
organ is developed, and they rest upon a delicate connective-tis
membrane, which is blended with the so-called tunica albugin
Interposed between the columnar cells there are a few spheroidal c
of larger size, which are primordial ova. The connective-tissue m

e is continuous with the peritoneum, which forms the mesovarium
g the margins of the hilum, and is covered by endothelium. Within
membrane, and blended with it, there is a continuous covering,
isting of fibrous connective tissue, which is called the *tunica albu-*
a, from its supposed resemblance to the tunica albuginea of the
s. It is, however, really a condensation of the ovarian stroma at
surface. This stroma pervades the interior of the ovary, and is
posed of fibrous connective tissue, which is richly provided with
dle-shaped cells and elastic tissue. There are also a few plain
cular fibres in the deeper part of the ovary close to the hilum. The
dle-shaped cells are regarded by some authorities as muscular fibre-
, but they probably belong to the connective tissue of the stroma.
stroma is freely permeated by bloodvessels, and contains the
cular ovarian follicles. Immediately within the surface there is a

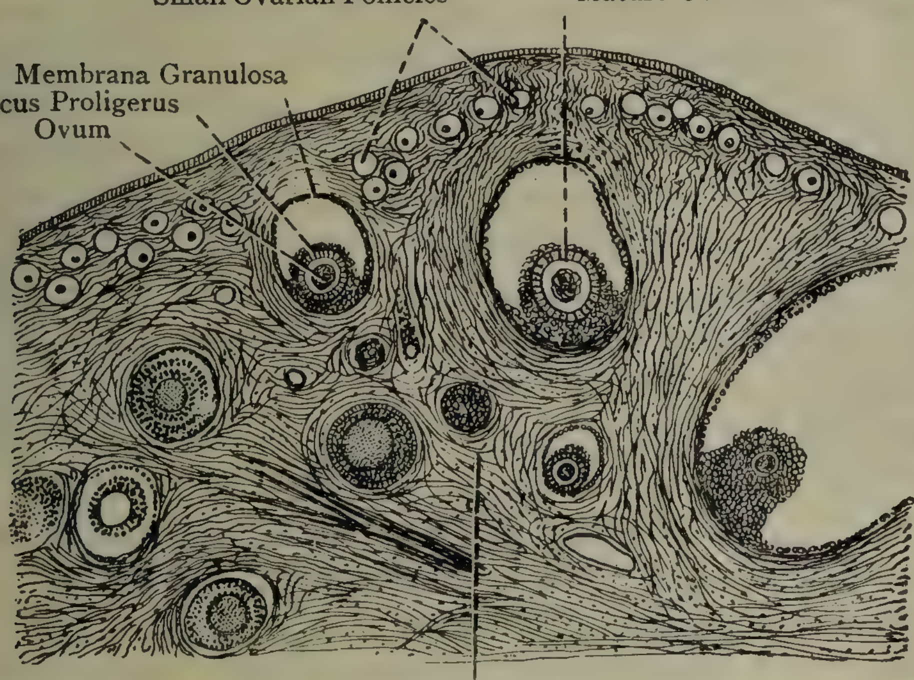


FIG. 569.—SECTION OF THE OVARY, SHOWING ITS MINUTE STRUCTURE.

r of the stroma which presents a granular appearance, especially in
ng persons, due to the presence of an immense number of ovarian
cles, with their contained ova, in an early stage. This part of the
ry is called the *cortex*, the remainder being known as the *medulla*.
ng more deeply in the stroma there is another set of ovarian follicles,
numerous but of larger size, these being in a more advanced stage.
more deeply there is another and less numerous set of follicles, of
larger size, which are almost in a state of maturity. When these
er have attained full development they pass towards the surface,
re they may sometimes be seen as clear follicles causing slight pro-
ions. When fully developed, they attain a diameter of about
nch. At periodical intervals one or more of these mature follicles
ture, this being accompanied by the discharge of a fluid—the liquor
culi—and the simultaneous escape of the contained ovum or ova.
er the discharge of its contents the follicle becomes filled with blood

and cellular tissue, and assumes a yellow colour. It is then known a *corpus luteum*. This undergoes atrophy in the virgin, and, assumi a white colour, is known as a *corpus albicans*.

Structure of the Vesicular Ovarian Follicles (Graafian Follicles). The smallest follicles near the surface, which are about $\frac{1}{100}$ inch diameter, consist of a single investing layer of flattened cells clos embracing the contained ovum. It is computed that the ovaries o child at birth contain as many as 70,000 of these follicles. In follic a little more advanced the investing epithelium becomes column and is arranged in two layers—outer and inner, the latter surroundi the ovum. In more mature follicles fluid, called the *liquor follic* accumulates between the outer and inner cellular layers, except at t point where the ovum lies. The outer layer is then known as t **membrana granulosa,** and the inner as the **discus proligerus.** The ce of these two layers became continuous at the part where the liqu folliculi is absent, so that in this manner the ovum is anchored to o point of the wall of the follicle. In the most mature follicles the liqu folliculi has increased in amount, and the cells of the membrana gran losa and discus proligerus have multiplied so as to form several stra Each of these follicles has a distinct wall, called the *theca folliculi*, wh is formed by a condensation of the surrounding stroma, and in wh two layers can be recognized—an outer fibrous and an inner vascul There is usually only one ovum in each follicle.

For structure of the ovum, see p. 14.

Blood-supply of the Ovary.—The ovary receives its blood from t ovarian artery.

Nerves.—These come from the ovarian sympathetic plexus, wh derives its fibres from the renal and aortic plexuses, and accompan the ovarian artery.

Lymphatics.—The lymphatic vessels of the ovary accompany t ovarian bloodvessels, and terminate in the *juxta-aortic glands* on eit side. They are joined by most of the lymphatics of the body of t uterus and by those of the uterine tube.

The ovaries represent the testes in the male, and they have b called the *testes muliebres*.

Ligament of the Ovary.—This is composed of plain muscular a fibrous tissues, the former being continuous with the muscular tis of the uterus. It derives its blood-supply from the ovarian art and represents the upper part of the gubernaculum testis in the m fœtus.

Structure of the Uterine Tubes.

The wall of the **uterine tube** is composed of four coats—ser muscular, submucous, and mucous. The **serous coat** is formed the peritoneum. The **muscular coat** is composed of plain muscu tissue arranged as an *outer longitudinal* and *inner circular layer*, latter being the thicker. The **submucous coat** is areolar in structu The **mucous coat** is continuous with that of the uterus on the one ha

with the peritoneum on the other at the margins of the fimbriæ. s thrown into longitudinal folds, which are simple in the isthmus, complex in the ampulla, where they are beset with secondary folds, communicate in such a manner as to give rise to alveolar spaces, s imparting an almost glandular appearance to the coat. In transse section the tube presents a branched lumen, which is nearly filled the leaf-like processes formed by the mucous folds. The mucous nbrane is covered by ciliated columnar epithelium, which, at the margins of the fimbriæ, passes into the endothelium of the perieum.

Blood-supply.—The ovarian and uterine arteries.

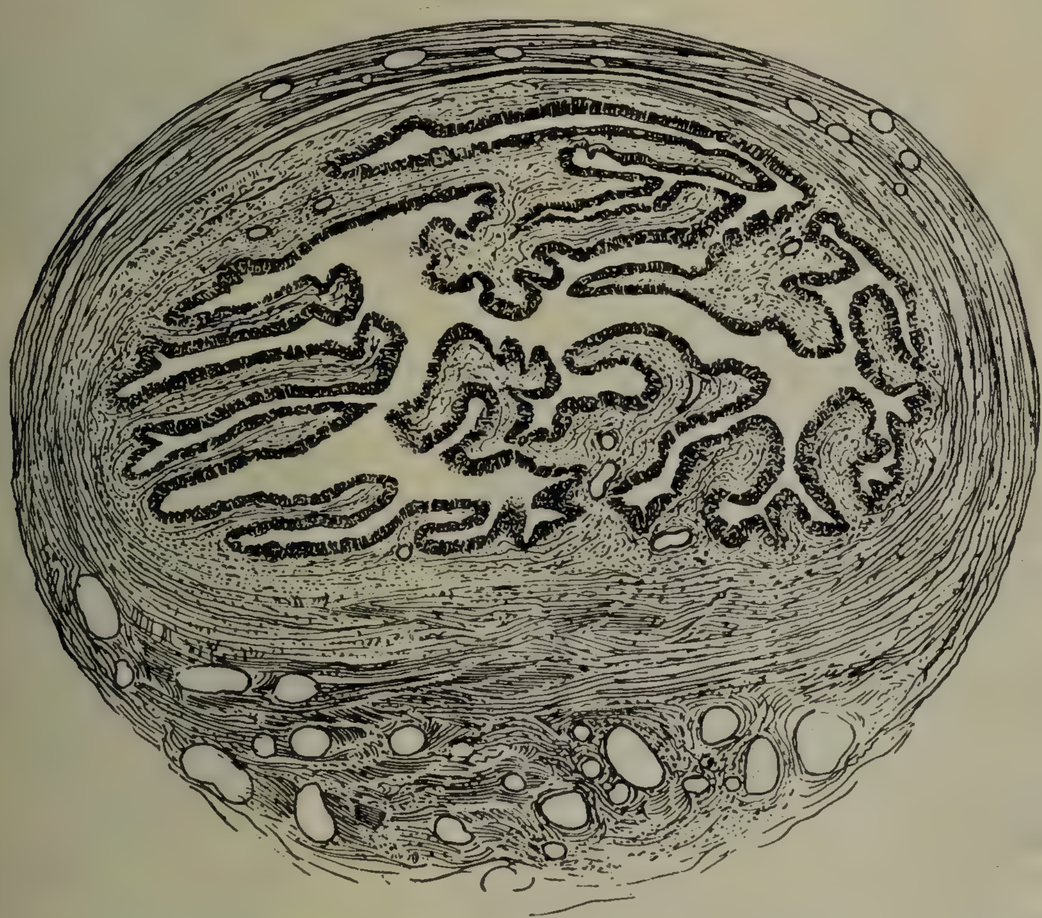


FIG. 570.—TRANSVERSE SECTION OF THE UTERINE TUBE (MAGNIFIED).

Nerves.—These are derived from the ovarian and uterine sympaetic plexuses.

Lymphatics.—These pass to the *median lumbar glands* along with ose of the ovary and upper part of the body of the uterus.

Structure of the Uterus.

The wall of the uterus consists of three coats—serous, muscular, d mucous—there being no submucous coat.

The **serous coat** is formed by the peritoneum, already described.

The **muscular coat** is composed of plain muscular tissue, with an mixture of areolar tissue, and it imparts great thickness to the wall. e muscular tissue is disposed in three strata—outer, middle, and ner. The *outer stratum* is thin, and its fibres are disposed longitudinally

over the front and back of the organ, becoming continuous with o
another by turning over the fundus. Those nearest the lateral bord
incline outwards, and are prolonged into the ligamenta teres, uter
tubes, and ligaments of the ovaries. Some from the back of the sup
vaginal portion of the cervix are prolonged into the recto-uterine fol
The *middle stratum* is very thick, and is composed of fibres which int
lace in a complex manner over the body, but in the neck they a
arranged circularly. The bloodvessels and nerves are freely int
spersed throughout this layer. The *inner stratum*, which is also ve

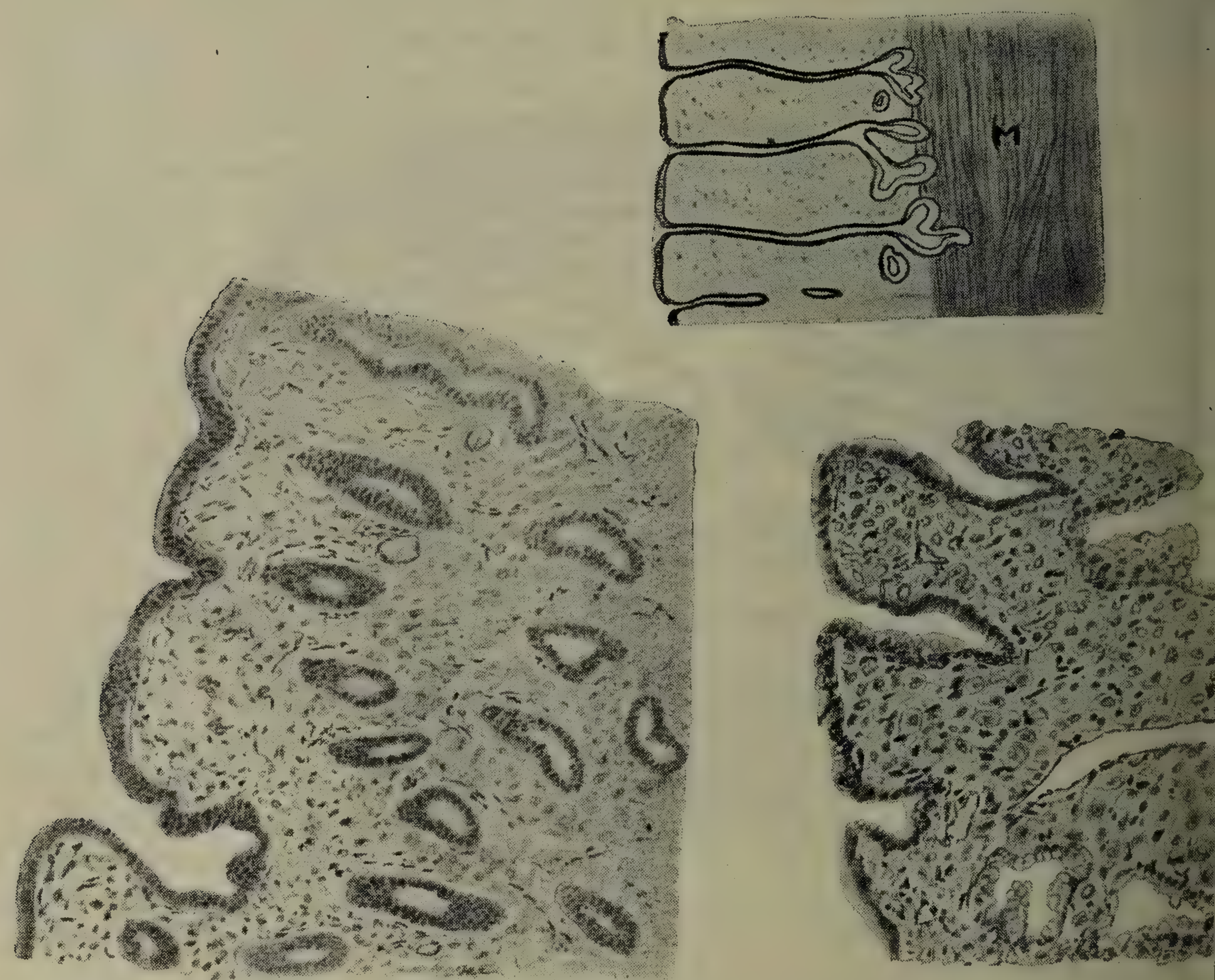


FIG. 571.—UPPER FIGURE, DIAGRAM TO SHOW COMPOSITION OF UTERINE WA
M, muscular wall. The lower sections show on the left a piece of premenstr
mucosa; on the right one from an early pregnancy. The stroma-cells a
enlarging, and in the last specimen are very evident as decidual cells.

thick, has its fibres disposed longitudinally in the cervix. As th
ascend over the body they become oblique, and at the superior ang
they run circularly. The uterine glands project into this stratu
and it contains a free admixture of areolar tissue. It is right to menti
that the inner stratum is regarded as a very much thickened muscula
mucosæ, according to which view it would form a part of the muco
coat (Williams).

The **mucous membrane** of the *cavity of the body* is smooth, and so
in consistence, and is covered by ciliated columnar epithelium. It

t with a number of openings, which are the mouths of the **uterine** **tricular glands.** These are simple tubular glands, which extend somewhat convoluted manner through the entire thickness of the ous coat, and project by their deep blind ends into the inner cular stratum, there being no submucous coat. Each gland is posed of a basement membrane, which is lined with ciliated mnar epithelium, continuous with that of the cavity of the body. h has a distinct lumen, except at its deep end, where it is filled ı cells. The mucous membrane of the *canal of cervix* is of firmer sistence than that of the cavity of the body, and, as has been stated, resents the appearance known as the arbor vitæ. It is provided ı papillæ, and is covered *olumnar epithelium*, except : the os externum, where epithelium is of the *strati- squamous* variety, like that ering the intravaginal por- of the cervix and lining vagina. On the summits he rugæ the columnar cells ciliated, but in the furrows ween them they are devoid cilia. The mucous mem- ne is freely provided with **emose glands,** which in the er part of the cervix are d with columnar cells, and he lower part with cubical s. In both regions the s are non-ciliated. The nds in the lower part of cervix have each a large en, and they secrete a very acious mucus during preg- ıcy, which in the later ges of that period plugs the external os of uterus.

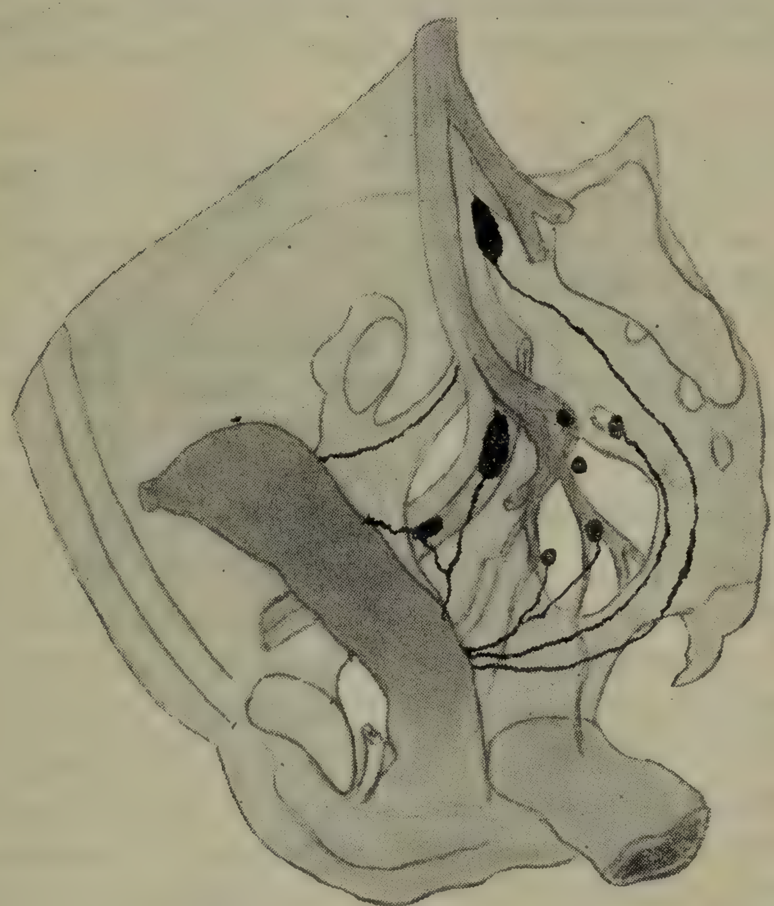


Fig. 572.—Scheme of the Lymphatic Drainage of the Uterus (after Cunéo et Marcille).

In addition to these glands clear vesicles of a yellowish colour, called **ovula Nabothi,** may be seen in the mucous membrane between the æ of the arbor vitæ, which are supposed to result from the blockage some of the racemose glands.

Blood-supply.—The uterus is supplied with blood by the uterine eries, and the uterine branches of the ovarian arteries.

Nerves.—The chief nerves are derived from the uterine sympa- tic plexus, which is an offshoot from the pelvic plexus, and accom- nies the uterine artery. It is to be noted that the pelvic plexus ntains spinal fibres derived from the third and fourth sacral nerves metimes also the second), and from the upper two or three lumbar rves, as in the case of the bladder and rectum. The uterus also

receives sympathetic fibres from the ovarian plexus, which is deri
from the renal and aortic plexuses.

Lymphatics—Cervix Uteri.—The lymphatic vessels of the ce have a threefold destination—namely, (1) the *middle chain* of *external iliac glands*, (2) the *internal iliac glands*, and (3) the *inner gr* of the *common iliac glands.*

Body.—(1) Most of the lymphatics of the body of the uterus the lymphatics of the ovary, and pass to the *juxta-aortic glands.* (2 few lymphatics pass to the *middle chain* of the *external iliac gla* (3) Some lymphatics accompany the ligamentum teres of the ute and terminate in the *superficial inguinal glands.*

The lymphatics of the cervix communicate freely with those the body and with those of the upper part of the vagina.

Structure of the Vagina.

The wall of the vagina is composed of three coats—fibrous, m cular, and mucous.

The **fibrous coat** is composed of dense connective tissue.

The **muscular coat** consists of plain muscular tissue arranged an *outer longitudinal* and *inner circular layer,* both being closely c nected. Embedded in this coat there is a network of anastomos veins, representing erectile tissue, which is well developed round lower part of the passage. The plain muscular coat is replaced at external orifice by the striated bulbo-spongiosus muscle.

The **mucous membrane** is covered by stratified squamous epitheli and is provided with papillæ. In the upper part of the passage it c tains mucous glands. Along the middle line of the anterior and poste walls it presents a ridge, these ridges being called the **columns** of vagina, or *columnæ rugarum.* Passing off from them at right an there are, in the virgin, numerous transverse rugæ, these appearan being well marked in the lower part of the passage and absent in upper part.

Blood-supply.—The vagina is supplied with blood by the vagi arteries, the vaginal branches of the uterine arteries, and branches the internal pudendal arteries.

Nerves.—These are derived from the vaginal sympathetic ple of each side, which is an offshoot from the pelvic plexus.

Lymphatics.—The lymphatic vessels are disposed in two set superior and inferior. The *superior lymphatics* come from about upper two-thirds of the vagina, and they pass to (1) the *middle ch* of the *external iliac glands,* and (2) the *internal iliac glands* on eit side. The *inferior lymphatics* come from about the lower third, include those from the vaginal surface of the hymen; they pass the *inner group* of the *common iliac glands.* The lymphatics fr the perineal surface of the hymen pass to the *superficial ingu glands.*

The superior and inferior vaginal lymphatics communicate fr

one another; the superior lymphatics communicate with those ıe cervix uteri, and the inferior set communicate with those of the a.

Development of the Uterine Tubes, Uterus, and Vagina.

he uterine tubes, uterus, and vagina are developed from the para-mesonephric , as described on pp. 101 and 102.

he two para-mesonephric ducts have been seen to meet and fuse into a single in the **transverse pelvic ridge** of mesoderm, the single tube passing to the l wall of the uro-genital sinus and lying in the central thickened part of the verse ridge, which is termed the **genital cord.** The fused tubes within ord make the *mucous lining of the uterus and vagina,* the thick mesoderm e cord forming the *walls of these parts*; the lateral portions of the trans- ridge become the central parts of the *broad ligament* on each side of the ıs.

he transverse ridge is continuous on each side with the mesonephric ridge, ıs, in fact, to be considered as made by the continuation of each ridge into elvis, where it meets its fellow of the other side. Hence the para-mesonephric , which are in the free edges of the mesonephric ridges, are also in the free of the transverse ridge on each side of the central thickened ' cord '; when equalities of growth-rate the ducts become altogether intrapelvic in position, necessarily lie in the free edge of the broad ligament on each side as the **ne tubes.** Their *fimbriæ* begin to be apparent in the second month, are r marked in the third month, and grow slowly after this. *Accessory ab- nal ostia* are sometimes found in the embryo, and are well known to occur e adult. The dilatations of the tubes appear during the later fœtal months, ter birth. The narrowed uterine ends are due to the inclusion of these ends ıe mesodermal thickening that forms the muscular uterine wall. This ening begins in the third month, and not only takes in the ends of the tubes, includes also the attachment to these of the inguinal folds, thus leading to livision of each of these into *ligamentum teres* and *ligament of ovary.* In the h month the vaginal lumen is blocked by solid epithelial masses; these break ı centrally in the sixth month, and the lumen is re-established.

he remnants of the mesonephric duct and its associated tubules, being among structures included within the mesonephric ridge, find their way into the d ligament with the para-mesonephric ducts as growth proceeds. The nephric duct becomes the duct of the epoöphoron, and the tubules form the igial remnants known as the paroöphoron and epoöphoron; it is probable the ' appendix vesiculosa ' also belongs to this series, but some maintain that a persisting remnant of the pronephric system.

he abnormal condition of the uterus known as *uterus bicornis* is brought ıt by the fact that the two para-mesonephric ducts have united at a more erior (caudal) level than they usually do. The condition known as *uterus ornis* is due to imperfect development of one or other para-mesonephric duct. xtremely rare cases the para-mesonephric ducts fail to unite, and by opening pendently into the uro-genital sinus they give rise to a *double uterus* and *uble vagina.*

Structure of the Urethra.

The wall of the urethra is composed of three coats—muscular, tile, and mucous. The **muscular coat,** which is continuous with t of the bladder, is composed of plain muscular tissue arranged as *outer circular* and an *inner longitudinal layer.* The circular fibres well developed, especially at the upper end, where they partake ıewhat of the nature of a sphincter muscle. Superficial to the

circular fibres the urethra, as it lies between the two layers of t perineal membrane, is embraced by the striated fibres of the sphinc urethræ. The **erectile coat** is composed of a rich plexus of veins, su ported and pervaded by areolar and elastic tissues. This plexus continuous above with that around the neck of the bladder. T **mucous coat** is covered by *transitional epithelium* in its upper pa and *stratified squamous epithelium* in its lower part. It is provid with papillæ, and is thrown into longitudinal folds, which are tempora above, but permanent below. One fold, situated on the posterior wa is larger than the others, and is known as the **crest.** The mucous me brane is furnished with tubular mucous glands, and between t permanent folds in the lower part there are crypts or lacunæ.

Lymphatics.—The lymphatic vessels of the female urethra join th of the bladder, which pass to the *external iliac, internal iliac,* and *comm iliac glands.*

Development of the Urethra.—The female urethra is developed from ventral or uro-genital compartment of the cloaca, caudal to that part wh gives rise to the bladder. It represents the prostatic portion of the male uret as low as the prostatic utricle.

The Articulations of the Pelvis.

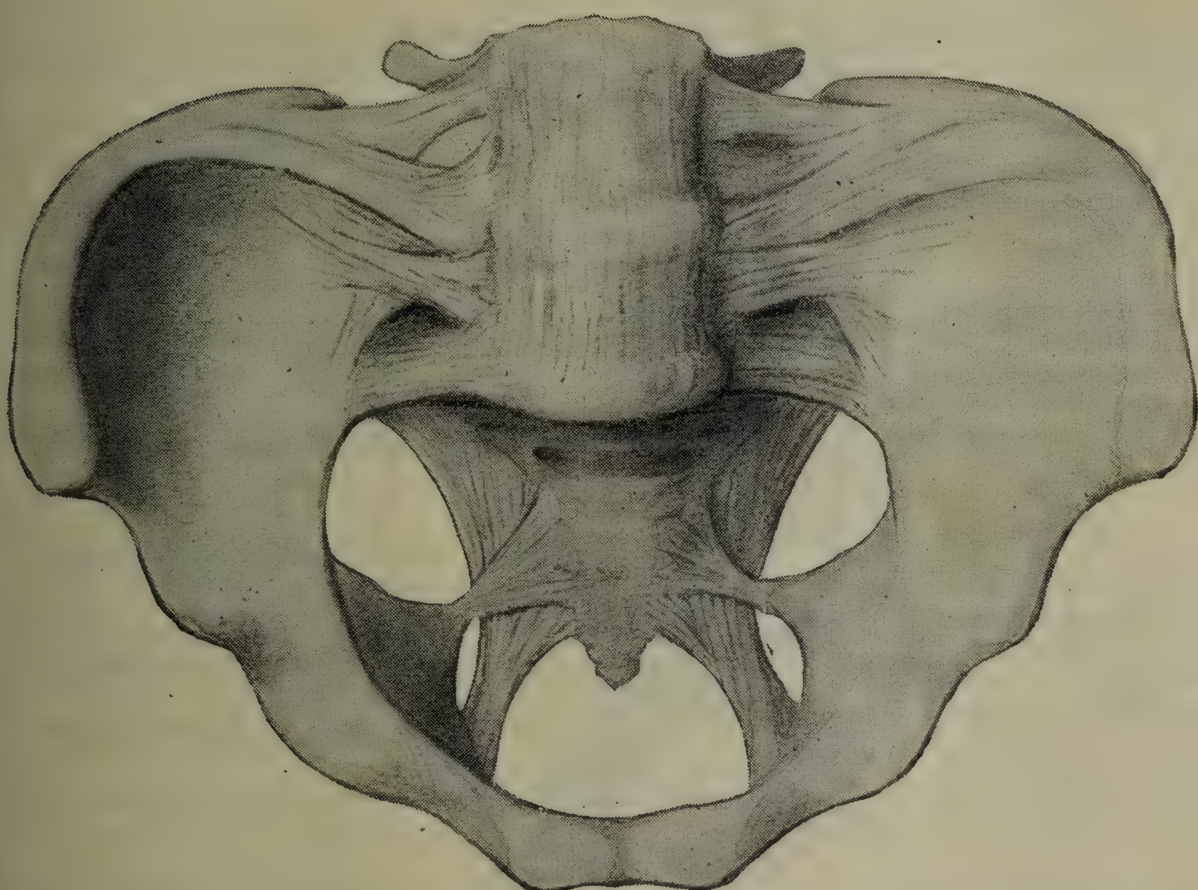
Lumbo-sacral Articulation.—The union between the fifth lumb vertebra and the base of the sacrum is effected by means of the follo ing ligaments: an intervertebral disc, prolongations of the anter and posterior longitudinal ligaments of the bodies of the verteb above, capsular ligaments and synovial membranes for the articu processes, ligamenta flava for the laminæ, and interspinous and sup spinous ligaments for the spinous processes. These are similar to t corresponding ligaments above the level of the fifth lumbar verteb The articulation between the bodies of the fifth lumbar and the fi sacral vertebræ belongs to the class of **secondary cartilaginous join** and the joints between the articular processes belong to the class **synovial joints,** and the subdivision **plane joints.** In addition to t foregoing ligaments there are two special ligaments, called lumb sacral and ilio-lumbar. The **lumbo-sacral ligament** at either si extends from the lower aspect of the transverse process of the fif lumbar vertebra anteriorly to the upper surface of the ala of the sacru at its anterior and outer part close to the sacro-iliac articulation. It somewhat fan-shaped, and corresponds to the intertransverse ligamen of the lumbar vertebræ and the superior costo-transverse ligaments the thoracic region. The **ilio-lumbar ligament** extends from the of the transverse process of the fifth lumbar vertebra to the inner of the iliac crest, where it is attached for about 2 inches above t back part of the iliac fossa. It is triangular, and its direction is o wards and slightly backwards. It is closely associated with the low part of the anterior layer of the lumbar fascia.

Arterial Supply.—Ilio-lumbar and superior lateral sacral arteries

Jerve-supply.—Fourth and fifth lumbar nerves, and sympathetic ients.

Movements.—Flexion, extension, and lateral movements between opposed bodies, and gliding and rotation between the articular esses.

acro-coccygeal Articulation.—This belongs to the class of **secondary laginous joints.** The bony elements are the fifth sacral and first ygeal vertebræ. The opposed surfaces are transversely oval, and separated by an intervertebral disc, unless in advanced life, when ylosis takes place, this occurrence being earlier and more frequent ie male than in the female. The ligaments are as follows: **anterior superficial posterior sacro-coccygeal,** which are continuations of



. 573.—View of Pelvic Skeletal Structures from Above and in Front.

anterior and posterior longitudinal ligaments of the bodies of the tebræ; **intercornual,** which pass between the sacral and coccygeal nua; and **lateral sacro-coccygeal,** which pass between the inferior eral angles of the sacrum and the transverse processes of the first cygeal vertebra. The latter ligament is liable to become ossified.

Arterial Supply.—Inferior lateral and median sacral arteries.

Nerve-supply.—Lower two sacral and coccygeal nerves.

Movements.—Forward and backward movements are allowed.

Intercoccygeal Articulations.—These only exist prior to middle . The union between the coccygeal segments is effected by inter-tebral discs, and anterior and posterior ligaments. The adjacent res of the sacro-tuberous and sacro-spinous ligaments serve as lateral aments.

Sacro-iliac Articulation. — This belongs to the class of **syno** **joints.** The bony elements are the auricular surfaces of the sacrum ilium. The cartilages of the auricular surface are about $\frac{1}{12}$ inch th and exist as two plates, one for each surface, a small but definite syno cavity existing between the two plates. The ligaments at the jo are anterior, and long and short posterior. The **anterior sacro-i** **ligament** is composed of short fibres which are placed in front of joint. The **short posterior sacro-iliac ligament,** which is very stro extends from the ligamentous surface of the ilium to the ligament surface of the sacrum and the tubercles on the dorsum of the bone,

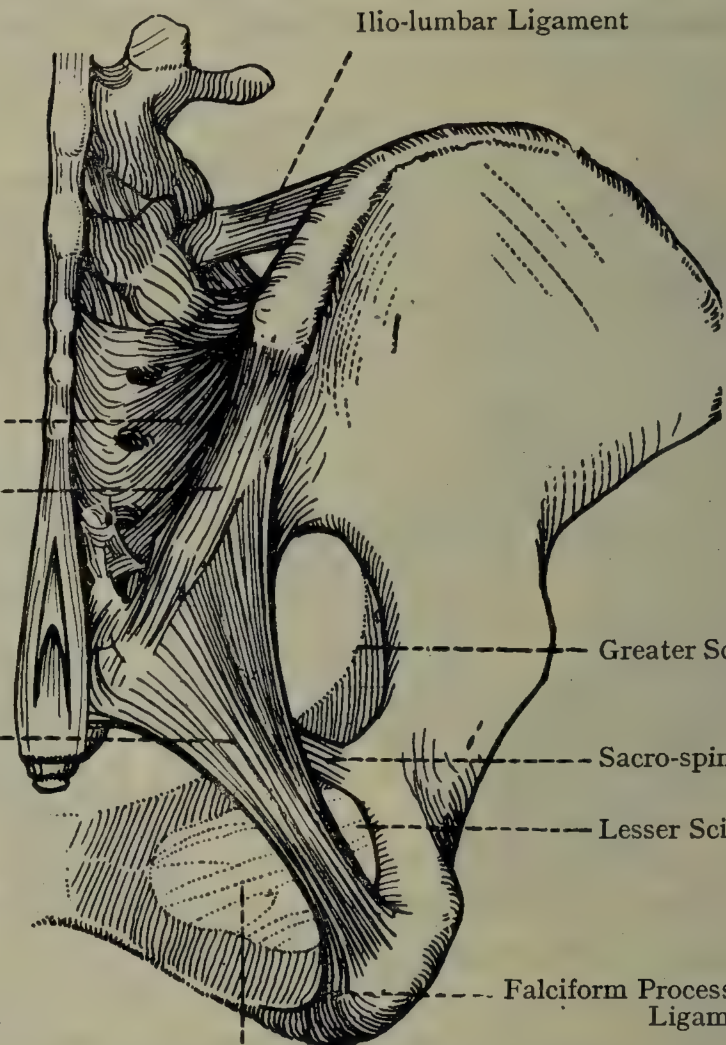


FIG. 574.—LIGAMENTS OF THE RIGHT HALF OF THE PELVIS (POSTERIOR VIEW).

direction of the fibres being downwards and inwards. The lo **posterior sacro-iliac ligament** lies superficial to the posterior, a extends from the posterior superior iliac spine and the adjacent p of the iliac crest to the third and fourth series of tubercles on the dors of the sacrum. It is really a detached part of the short posterior sac iliac ligament. The great and small sacro-sciatic ligaments are acc sory to this joint.

The **sacro-tuberous ligament** (**great sacro-sciatic ligament**) is tached by one extremity to the posterior inferior iliac spine, and sides of the last three sacral and first coccygeal vertebræ, and by

extremity to the inner border of the ischial tuberosity. From atter point it sends forwards an expansion, called the **falciform ss,** which is attached to a sharp ridge on the lower part of the inner ce of the ramus of the ischium close to its medial border. The ent is broad at its attached ends, especially the upper, but in ing towards the ischial tuberosity it becomes narrow. Its direction wnwards and forwards, and its ischial fibres are continuous with endinous origin of the long head of the biceps femoris. By its ficial surface it gives origin to part of the gluteus maximus, and ig on this surface are the plexiform loops formed by the lateral hes of the posterior primary divisions of the first three sacral es. Its deep surface gives origin to some fibres of the pyriformis, ower down is intimately connected with the sacro-spinous liga- . The falciform process affords attachment to the lower part of arietal pelvic fascia. The sacro-tuberous ligament is pierced by occygeal branch of the inferior gluteal artery, the sacral branch e internal pudendal artery, and the perforating cutaneous nerve the sacral plexus. The ligament assists in the formation of the er and lesser sciatic foramina.

ie sacro-tuberous ligament is to be regarded as a detached portion of the iead of the biceps femoris muscle.

he **sacro-spinous ligament (small sacro-sciatic ligament),** which is gular, is attached by its base to the sides of the last two sacral first coccygeal vertebræ, where it is intimately connected with the superficially placed sacro-tuberous ligament. Its apex is attached e tip of the spine of the ischium. Its deep surface is incorporated the coccygeus muscle, and along with the spine of the ischium it s the separation between the greater and lesser sciatic foramina.

he sacro-spinous ligament is to be regarded as resulting from the fibrous ieration of the superficial part of the coccygeus muscle.

rterial Supply of the Sacro-iliac Articulation.—Ilio-lumbar, superior al sacral, and superior gluteal arteries.

Ierve-supply.—Superior gluteal and anterior primary divisions, lateral branches of the posterior primary divisions of the first two al nerves.

Movements.—Stability being required at this joint, it is almost ovable. The two hip bones by their union at the pubic articulation an arch, the convexity of which is directed downwards and for- ls. The piers of this arch are separated by a wide interval into h the sacrum fits. The sacrum being narrower behind than in t, the superincumbent weight of the trunk has a tendency to dis- e it downwards into the pelvic cavity, but this is resisted partly the powerful posterior sacro-iliac ligaments, which suspend the e, and partly by the strong hold which the sacrum has upon the n, in virtue of the irregularities of the opposed surfaces. Under influence of the superincumbent weight there is a tendency on the

part of the sacrum to rotate round an axis passing transversely thro the sacro-iliac joints. This tendency, however, is checked by sacro-spinous and sacro-tuberous ligaments. The ilio-lumbar l ments prevent displacement of fifth lumbar vertebra over base of the sacrum.

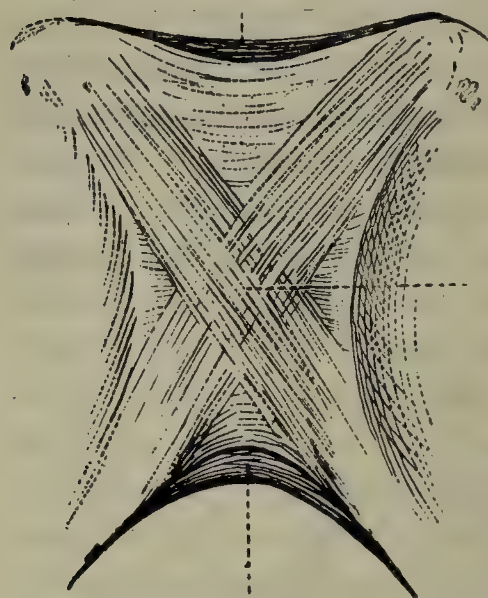


FIG. 575.—THE LIGAMENTS OF THE SYMPHYSIS PUBIS (ANTERIOR ASPECT).

The Pubic Symphysis.—T belongs to the class of **second cartilaginous joints.** The artic surfaces are the symphysial pects of the pubic bones. ligaments are anterior, poster superior, inferior, and interpu disc. The **anterior pubic ligam** is strong, and is composed superficial and deep fibres. superficial fibres are arranged an obliquely decussating mann and are chiefly constructed by aponeurotic fibres of the exter oblique and inner heads of recti abdominis muscles. The deep fibres are disposed transvers The **posterior** and **superior pubic ligaments** are weak, and consis scattered fibres. The **inferior ligament (arcuate ligament)** is a stro thick band of fibres, which lies at the antero-superior part of pubic arch, where it fills up and rounds off the subpubic angle. I attached superiorly to the lower part of the interpubic disc, and laterally to the adjacent parts of the inner lips of the inferior pubic rami. It is about $\frac{1}{4}$ inch in depth, and is slightly arched, from which latter circumstance it is known as the *arcuate ligament.* The **interpubic disc** lies between the plates of cartilage which cover the bony articular surfaces. It is composed of fibro-cartilage, is thicker in front than behind, and usually contains a fissure at its upper and back part, which may extend for one-half, or even the whole length, of the disc as an oblique cleft parallel to the plane of the bony surfaces. This fissure is brought about by absorption of the tissues in that situation, and it does appear until about the tenth year of life. It is larger in the fer than in the male.

FIG. 576.—VERTICAL SECTION THE PUBIC SYMPHYSIS.

The depth of the symphysis pubis is less in the female than in male.

rterial Supply.—Pubic branches of the inferior epigastric and rator, and superficial external pudendal arteries.

'erve-supply.—Probably the hypogastric branch of the ilio-hypo-ric, ilio-inguinal, and pudendal nerves.

Iovements.—Very slight separation is allowed at this joint, due to ing of the connecting structures. This is most apparent during nancy and parturition.

reater Sciatic Foramen.—This foramen is formed by the greater ic notch, the spine of the ischium, the sacro-tuberous ligament, the sacro-spinous ligament. For its compartments and the struc-s which pass through them, see p. 534.

esser Sciatic Foramen.—This foramen is formed by the lesser ic notch, the spine of the ischium, the sacro-tuberous ligament, and sacro-spinous ligament. For the structures which pass through it, Gluteal Region.

Obturator Membrane and Obturator Canal.

The **obturator membrane** is attached to the posterior margin of the umference of the obturator foramen, except superiorly opposite the rator groove; this last it converts into a fibro-osseous canal for passage of the obturator vessels and nerve. In this situation it is ed posteriorly by the parietal pelvic fascia. Its fibres are arranged n irregular, decussating manner. Its posterior or pelvic surface is ely covered by the obturator internus muscle. The anterior or oral surface is in like manner covered by the obturator externus cle, and at its circumference there is an arterial loop formed by the erior and anterior terminal branches of the obturator artery.

The **obturator canal** is a fibro-osseous canal, which is situated above upper border of the obturator membrane. Its upper boundary, ch represents the osseous element, is formed by the obturator groove the inferior surface of the superior pubic ramus, the direction of the ove being downwards, forwards, and inwards. The lower boundary, ch represents the fibrous element, is formed by the junction of the ietal pelvic fascia with the upper border of the obturator membrane r the upper border of the obturator internus. The canal transmits obturator vessels and obturator nerve, the nerve being above the ery.

CHAPTER XII

THE THORAX

Thoracic Wall.

Muscles—Intercostal Muscles.—The classic description of t
muscles gives them as two in number in each space, external
internal, arranged as thin sheets of obliquely-disposed muscular fil
with a large admixture of tendinous fibres.

External Intercostal Muscles—*Origin.*—The lower border of
upper rib bounding an intercostal space.

Insertion.—The outer margin of the upper border of the lower

Nerve-supply.—The intercostal nerve of the corresponding spa

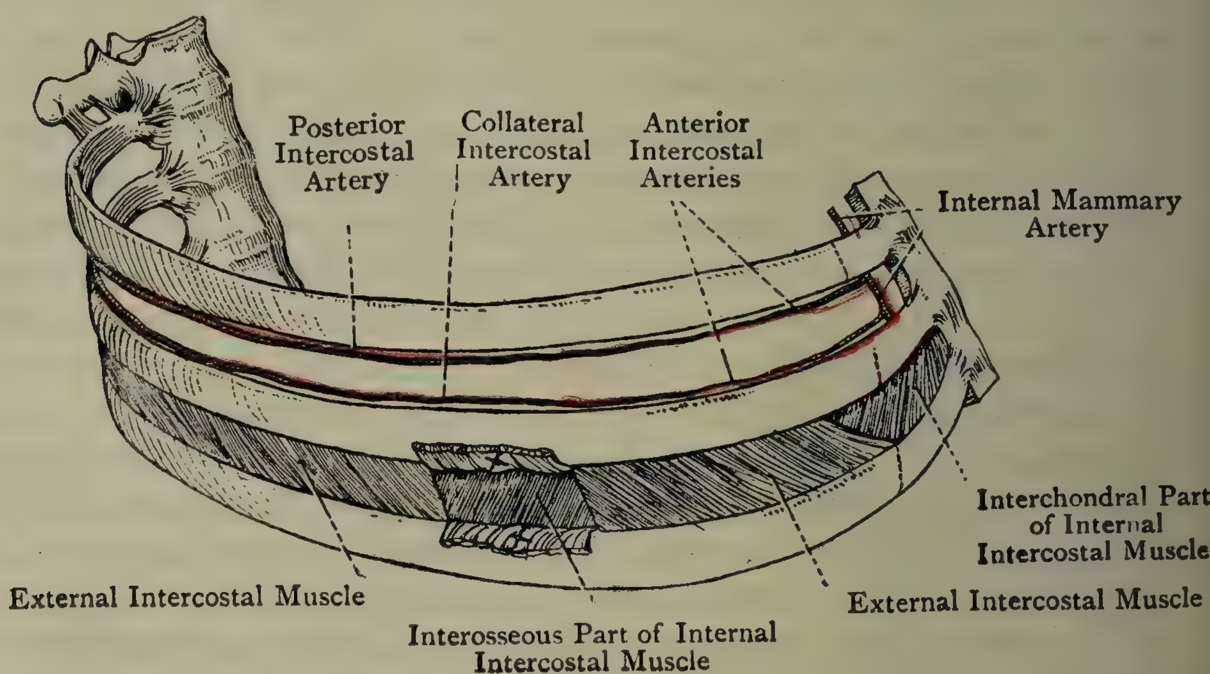


FIG. 577.—DIAGRAM OF THE INTERCOSTAL MUSCLES AND INTERCOSTAL ARTE

A small portion of the external intercostal muscle has been divided and reflected.

The fibres of each muscle are directed downwards and forw
and in this respect coincide with those of the obliquus exte
abdominis. The muscles, as a rule, extend as far forwards as
junction of the ribs with their cartilages, but sometimes they
short of this point, especially in the upper spaces. From the p
where the fibres cease the upper six muscles are continued inw
to the side of the sternum by a thin delicate membrane, called
anterior intercostal membrane. This occupies the spaces between
true costal cartilages. Posteriorly the muscles extend as far as
tubercles of the ribs.

[I]nternal Intercostal Muscles.—*Origin.*—The upper margin of the al groove of the upper rib.

[I]nsertion.—The inner margin of the upper border of the lower rib.

[N]erve-supply.—The intercostal nerve of the corresponding space.

[T]he fibres of each muscle are directed downwards and backwards, and is respect coincide with those of the obliquus internus abdominis. upper six muscles extend as far inwards as the side of the sternum, the lower two are continuous anteriorly with the obliquus internus ominis. Posteriorly the muscles extend as far back as the angles ie ribs. In this situation each is replaced by a delicate membrane d the *posterior intercostal membrane*, which lines the adjacent ion of the external intercostal muscle, and ds behind with the superior costo-transverse nent. The internal intercostal muscles are ered internally by the parietal pleura.

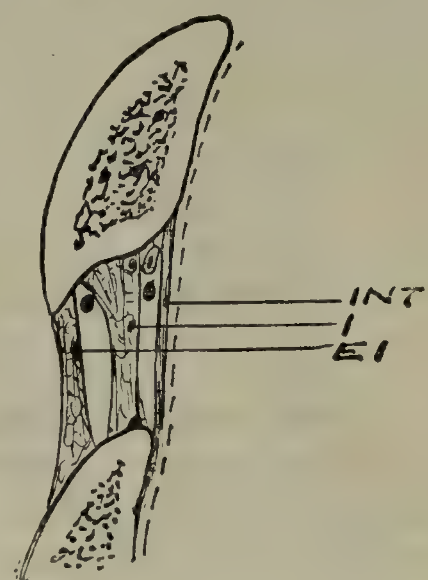


Fig. 578.—Diagram of Section across an Intercostal Space.

EI, I, external and internal intercostal muscles; INT, intercost. intimus, or intracostal. Pleura represented by interrupted line. Lateral cutaneous nerve shown between EI and I.

[A]ction of the Intercostal Muscles.—This sub- has given rise to much discussion and erence of opinion. Three views are entered: (1) According to Haller, the external internal intercostal muscles both act as ators of the ribs, and are therefore muscles ispiration. Inasmuch as the fibres of the muscles decussate, they must, according to view, act on the principle of the parallelon of forces. The common nerve-supply of two muscles tends to favour this view. According to Hamberger, the external interal muscles are elevators of the ribs, and efore muscles of inspiration; whilst the inal intercostal muscles are depressors of ribs, and therefore muscles of expiration. According to Hutchinson, the external interal muscles and the *interchondral portions* of internal intercostal muscles act as elevators the ribs, and are therefore muscles of in-ation; whilst the *interosseous portions* of the internal intercostal scles act as depressors of the ribs, and are therefore muscles of iration.

When a rib is elevated, its lower border is at the same time rted.

Subcostal Muscles.—Deep to the internal intercostal muscles the ains of a third sheet of muscular fibres can often be demonstrated. sheet is best developed dorsally and in connection with the lower ces. The direction of the fibres is similar to that taken by the es of the internal intercostal, but unlike these last the fibres, ead of passing between adjacent ribs, pass between ribs some ces apart. The fibres constitute the subcostal muscles, which are the same plane as the sterno-costalis and the costal fibres of the

diaphragm, and represent in the thoracic wall the transversus mus of the abdominal wall.

For the levatores costarum muscles, see Index.

It is customary, in modern descriptions of the intercostal muscu ture, to speak of three layers of muscles in this situation. T additional fibres are referred to as **intercostales intimi**: they w described and figured many years ago by Henle, and are usually tal to be partly detached fibres of the internal intercostals. Their fib have the same direction as those of the internal intercostals, from wh they are separated by the intercostal vessels and nerves (Fig. 57 They form a very thin layer, aponeurotic in some places, and tra lucent, better developed in the lower part of the thoracic wall, a more particularly in the middle portions of the spaces.

They are frequently considered to be parts of the same sh as the sterno-costalis (triangularis sterni) and subcostal fibr but this does not seem to be at all certain. If this view is tak the three kinds of muscle are grouped together as the **transver thoracis,** implying their general continuity with the sheet of abdominal transversus.

Intercostal Nerves.—These are eleven in number on each side, a are the anterior primary divisions of the upper eleven thoracic spi nerves. The anterior primary division of the twelfth thoracic spi nerve is not an intercostal nerve, but lies along the lower border the twelfth rib, and is known as the subcostal nerve ('last dor nerve').

The lower five intercostal nerves ultimately leave the intercos spaces, and pass into the anterior abdominal wall.

Upper Six Intercostal Nerves.—Each of these nerves, as it ent the back part of an intercostal space, lies between the posterior int costal membrane and the parietal pleura. About the level of the an of the rib it pierces the posterior intercostal membrane, and pas forwards in the costal groove of the upper rib, lying between intercostal muscles. It continues its forward course in this posit in company with the intercostal artery and intercostal vein, the or of these from above downwards being intercostal vein, intercos artery, and intercostal nerve. The nerve is concealed by the ov lapping lower border of the upper rib.

At (or just beyond) the angles of the ribs between which it is pass the intercostal nerve gives off a collateral branch and, a little furt on, its lateral cutaneous branch. The **collateral** branch runs forwa along the upper surface of the rib below the space, supplying muscles and terminating either in them or by forming a connect loop with the main nerve some distance from the sternum. The **late cutaneous** branch pierces the internal intercostal muscle to run forwa between this and the external muscle: it pierces this to reach the surfa the actual site of the perforation varying, of course, according to level of the nerve. The main intercostal nerves themselves run

reen the intercostales interni and intimi after they have given off branches described.

Having arrived at the anterior extremity of the osseous rib, each e, still internal to the internal intercostal muscle, passes inwards ts deep surface, lying at first upon the parietal pleura, and subently upon the sterno-costalis muscle, crossing in its course the rnal mammary vessels. On reaching the side of the sternum it es straight forwards, to become an anterior cutaneous nerve, cing in succession the following structures: the interchondral ion of the internal intercostal muscle; the anterior intercostal ibrane; the pectoralis major muscle; and the deep fascia.

Branches.—These are muscular, lateral cutaneous, and anterior ineous.

The *muscular branches* supply the following muscles: the levatores arum, serratus posterior superior, subcostal muscles, intercostal

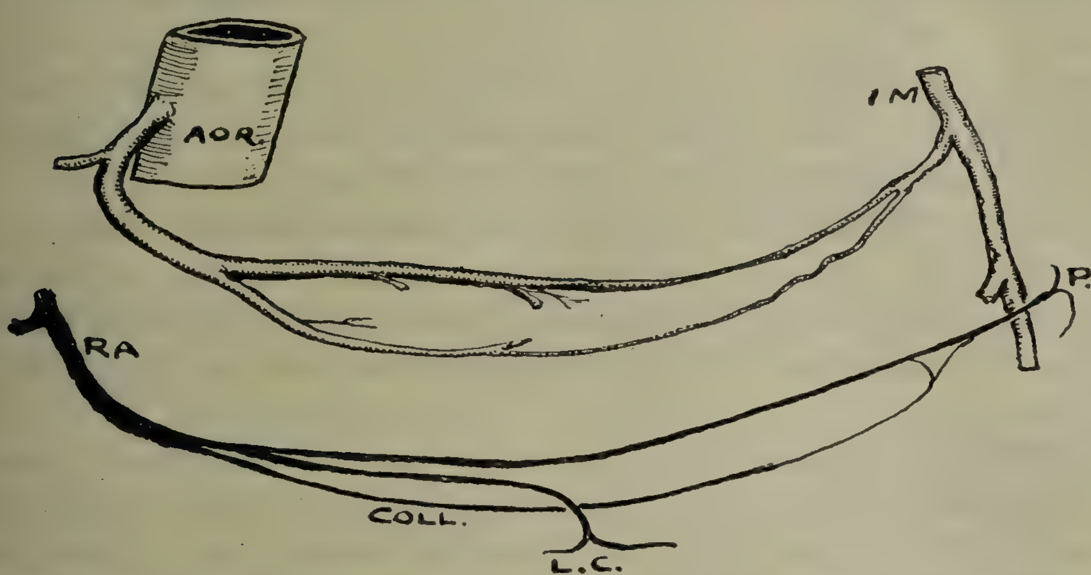


FIG. 579.—PLANS OF INTERCOSTAL ARTERIES AND NERVE.
internal mammary artery; AOR, aorta; RA, anterior primary ramus of thoracic spinal nerve; COLL, collateral branch; LC, lateral cutaneous branch; P, anterior terminal perforating, passing in front of internal mammary.

scles, the sterno-costalis, the serratus posterior inferior, and the scles of the anterior abdominal wall.

The *lateral cutaneous nerves* arise just beyond the costal angles, l run as described above. They pierce the external intercostal scles, and make their appearance under fibrous arches connecting costal slips of origin of the serratus anterior. The first intercostal ve, as a rule, gives off no lateral cutaneous branch, and that of the ond is known as the intercosto-brachial nerve.

The *anterior cutaneous nerves* are the terminal branches of the upper intercostals, that of the first being sometimes absent. For their criptions, see Index.

Intercostal Arteries.—These vessels are arranged in two sets—sterior and anterior.

Posterior Series.—The intercostal arteries of the first two spaces derived from the *superior intercostal artery* (see Index). The

intercostal arteries of the lower nine spaces are branches of the scending thoracic aorta, and are called the *posterior intercostal arter* Each at first lies between the posterior intercostal membrane and parietal pleura. About the level of the angle of the rib it pierces posterior intercostal membrane, and gives off its collateral intercos branch, which inclines downwards. These two arteries now p forwards between the two intercostal muscles, the main poster intercostal lying in the costal groove of the upper rib, where it the intercostal vein above it and the intercostal nerve below it, a the collateral intercostal lying along the upper border of the lov rib. These two vessels, in the case of the upper nine spaces, termin by anastomosing with the anterior intercostal arteries, which are in number in each of these spaces, and will be presently describ These anastomoses take place a little in front of the mid-point betw the vertebral column and the side of the sternum.

Branches.—These are posterior, collateral intercostal, and late cutaneous.

The *posterior branch* passes backwards to the muscles and inte ment of the back, giving off in its course a *spinal branch,* which ent the vertebral canal through the intervertebral foramen.

The *collateral intercostal branch,* as stated, arises about the le of the angle of the rib, and inclines downwards to the upper border the lower rib, along which it passes between the intercostal muscles.

The *lateral cutaneous branch* accompanies the corresponding late cutaneous nerve.

The posterior intercostal and collateral intercostal arteries gi branches to the intercostal muscles and ribs. Those of the thi fourth, and fifth spaces, at least, furnish branches to the mamma gland and pectoral muscles, anastomosing with the thoracic branc of the acromio-thoracic artery from the first part of the axillary, a with the lateral thoracic from the second part of that vessel. T first posterior intercostal artery, as it enters the *third* intercostal spa gives off a branch which ascends to the back part of the second int costal space, and anastomoses with the branch of the superior intercos artery to that space.

Anterior Series.—The internal mammary artery furnishes t *anterior intercostal arteries* to each of the upper six intercostal spac and the musculo-phrenic branch of the internal mammary furnis two *anterior intercostal arteries* to each of the seventh, eighth, a ninth intercostal spaces. The arteries of the upper six spaces lie first upon the sterno-costalis muscle, and then upon the parietal pleu being under cover of the internal intercostal muscle. Afterwards the anterior intercostal arteries pass between the external and inter intercostal muscles. In each space they anastomose with the poster intercostal and collateral intercostal arteries, and also with the c responding intercostal arteries of the upper two spaces.

Branches.—These are distributed to the intercostal muscles, ri mammary gland, and pectoral muscles.

The lower two intercostal spaces are not furnished with anterior ɜrcostal arteries. The posterior intercostal arteries of these spaces, ɜr leaving them, enter the abdominal wall, and pass forwards ween the internal oblique and transversalis muscles to the rectus lominis, in which they anastomose with the superior epigastric l inferior epigastric arteries.

Intercostal Veins.—These veins accompany the corresponding ɛeries.

The *posterior intercostal vein* passes backwards in the costal ɔove of the upper rib in company with the posterior intercostal ery, above which it lies. In the region of the angle of the rib it is ned by the *collateral intercostal vein*, which accompanies the correɔnding artery. Close to the vertebral column the posterior intercostal n receives a large posterior branch, which returns blood from the ıscles and skin of the back, the vertebral venous plexus, and the ɛtebral canal. The mode of termination of the posterior intercostal ns differs on the two sides, and will be described in connection :h the dissection of the posterior wall of the thorax.

The *anterior intercostal veins* accompany the anterior intercostal ɛeries. Those of the upper six intercostal spaces pass to the internal ımmary, and those of the succeeding three spaces pass to the musculorenic veins.

Intercostal Lymphatics.—The lymphatic vessels of the intercostal ıces pass partly to the posterior intercostal glands, which lie at the ck parts of the intercostal ıces, and partly to the anter intercostal or sternal glands, ich lie along the course of ɜ internal mammary artery.

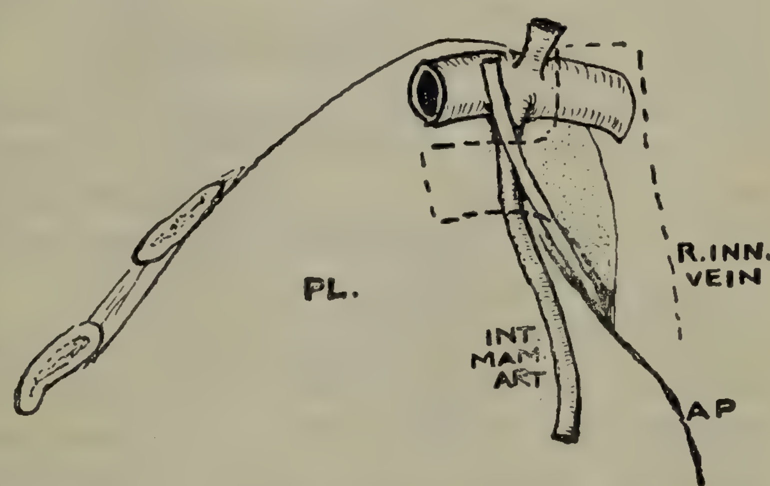


Fig. 580.—To show the Interrelations of the Right Internal Mammary Artery and Phrenic Nerve, and their Relations to Subclavian and Innominate Veins (Interrupted Lines) and to Pleura.

AP, anterior margin of pleura (PL). The mediastinal surface is stippled.

Internal Mammary Artery.—is vessel arises from the lower ɛ of the first part of the bclavian artery, and passes wnwards, forwards, and inırds behind the inner part of ɜ clavicle and the first costal rtilage. It then descends verally behind the succeeding stal cartilages as low as the th intercostal space, where it rminates by dividing into two anches—namely, the superior igastric and the musculorenic. The artery lies about $\frac{1}{2}$ inch from the margin of the sternum.

Cervical Relations—*Anterior.*—The clavicular portion of the sternoastoid muscle, and the internal jugular and subclavian veins. The ırenic nerve crosses it superficially from without inwards. *Posterior.* The dome of the pleura.

Thoracic Relations—*Anterior*.—The pectoralis major; upper
costal cartilages; anterior intercostal membrane; internal intercos
muscles; and upper six intercostal nerves. *Posterior*.—The ple
above, and subsequently the sterno-costalis muscle. *Lateral*.—
artery has a vena comes on either side of it. The anterior intercos
or sternal glands lie along the course of the vessel.

Branches.—The artery gives off no branches in the neck. In
thoracic part of its course it furnishes the following branches:

Pericardiaco-phrenic.	Anterior intercostal.
Mediastinal.	Perforating.
Pericardial.	Musculo-phrenic.
Sternal.	Superior epigastric.

The *pericardiaco-phrenic artery*, long and slender, arises high up, a
accompanies the phrenic nerve to the diaphragm. It gives twigs
the pericardium and pleura, and in the diaphragm it anastomoses w
the phrenic branch of the abdominal aorta and with the muscu
phrenic branch of the internal mammary. The *mediastinal branc*
are distributed to the contents of the mediastinum—namely,
remains of the thymus body, mediastinal glands, and areolar tiss
The *pericardial branches* supply the front part of the pericardium.
sternal branches are distributed to the sternum and the sterno-cost
muscle. The *anterior intercostal arteries* are two in number to each
the upper six intercostal spaces. For their description, see Ind
The *perforating branches* are six in number, one arising opposite e
of the upper six intercostal spaces. Each vessel pierces the inter
intercostal muscle, anterior intercostal membrane, and pectoralis maj
It then gives a few twigs to the front of the sternum, and turns o
wards to supply the skin of the pectoral region. The second, thi
fourth, and fifth perforating branches give offsets to the inner port
of the mammary gland.

The *musculo-phrenic artery* is one of the terminal branches of
internal mammary. It arises from that vessel in the sixth intercos
space, and passes obliquely downwards and outwards behind
seventh, eighth, and ninth costal cartilages. About the level of
tenth rib it perforates the diaphragm, and terminates in the late
wall of the abdomen, where it anastomoses with the ascending bran
of the deep circumflex iliac artery. It gives off anterior intercos
and muscular branches. The anterior intercostal arteries are two
number to each of the seventh, eighth, and ninth intercostal spac
in which they are disposed in a manner similar to the anterior intercos
branches of the internal mammary. The muscular branches
distributed to the diaphragm and lateral wall of the abdomen.
the diaphragm they anastomose with the phrenic branch of
abdominal aorta and the pericardiaco-phrenic branch of the inter
mammary.

The *superior epigastric artery* is the other terminal branch of
internal mammary, of which it is the continuation. It descen

nd the seventh costal cartilage, and passes through the areolar val between the sternal and costal portions of the diaphragm. In manner it enters the sheath of the rectus abdominis, lying at first nd the muscle, but afterwards entering it. In the muscle it tomoses with the inferior epigastric artery, which is a branch of external iliac.

he branches of the superior epigastric artery will be found deed on p. 731.

he **internal mammary veins** (**venæ comites**) are two in number, lie one on each side of the artery. They are formed respectively

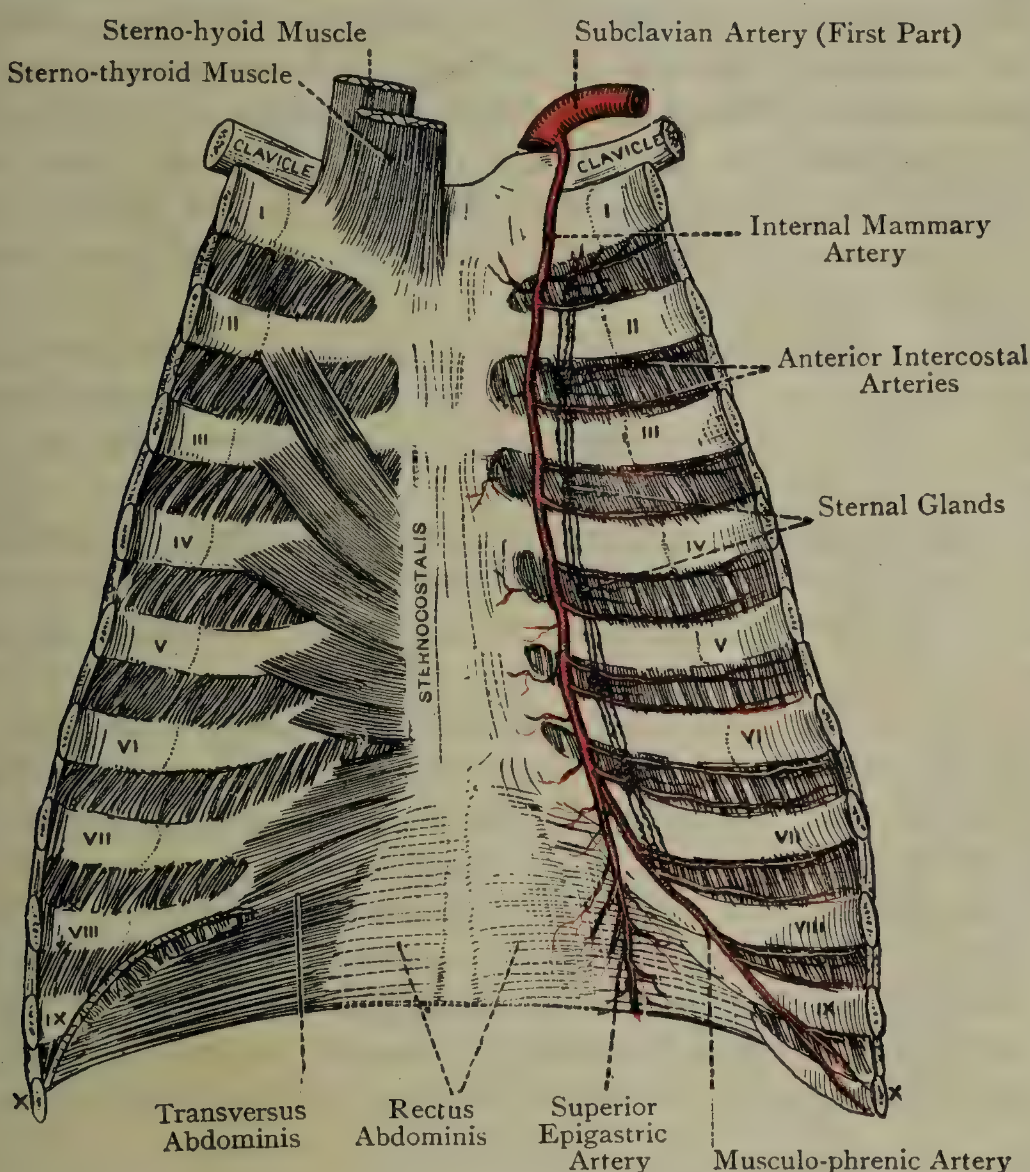


FIG. 581.—DISSECTION OF THE ANTERIOR WALL OF THE THORAX (POSTERIOR VIEW).

he union of the venæ comites of the musculo-phrenic and superior astric arteries. In their course they receive tributaries correspond- to the branches of the artery. About the level of the first rcostal space the outer vein crosses over the artery and joins the r vein to form a single vessel, which opens into the corresponding minate vein. The internal mammary veins are provided with es at intervals.

ternal or Internal Mammary Lymphatic Glands.—These glands a chain along the internal mammary vessels. They are usually ined, however, to the first three spaces, there being one, or it may

be two, in each of these spaces. They usually lie in front of the inter
mammary vessels.

They receive their *afferent* vessels from (1) the inner third of
mammary gland, (2) the anterior half of the costal pleura, (3)
anterior halves of the external and internal intercostal musc
(4) the lymphatics which accompany the superior epigastric arte
and (5) the anterior group of superior diaphragmatic glands. Th
efferent vessels pass to the *thoracic duct,* or to the *right lymphatic d*
according to the side on which the glands lie. Frequently one
more of these vessels drain to the supraclavicular group of glands
fact which explains the infection (which sometimes occurs) of th
glands in malignant disease of certain abdominal viscera.

Sterno-costalis (Triangularis Sterni)—*Origin.*—(1) The deep surf
of the xiphoid process and body of the sternum close to the late
border, and extending as high as the level of the third costal cartila
and (2) the deep surfaces of the lower two or three true costal cartila
at their sternal ends.

Insertion.—The deep surfaces and lower borders of the cos
cartilages from the sixth to the second. The insertion takes pl
by separate slips, and one or two of the upper slips may be parti
attached to the rib itself.

Nerve-supply.—The intercostal nerves of the adjacent spaces.

The lowest fibres of the muscle are horizontal; the succeeding fib
pass obliquely upwards and outwards; and the upper fibres are alm
vertical.

Action.—To depress the anterior extremities of the ribs, and
take part in expiration. It fixes the anterior part of the chest w
and so assists the actions of the muscles, particularly those of
pectoral group, attached to that region.

The muscle forms a thin musculo-tendinous sheet, which is situa
on the deep surfaces of the costal cartilages and side of the sternu
and is serially continuous with the transversalis abdominis mus
It supports the internal mammary vessels, sternal glands, and cert
of the intercostal nerves, whilst its deep surface rests upon the parie
pleura.

Thoracic Cavity.

Contents and their General Position.—The thoracic cavity is chi
occupied by the lungs and heart. The lungs are situated one in ea
half of the cavity, and each lung is provided with a serous membra
called the *pleura.* The heart lies obliquely between the lungs, project
more to the left of the sternum than to the right, and is enclosed wit
a fibro-serous sac, called the *pericardium.* Each lung is free to expa
except at the *hilum,* which is situated on its inner surface. Thro
this hilum the bronchus, pulmonary artery, and pulmonary ve
pass, along with other structures, and the pedicle so formed is ca
the *root* of the lung. The upper part, or apex, of the lung rises i
the root of the neck, where it is covered by the cupola of the pleu

in turn being covered by the suprapleural membrane. The lower , or base, of the lung rests upon the corresponding half of the hragm, the heart lying upon the central tendon of that muscle.

The two pleural sacs fill the spaces enclosed by the ribs of their sides, but an interval exists between them; this is the **mediastinum** s. 582 and 583). Nearly all the contents of the thorax (other than lungs and pleuræ) lie in the iastinal space, which, as will be ., is arbitrarily divided for conience and description.

The pulmonary artery springs n the base of the right ventricle he heart, and the aorta from base of the left ventricle. The innominate vein courses along upper aspect of the arch of the a in front of the origins of the ominate, left common carotid, left subclavian arteries, and es with the right innominate n behind the sternal end of the right costal cartilage to form superior vena cava. This latter sel opens into the posteroerior angle of the right atrium he heart, and, just before piercthe pericardium, receives the a azygos which arches forwards r the right bronchus. The inor vena cava, having entered thorax through the foramen for a cava in the central tendon the diaphragm, almost immetely opens into the posterorior angle of the right atrium of heart.

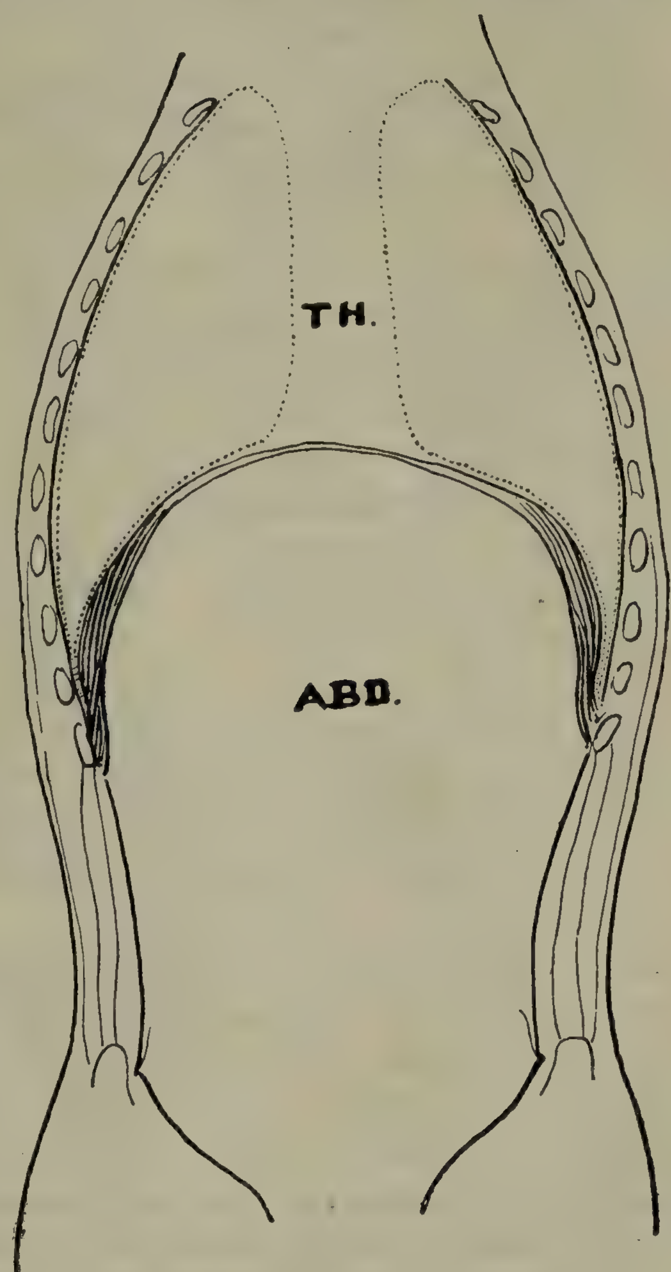


Fig. 582.—Scheme of a Coronal Section of the Trunk, showing the High Arch of Diaphragm leading to a Costophrenic Sulcus of Pleura (Dotted Line).

TH is placed in the mediastinum between the pleural sacs.

The phrenic nerve on each side cends in front of the root of lung, and is intimately related the pericardium, especially on left side. The small anterior monary plexus of nerves lies in nt of the root of each lung. The vagus nerve on each side descends ind the root of the lung, and forms in that part of its course the ch larger posterior pulmonary plexus. The following important ves descend in front of the arch of the aorta: the left phrenic, the vagus, the superior cervical cardiac branch of the left sympathetic, l the lower cervical cardiac branch of the left vagus. The left

superior intercostal vein lies in front of the back part of the a
arch, usually intervening between the phrenic in front and the v
behind. The superficial cardiac plexus of nerves lies within
concavity of the arch of the aorta, and the deep cardiac plexus
behind the arch and in front of the trachea close to its bifurca
into the two bronchi. The left recurrent laryngeal nerve p
backwards under the arch, and then ascends behind it. Within

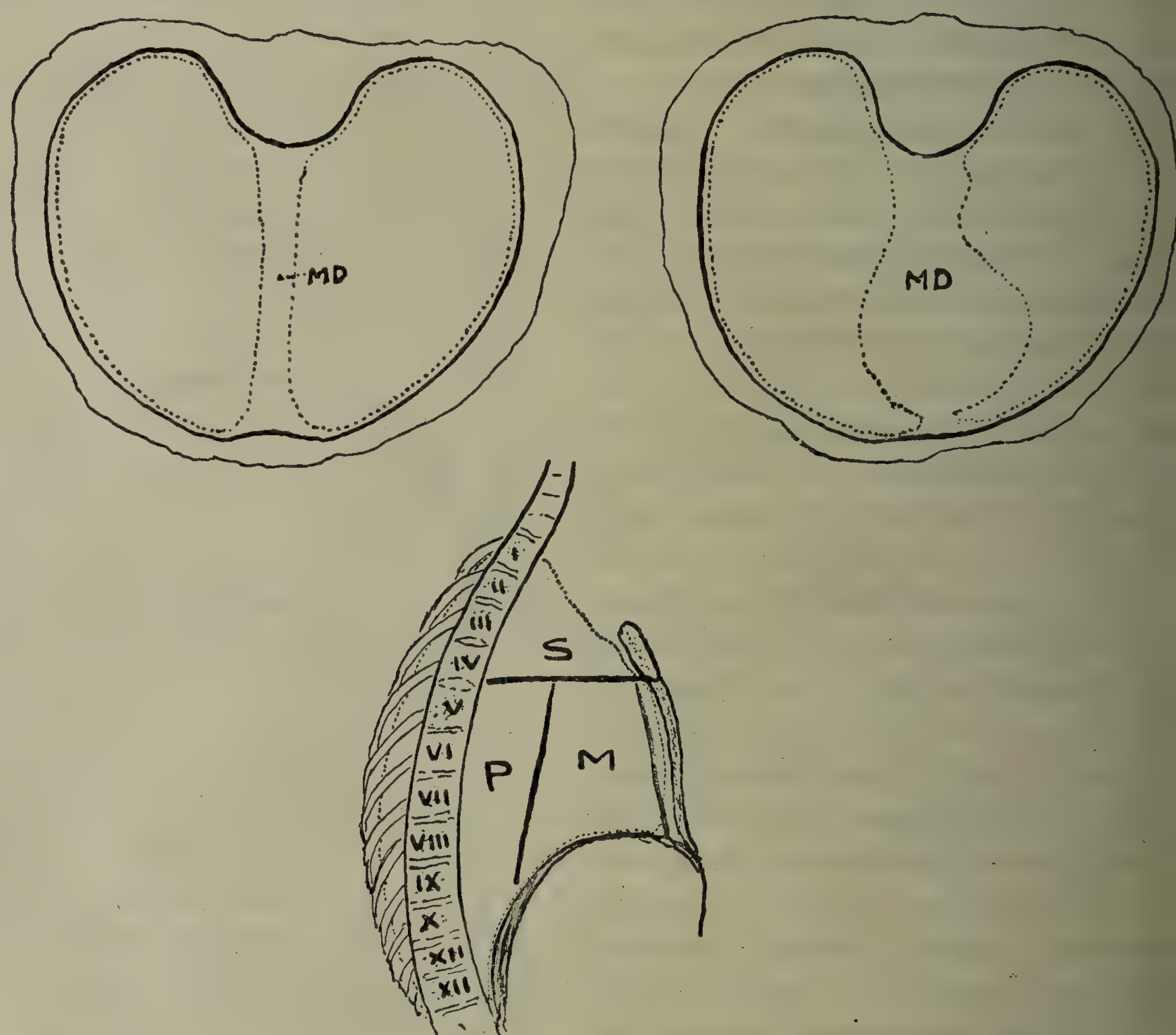


Fig. 583.—Diagrams showing, in the First Figure, how the Mediasti is simply the Interval between the Two Pleural Sacs, a Defini which holds even when, as in the Second Figure, it is much tended by Pericardium, etc.

The lower figure shows how the space between the pleural sacs can be div into a superior (S) mediastinum and an 'inferior'; this term, howeve not commonly used, the lower space being subdivided, by the subver planes of the front and back walls of the pericardium, into a posterior (middle (M), and a rather doubtful anterior space.

concavity of the aortic arch the trunk of the pulmonary artery bre
up into its right and left divisions, and the ligamentum arterios
extends from the root of the left pulmonary artery to the back p
of the concavity of the aortic arch immediately beyond the origi
the left subclavian artery; the recurrent laryngeal nerve winds ro
its left side prior to passing upwards behind the arch of the ao
The gangliated trunk of the sympathetic lies very deeply, and desce

the heads of the ribs close behind the parietal pleura, and the or three splanchnic nerves lie obliquely on the sides of the bodies ie lower thoracic vertebræ.

'he œsophagus lies in contact with the front of the vertebral mn, and the trachea is anterior to it. The descending thoracic a lies very deeply, being situated at first on the left side of the ebral column, but subsequently in front of it. The thoracic duct nds on its right side, and the vena azygos ascends on the right of the thoracic duct, both structures being under cover of the hagus. The superior and inferior venæ hemiazygos, upper and r, as well as the two transverse azygos veins, upper and lower, losely related to the vertebral column.

'he thoracic cavity contains the following sets of lymphatic glands: anterior mediastinal or anterior group of superior diaphragmatic ds in front of the pericardium; the superior mediastinal above pericardium, along the arch of the aorta and innominate veins; posterior mediastinal behind the pericardium; the posterior costal in the back parts of the intercostal spaces; and the bronchial he interval between the diverging bronchi, and also at the root ach lung. In early life a portion of the thymus body, which is of large size, lies behind the upper part of the sternum, whence tends into the lower part of the neck.

'leuræ.—The pleuræ are the two serous sacs which invest the s, and line the adjacent parietes. Each forms a closed sac, which uite distinct from its fellow. Like other serous membranes, the ra consists of two portions—parietal and visceral—which, however, continuous with one another.

The **parietal pleura** lines the parietes, and is divisible into five ions—namely, costal, diaphragmatic, pericardial, cervical, and iastinal. The *costal pleura* lines the inner surfaces of the ribs and rnal intercostal muscles. The *diaphragmatic pleura* covers the er surface of one half of the diaphragm. The *pericardial pleura* intimate contact with the pericardium, the phrenic nerve and mpanying vessels alone intervening. The *cervical pleura* forms t is known as the **cupola** (*dome*), and rises into the neck for about ch above the clavicle, being a little higher on the right side than he left, on account of the projection formed by the liver. The *iastinal pleura* of each side bounds the *mediastinum*.

The **viscera pleural** closely invests the lung, and is known as the *nonary pleura*. It is intimately connected with the lung substance, extends into the fissure, or fissures, which map out the lung into s. Below the root of each lung it forms a fold, called the *pulmonary ment*, which descends to the diaphragm; medianly the fold is cted in front on to the pericardium, and behind on to the œso-gus.

Continuity and Reflections of the Pleura—(1) *In the Transverse ection.*—Commencing at the deep surface of the sternum, the etal pleura of each side passes backwards to the pericardium, the

two being in contact except for a little inferiorly. They form
lateral boundaries of the space which is called the *anterior mediastin*
When they reach the pericardium the two pleuræ separate, each keep
to its own side of that sac, and so forming the pericardial ple
which bounds laterally the space known as the *middle mediastin*
Each pleura in this manner reaches the anterior aspect of the r
of the corresponding lung, where it becomes the visceral pleura. T
covers the front of the root of the lung, and then invests the en
organ, dipping into its fissure or fissures, as the case may be, and giv
a covering to the posterior aspect of the root. On leaving the b
of the root of each lung, the two pleuræ pass backwards slightly c
the pericardium, trachea, and œsophagus, and over the descend
thoracic aorta, to the lateral aspects of the bodies of the thor
vertebræ. These portions form the lateral boundaries of the sp
which is called the *posterior mediastinum*. From the vertebral colu
each pleura passes outwards over the gangliated trunk of the sy

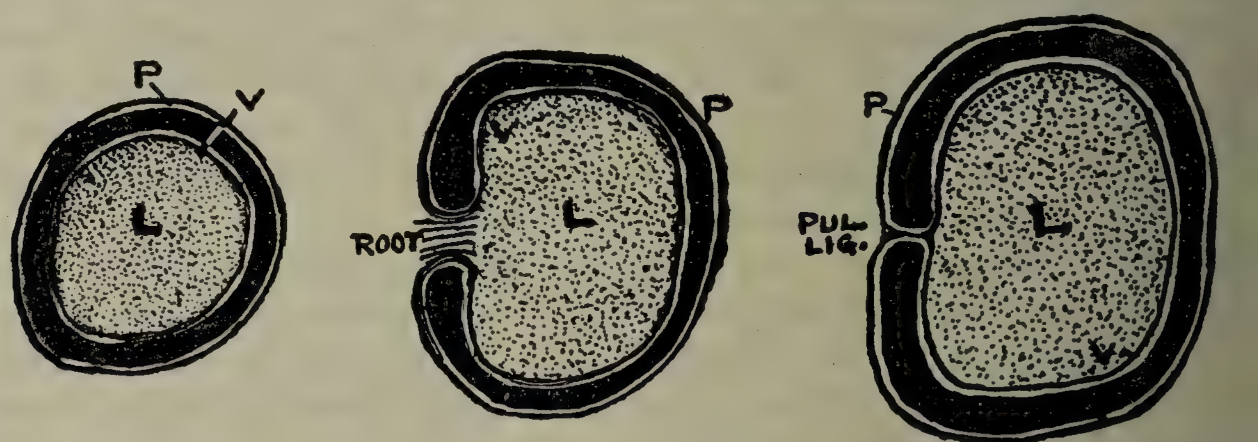


FIG. 584.—SCHEMES TO SHOW PLEURAL CONDITIONS ABOVE, THROUGH, BELOW THE ROOT OF LUNG (L).

P, parietal pleura; V, visceral pleura.

pathetic, and then lines the inner surfaces of the ribs, as well as
internal intercostal muscles. In this manner it reaches the d
surface of the sternum.

From the foregoing description it will be evident that the pleu
in passing from the deep surface of the sternum to the vertebral colum
meets with, and is reflected over, the lung and its root. At the le
of the manubrium sterni the pleura passes uninterruptedly backwa
to the vertebral column. That of the right side passes over the s
of the superior vena cava, innominate artery, right innominate v
and trachea; whilst that of the left side passes over the side of
left common carotid and left subclavian arteries, œsophagus, a
thoracic duct. The two pleuræ, as they pass backwards at this le
form the lateral boundaries of the space which is called the *supe*
mediastinum.

Below the level of the root of the lung the antero-posterior reflect
of the pleura is complicated by a triangular fold, called the *pulmon*
ligament. This fold consists of two layers of pleura in close appositi

ch are continuous superiorly with the anterior and posterior pleural estments of the root of the lung. It extends, on the one hand, veen the lower border of the root of the lung and the diaphragm, which latter it is attached, and, on the other hand, between the cardium and the inner surface of the lung below the level of the . In the last-named situation its two layers separate to encase lung at that level. Its lower border is free and concave.

(2) *In the Vertical Direction.*—*Superiorly* the parietal pleura of 1 side rises in the form of a cupola into the root of the neck for about ch above the clavicle, where it is covered by *suprapleural membrane son's fascia*). This fascia is derived from the scalene group of cles, and is attached, on the one hand, to the medial border of the rib, and, on the other, to the front of the transverse process of the

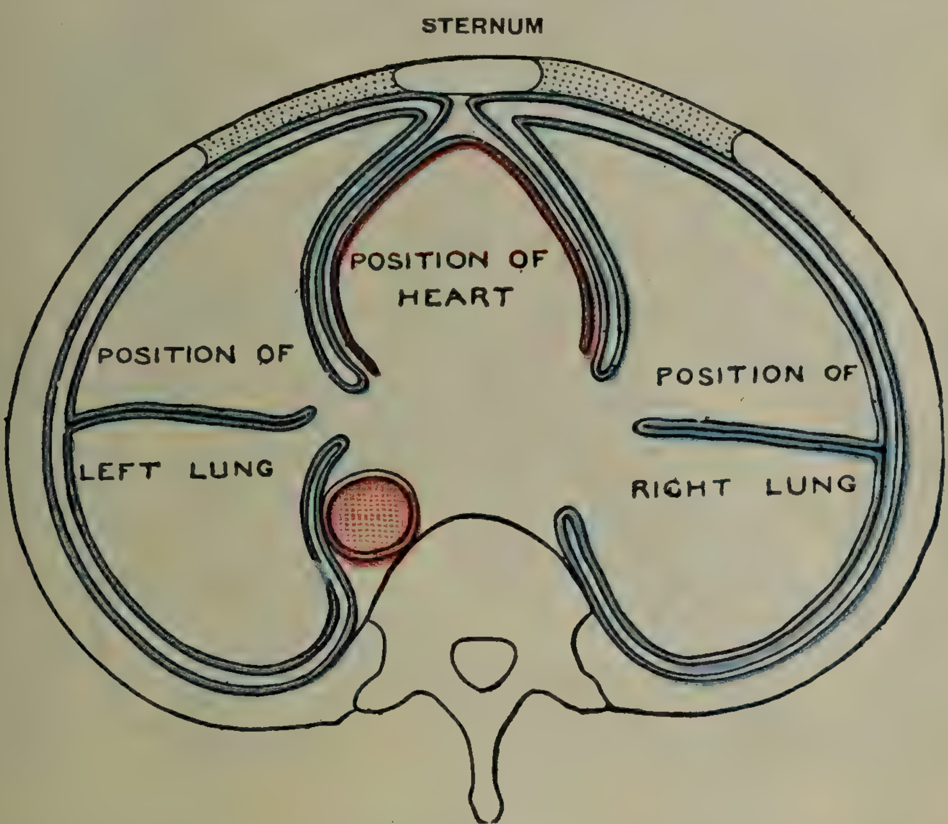


FIG. 585.—DIAGRAM SHOWING THE REFLECTIONS OF THE PLEURÆ (TRANSVERSE SECTION).

enth cervical vertebra. The subclavian artery and innominate 1 are intimately related to the cupola of the pleura internally and eriorly, the artery being the higher of the two. Immediately in it of the artery the phrenic and vagus nerves and the internal mmary vessels lie in contact with the pleura. *Inferiorly* the ietal pleura of each side is reflected from the thoracic wall on to upper surface of the corresponding portion of the diaphragm, ch it covers where the base of the lung rests upon it. The intering portion of the diaphragm (central tendon) is covered by the ous portion of the pericardium. Medially the diaphragmatic pleura omes continuous with the mediastinal pleura.

Lines of Reflection of the Pleuræ—*Sternal Reflection.*—Behind the nubrium sterni the right and left pleuræ are separated from each er by an interspace which represents the *superior mediastinum.*

At the level of the junction of the manubrium and body of the stern they meet each other, and descend behind the body of the bon close contact and inclining slightly to the left of the median line. the level of the lower border of the fourth costal cartilage the pleura parts company with the right, and passes outwards downwards close to the left border of the sternum, and in intin

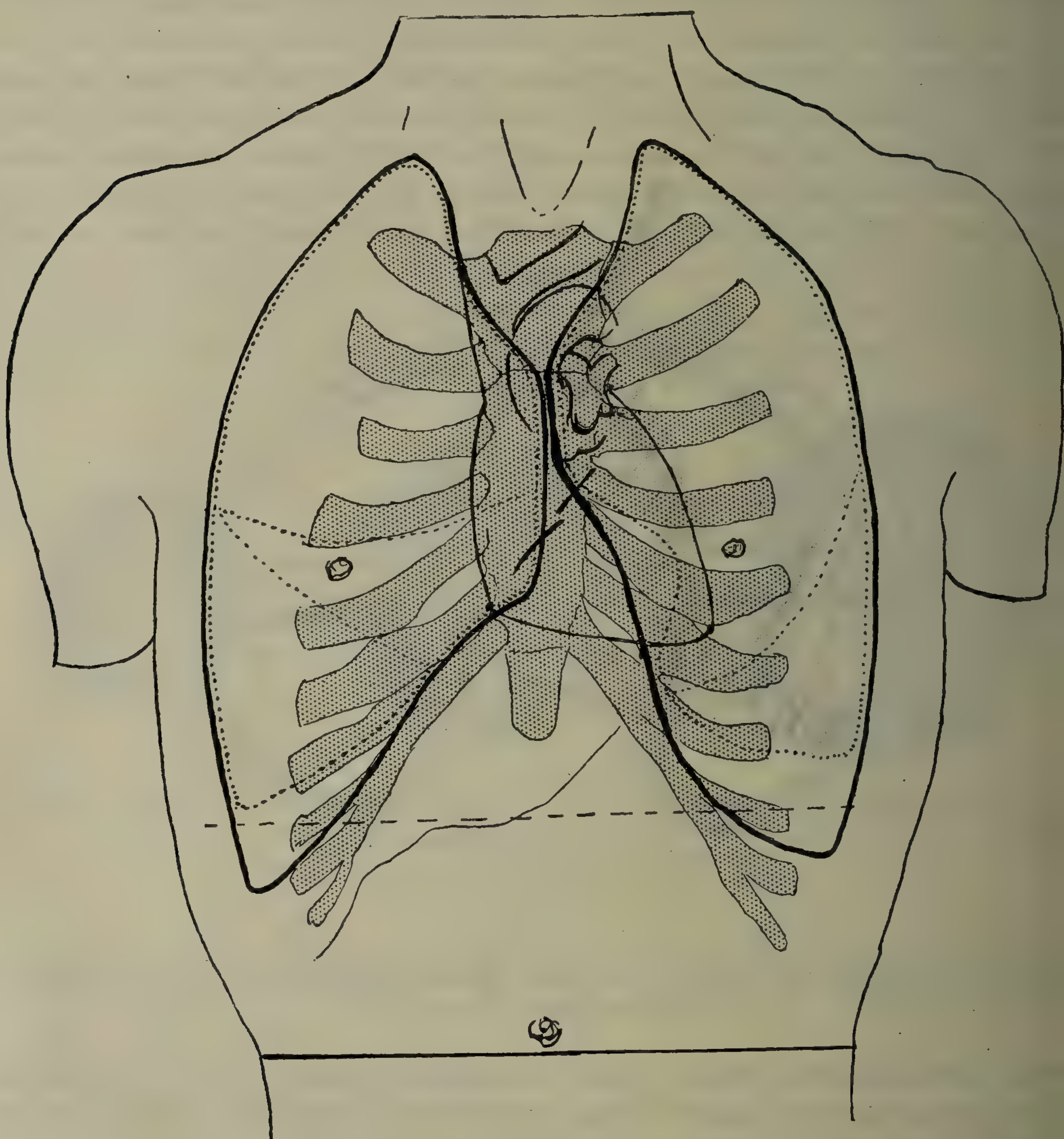


FIG. 586.—SURFACE MARKINGS ON FRONT OF THORAX.

Thick black lines mark pleura; dotted lines within these show lungs and fissures; fine lines heart and main vessels and lower edge of liver medi interrupted line shows transpyloric plane.

relation with the pericardium. There is, however, a small triang area of that sac which is uncovered by the pleura, and lies in di relation to the anterior thoracic wall. The left pleura continues downward course as far as the inner surface of the sixth costal cartil lying not far from the left border of the sternum. At this leve again passes outwards and downwards, to be reflected on to diaphragm. The *right* pleura pursues an undeviating course downwa

nd the sternum as far as the junction of the body and xiphoid ess. At this level it leaves the bone, and passes obliquely outwards, ıwards, and backwards over the inner surface of the seventh costal ılage, from which it is reflected on to the diaphragm.

'osto-diaphragmatic Reflection.—The level of this reflection may be idered, in the first place, as it affects certain definite vertical lines. he left sternal line it takes place at the level of the sixth costal

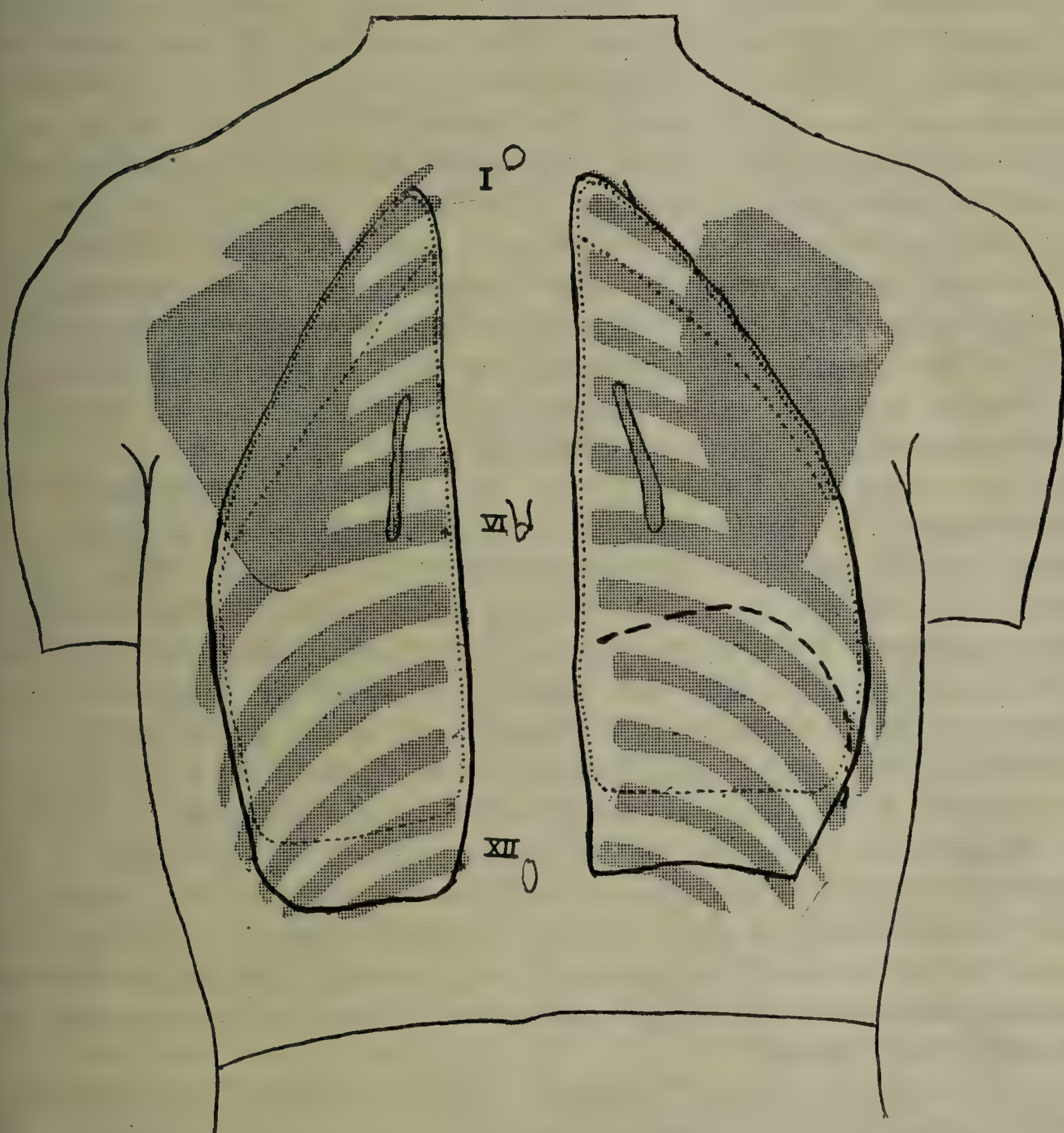


FIG. 587.—SURFACE MARKINGS ON BACK OF THORAX.

ıra, thick line; lungs and fissures, dotted lines within these; uppermost level of diaphragm and liver on right side, interrupted line. First, sixth, and twelfth thoracic spines marked. Roots of lungs indicated.

tilage, and in the right sternal line at the level of the seventh costal tilage. In the left mammary line it takes place at the level of the ıth costal cartilage, where it joins the osseous part of the rib, and the right side at a similar level. In the left mid-axillary line it es place on a level with the lower border of the tenth rib, this being lowest point to which the pleura descends. In the right mid-llary line it takes place on a level with the upper border of the tenth , or, it may be, the lower border. Posteriorly, in the scapular line

(inferior angle of the scapula) on each side it takes place at the le of the lower border of the twelfth rib. From this point inwards the vertebral column the line of pleural reflection is a little below adjacent border of the twelfth rib, and is very nearly midway betw the vertebral end of that rib and the first lumbar transverse proces

From the foregoing description it will be evident that the ple descends lowest in the mid-axillary line, and that posteriorly, cl to the vertebral column, it actually descends below the level of lower border of the twelfth rib. The direction of the line of cos diaphragmatic reflection, from before backwards, is at first obliqu downwards and outwards until the level of the tenth rib is reach The line then passes backwards and upwards to the vertebral colu The costo-diaphragmatic pleural line is on a distinctly lower le than the margin of the base of the lung, but it is a little above the l of the costal attachment of the diaphragm. The portion of diaphragm below the line is therefore in direct contact with the thora wall and adjacent internal intercostal muscles, without the intervent of the pleura, and the costo-diaphragmatic reflection is connected these structures by a fascial expansion.

The free surfaces of the parietal and visceral pleuræ are in hea in close contact. They are polished, and moistened by a slight amo of serous fluid, so that they glide smoothly upon each other. In ca of pleurisy, however, certain changes take place. The free surfa become roughened by the deposit of lymph, and the movement of lung is accompanied by the sound known as pleuritic fricti Adhesions are also frequently formed, and a serous exudation ta place into the pleural sac, which tends to compress the lung injurious the condition being known as pleurisy with effusion. In cases serous exudation the cavity of the pleura, which is a shut sac, is clea demonstrable, but in health no such cavity exists, the parietal a visceral pleuræ being at all times in intimate contact with each oth The attached surfaces of the parietal and visceral pleuræ are roughe by fibrous processes, by means of which they are connected to parts which they cover.

The costal pleura is the thickest, and can readily be stripped fr the inner surfaces of the ribs and internal intercostal muscles. Th is a fairly thick layer of subserous areolar tissue on its attached surfa The diaphragmatic and pericardial pleuræ are thinner than the cos pleura, and are more adherent to the subjacent structures. T diaphragmatic pleura follows closely the upper surface of the diaphra in its antero-posterior curvature, with the result that though in mammary line it is attached anteriorly to the eighth costal cartila it ascends when traced backwards to the level of the fifth costal cartila prior to turning downwards to the level of the twelfth rib. T pulmonary pleura is the thinnest and most adherent. Beneath there is a layer of subserous areolar tissue containing much elas tissue, and this is in continuity with the areolar tissue which perva the lung.

ifferences between the Two Pleural Sacs.—The *right* pleural sac rises higher he root of the neck, and is shorter and wider than the *left*. These differences ue partly to the projection formed by the liver on the right side, and partly e greater inclination of the heart to the left of the sternum than to the right.

lood-supply.—The *parietal pleura* receives its arteries from the rior and posterior intercostals, and from the various branches of internal mammary. The *visceral pleura* receives its blood from ronchial arteries.

he **veins** pursue courses corresponding to the arteries.

erve-supply.—The nerves are derived from the sympathetic, nic, vagus, and intercostal nerves.

ymphatics—Visceral or Pulmonary Pleura.—The lymphatic vessels is part of the pleura open into the *superficial lymphatics of the* s. **Parietal Pleura.**—The lymphatics of the *costal pleura* open the *lymphatics of the internal intercostal muscles*, which terminate) the sternal or internal mammary glands, and (2) the intercostal ds. The lymphatics of the *diaphragmatic pleura* open into the *hatics of the diaphragm.* The lymphatics of the *mediastinal pleura* into (1) the anterior mediastinal glands, and (2) the posterior astinal glands.

here are some costal pleural areas, however, which have particular ages. The 'apical' or **cervical** pleura, including that part below niddle of the first rib, drains into glands in the bottom of the neck, nd the lower end of the jugular, or it may be into the subclavian k; occasionally it seems to have some drainage into the uppermost of the axillary glands. Just below this area, and extending to about the fourth rib, is a second region which, beside the ary drainage into posterior intercostal and internal mammary ds, usually has some drainage through the thoracic wall into the ary glands, accompanying the lateral intercostal nerves and vessels. drainage into axillary glands may even (but unusually) extend down r as the sixth rib.

ructure.—The pleura is a typical serous membrane like the serous portion e pericardium, the peritoneum, and the tunica vaginalis. Such mem- es are called *serous* because their free surfaces are moistened by a small tity of serous fluid. Briefly stated, the pleura consists of a homogeneous, ective-tissue basement membrane, containing elastic tissue, and lined endothelium.

evelopment.—The pleura is developed from the walls of the cœlom, or -cavity, which is the cleft in the mesoderm separating the splanchnopleure omatopleure (see p. 78).

he Mediastinum.—The mediastinum is formed by the approxi- on of the two pleural sacs in the region of the median antero- erior line of the thorax. The interval between the two sacs is d the *mediastinal space*, and its boundaries are as follows: in front, ternum; behind, the bodies of the thoracic vertebræ; and on either the corresponding pleural sac. The mediastinal space contains tures so numerous as to necessitate its subdivision into four parts perior, anterior, middle, and posterior.

The **superior mediastinum** is situated above the pericardium, its **boundaries** are as follows: *in front*, the deep surface of the manub sterni, with the origins of the sterno-hyoid and sterno-thyroid mus *behind*, the bodies of the upper four thoracic vertebræ and the l portions of the longus cervicis muscles; *above*, an imaginary p corresponding to the superior aperture of the thorax; *below* imaginary plane passing from the lower border of the manub sterni to the lower border of the body of the fourth thoracic verte

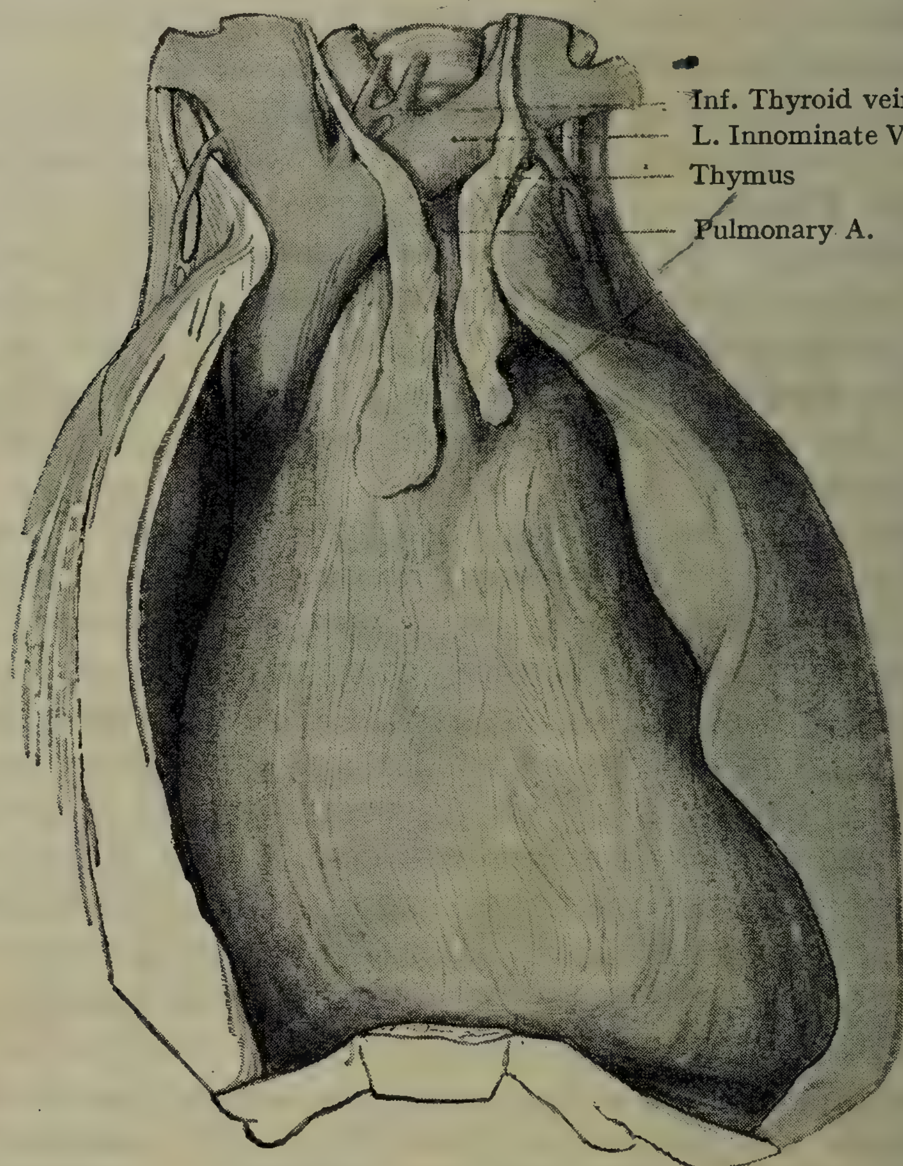


FIG. 588.—MEDIASTINAL CONTENTS EXPOSED BY PULLING BACK THE ANTE PARTS OF THE PLEURAL SACS.

Smaller mediastinal vessels are not shown.

and *laterally*, the mediastinal pleura of each side as it extends from deep surface of the manubrium sterni to the vertebral column.

Contents.—These are as follows: (1) the arch of the aorta; (2) innominate artery, and the thoracic portions of the left common car and left subclavian arteries; (3) the right and left innominate ve and the upper half, or extra-pericardial portion, of the superior v cava; (4) the phrenic, vagus, left recurrent laryngeal, and car nerves; (5) the trachea, œsophagus, and thoracic duct; (6) the supe mediastinal glands; and (7) the remains of the thymus.

In studying the topographical anatomy of the thorax it will

d convenient to use as a landmark the manubrio-sternal joint, h is often sufficiently superficial to be apparent as a transverse known as the *sternal angle* (angle of Louis). The angle is in the horizontal plane as the disc between the bodies of the fourth and thoracic vertebræ, and therefore indicates the level of the imaginary e separating the superior from the other divisions of the mediasti-. The angle marks the level at which the ascending aorta ends and descending aorta begins: the superior limit of the pericardium ~~and~~

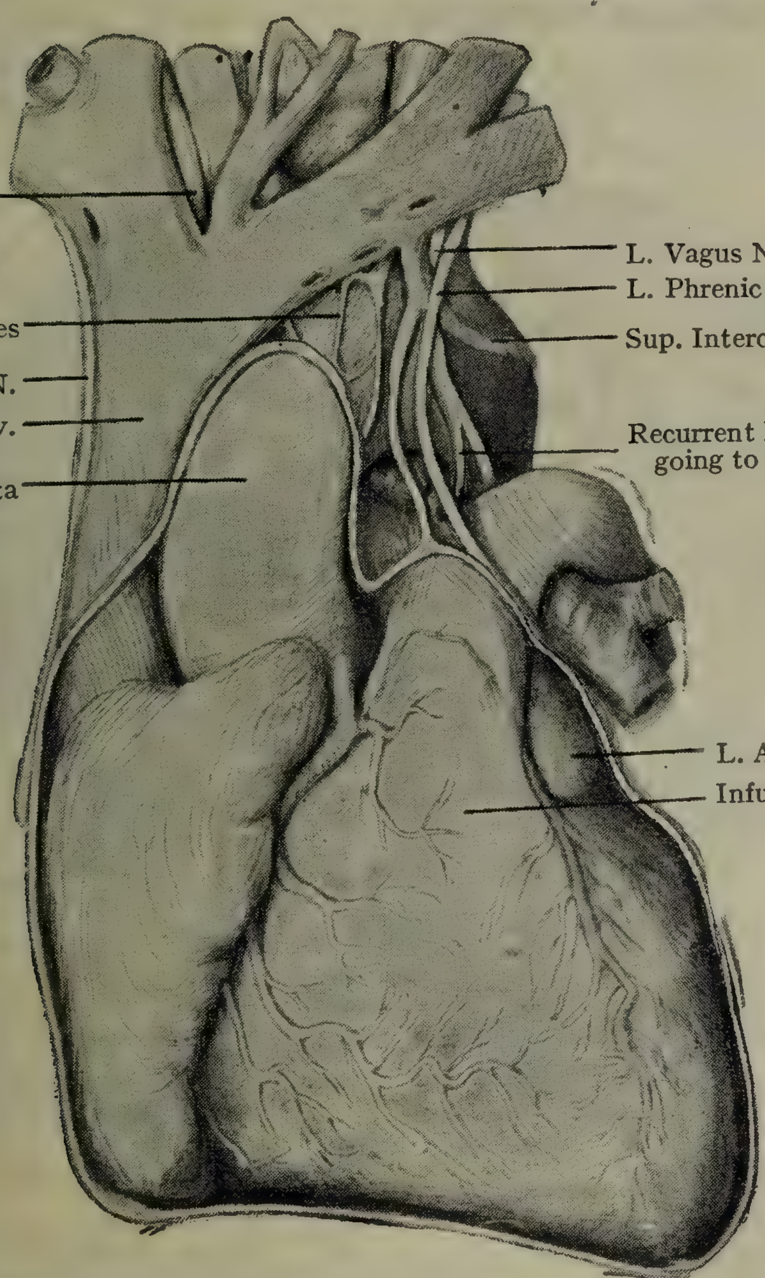


FIG. 589.—MAIN MEDIASTINAL STRUCTURES SEEN FROM THE FRONT (HEART EXPOSED).

he left side of the heart. At this same level the two pleural sacs meet ront, the trachea bifurcates, the vena azygos enters the superior a cava, the left recurrent laryngeal nerve winds round the ligatum arteriosum, the thoracic duct crosses the middle line, and the phagus reaches the middle line.

The **anterior mediastinum** is situated behind the body of the num, and its **boundaries** are as follows: *in front*, the deep surface he body of the sternum, and the left sterno-costalis muscle; *behind*, pericardium; and *laterally*, the mediastinal pleura of each side as

it extends from the deep surface of the body of the sternum to the lateral aspects of the pericardium. Its direction is downwards and to the left. At its upper part there is no interspace, because the two pleural sacs come into contact behind the first piece of the body of the sternum. Below this level, however, the left pleural sac diverges from its fellow, so as to leave an interspace.

Contents.—These are the anterior mediastinal glands, some lymphatic vessels, the anterior mediastinal branches of the internal mammary artery, and areolar tissue.

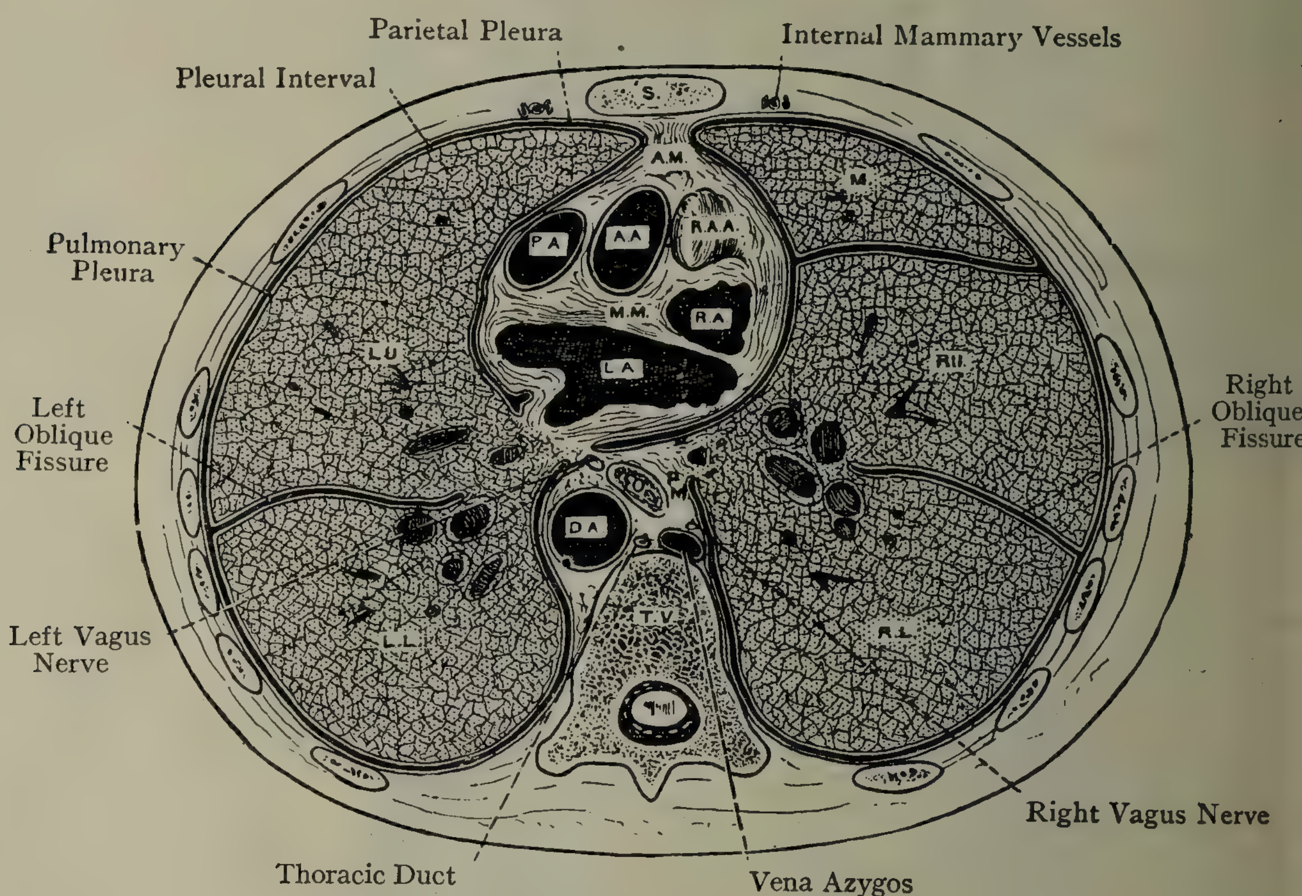


FIG. 590.—TRANSVERSE SECTION OF THE THORAX THROUGH THE SECOND STERNAL SEGMENT IN FRONT AND THE BODY OF THE NINTH THORACIC VERTEBRA BEHIND, SHOWING THE REFLECTIONS OF THE PLEURÆ AND THE POSITION OF THE VISCERA.

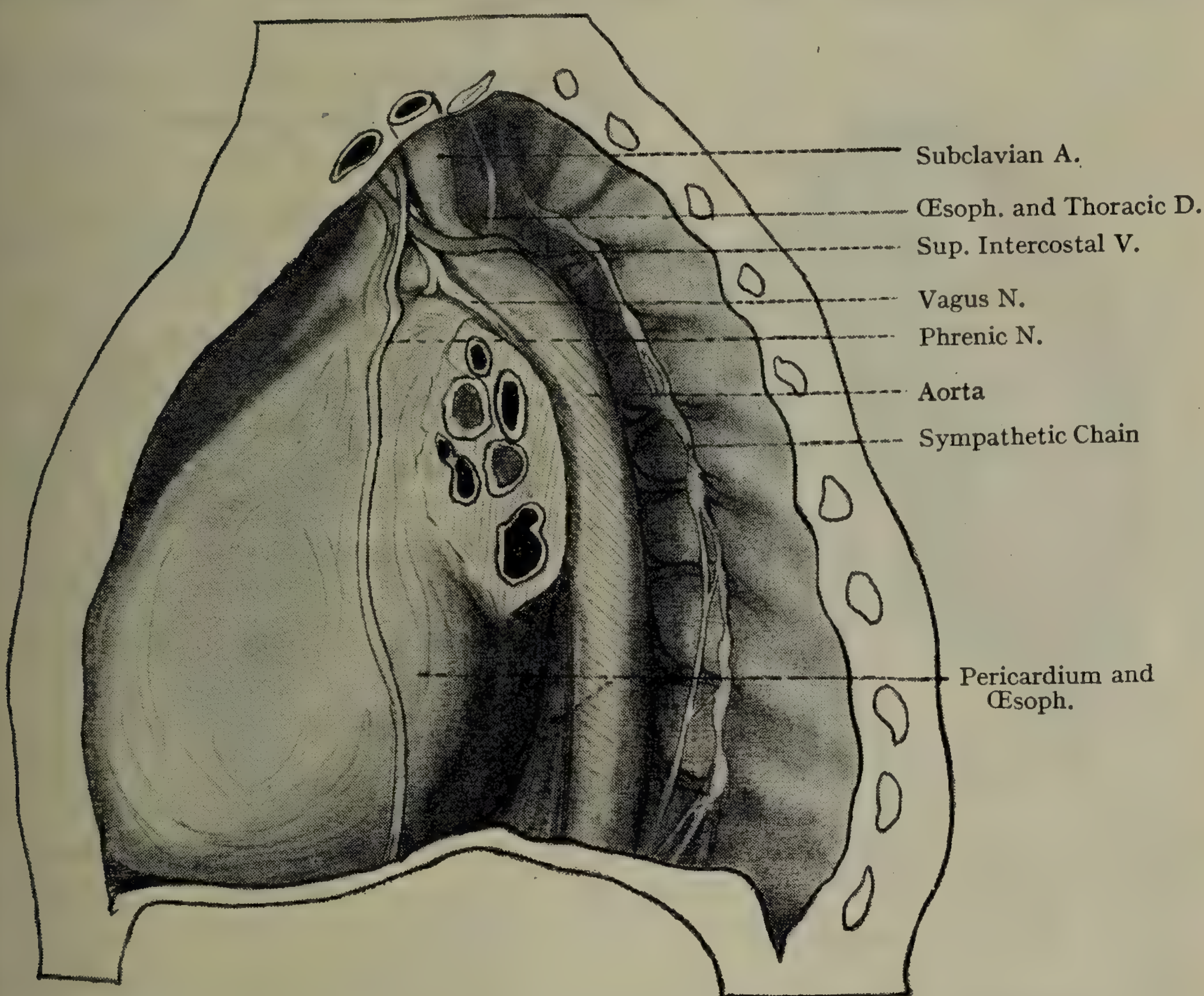
S. Sternum
A.M. Anterior Mediastinum
A.A. Ascending Aorta
P.A. Pulmonary Artery
R.A.A. Right Appendix
R.A. Right Atrium
M.M. Middle Mediastinum
L.A. Left Atrium
P.M. Posterior Mediastinum
O. Œsophagus
D.A. Descending Thoracic Aorta
T.V. Thoracic Vertebra
M. Middle Lobe of Right Lung
R.U. Right Upper Lobe
R.L. Right Lower Lobe
L.U. Left Upper Lobe
L.L. Left Lower Lobe

Anterior Mediastinal Glands.—These glands are situated within the areolar tissue of the *lower part* of the anterior mediastinum, between the lower part of the body of the sternum and the front of the pericardium.

They receive their *afferent* vessels from (1) the antero-median portion of the diaphragm, corresponding to the xiphoid process of the sternum; (2) the supero-anterior surface of the liver on either side of the falciform ligament; (3) the anterior part of the pericardium; (4) the anterior part of the mediastinal pleura. Their *efferent* vessels ascend and open into the *internal mammary* and *superior mediastinal* glands.

he **middle mediastinum** lies behind the anterior and below the rior mediastinum, and is the widest part of the interpleural space. **ontents.**—These are as follows: (1) the heart, enclosed in the ardium; (2) the ascending aorta; (3) the pulmonary trunk; ne lower half or intrapericardial portion of the superior vena cava; he phrenic nerves and the pericardiaco-phrenic vessels; (6) the cation of the trachea; and (7) the roots of the lungs.

he **posterior mediastinum** is situated behind the pericardium, and v the posterior part of the superior mediastinum, with which r it is continuous. Its **boundaries** are as follows: *in front*, the ardium, and below this the posterior part of the diaphragm;



. 591.—Structures in Posterior Mediastinum, seen from the Left.

nd, the bodies of the thoracic vertebræ below the level of the lower ler of the body of the fourth; and *laterally*, the mediastinal pleura ach side as it extends from the back of the root of the lung to side of the vertebral column.

ontents.—These are as follows: (1) the descending thoracic aorta; he œsophagus, and the two vagus nerves; (3) the thoracic duct; he vena azygos; (5) the superior and inferior venæ hemiazygos, with corresponding transverse azygos veins; (6) the greater splanchnic es, right and left; and (7) the posterior mediastinal glands.

Phrenic Nerve.—The nerve arises chiefly from the anterior primary sion of the fourth cervical nerve. It usually receives a small root

from the anterior primary division of the third cervical, and, a rule, an additional root from that of the fifth cervical. Hav descended on the superficial surface of the scalenus anterior mu to the root of the neck, it crosses the internal mammary artery sup ficially from without inwards. It then enters the thorax and desce in front of the root of the lung in close contact with the side of pericardium, and under cover of the mediastinal pleura. Hav reached the diaphragm, the nerve divides into several branches, wh pierce that muscle, to be distributed to its abdominal surface. terminal branches of each nerve are connected in the diaphragm w filaments of the corresponding phrenic plexus of the sympathe which is an offshoot from the cœliac plexus. At the place of junct of the two sets of fibres on right side there is a small gangli called the *phrenic ganglion.* the thorax the phrenic ne occupies the superior and mid mediastinal spaces. The *r* phrenic nerve lies in success on the outer side of the ri innominate vein and superior v cava, and then descends in fr of the root of the right lu Certain filaments from this ne not infrequently reach the un surface of the diaphragm passing through the vena ca aperture. The *left* phrenic ne descends in the interval betw the left common carotid a left subclavian arteries, where crosses the vagus nerve fr without inwards. It then pas behind the left innominate ve and crosses over the arch of aorta separated from the vagus by the left superior intercostal ve after which it descends in front of the root of the left lung. Ea nerve is accompanied by the pericardiaco-phrenic artery, which i branch of the internal mammary artery.

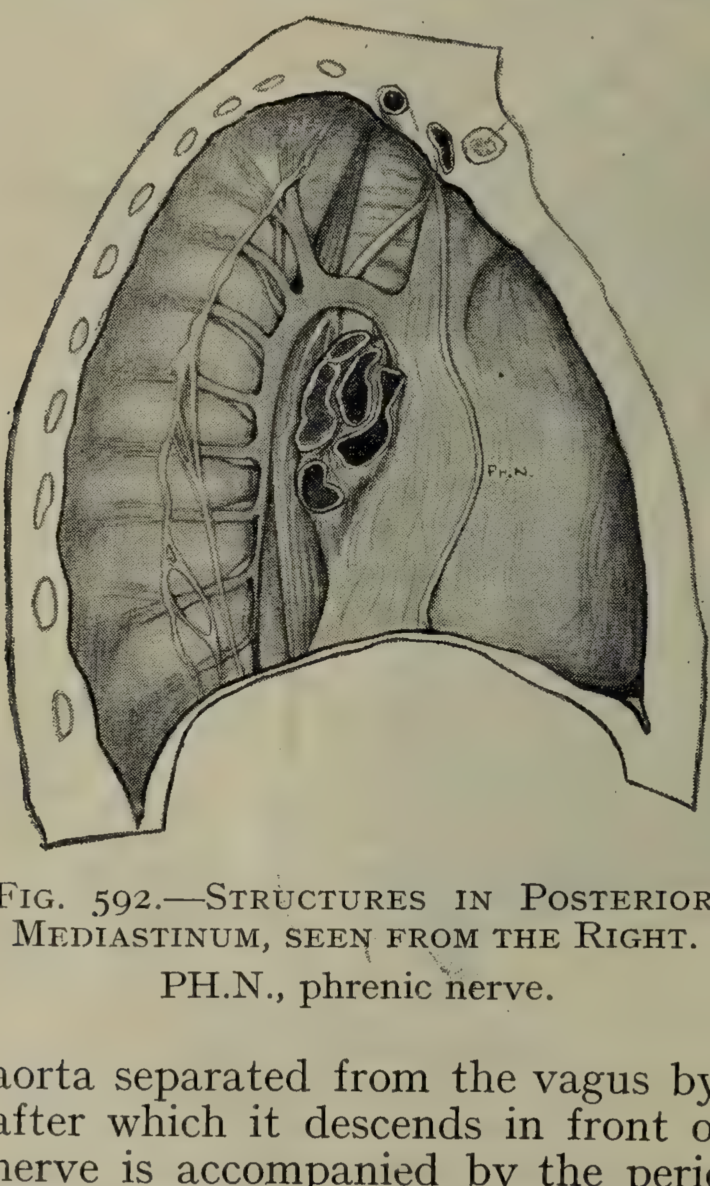


FIG. 592.—STRUCTURES IN POSTERIOR MEDIASTINUM, SEEN FROM THE RIGHT.
PH.N., phrenic nerve.

Branches.—The nerve of each side furnishes twigs to the pe cardium, the mediastinal pleura, the inferior vena cava, peritoneu liver, and suprarenal glands; its principal branches are, howev distributed to the diaphragm.

Differences between the Two Phrenic Nerves.—(1) The *right* nerve is shor than the left, because the right half of the diaphragm, having the bulk of liver below it, is higher than the left half. (2) The *right* nerve is straighter t the left, because the heart, enclosed in the pericardium, projects less to the ri side than to the left. (3) The *right* nerve occupies a deeper position in the up part of the thorax than the left.

Pericardium.—The pericardium is the fibro-serous sac which loosely ounds the heart in the middle mediastinum. It is somewhat cal, being wide below, where it is in contact with the diaphragm, narrow above, where it surrounds the great vessels connected the base of the heart. On each side it is intimately related to mediastinal pleura, and is embraced by the anterior portions of inner surfaces of the lungs. The phrenic nerve on each side descends ery close contact with it. In front of it are the body of the sternum the sternal ends of the corresponding costal cartilages. Its anterior ace is to a greater or less extent encroached upon by the adjacent

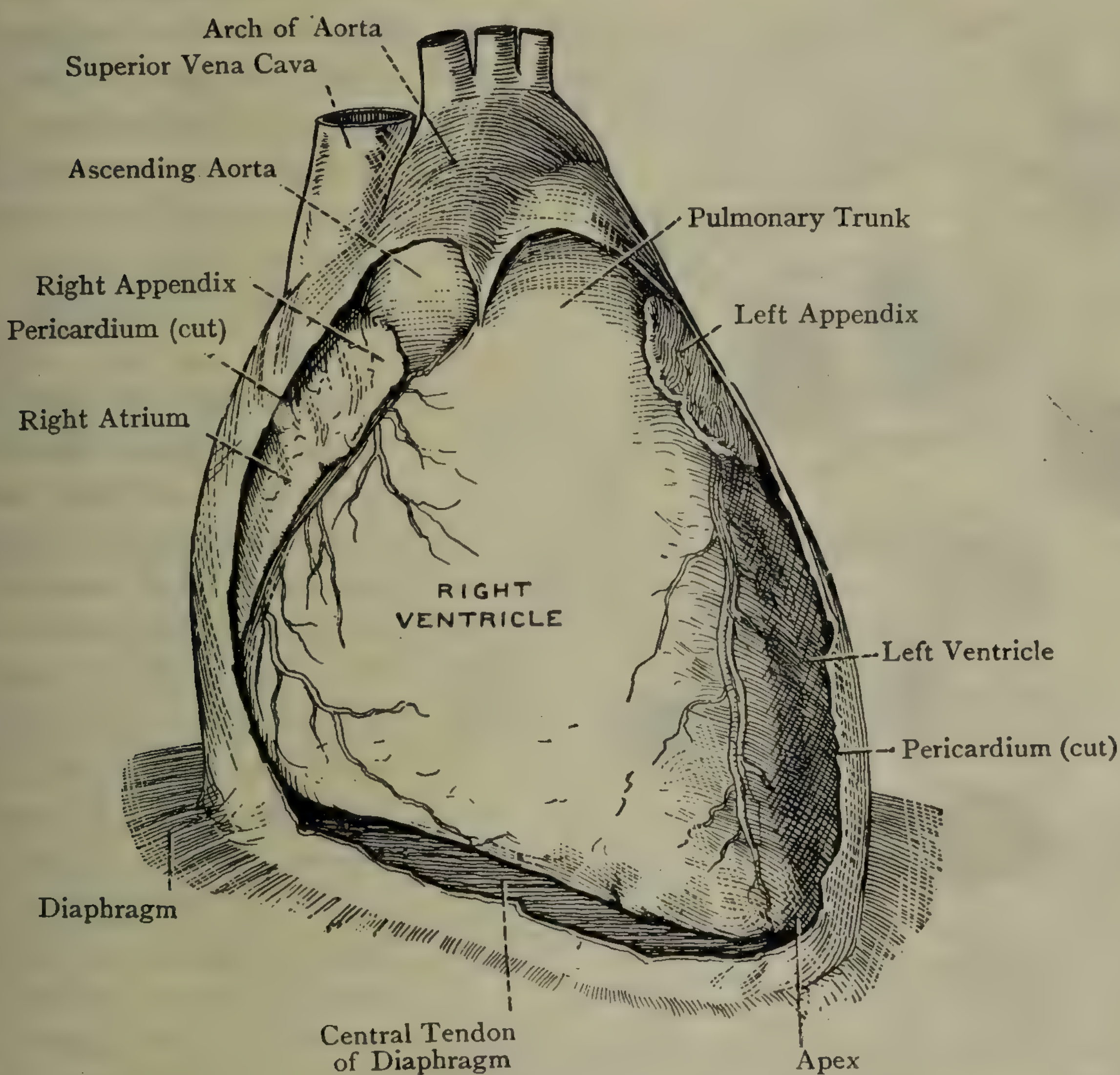


Fig. 593.—The Heart (Anterior View) and Pericardium.
The anterior part of the pericardium has been removed.

tions of the anterior margins of the lungs and by the two pleuræ. ere is, however, a small portion of this surface which is immediately ated to the sternum below the level of the lower border of the fourth costal cartilage at its sternal end. Posteriorly, the pericardium in front of the posterior mediastinum, and the œsophagus is here ated to it opposite the posterior aspect of the left auricle of the heart.

The pericardium consists of two portions—an external or fibrous, d an internal or serous. The **fibrous pericardium** is strong and dense. eriorly it is attached to the middle lobe of the central tendon of diaphragm, and slightly to its muscular part, more particularly

on the left side. Superiorly it ensheathes the great vessels connec with the base of the heart, with the single exception of the infer vena cava.

The fibrous layer is attached to the sternum by two fibrous ban which are known as the *superior* and *inferior sterno-pericard ligaments* of Luschka, the former being attached to the deep surf of the manubrium, and the latter to the deep surface of the xiph process.

The **serous pericardium** is a typical serous membrane, and consi of two layers, parietal and visceral, which together form a closed sa

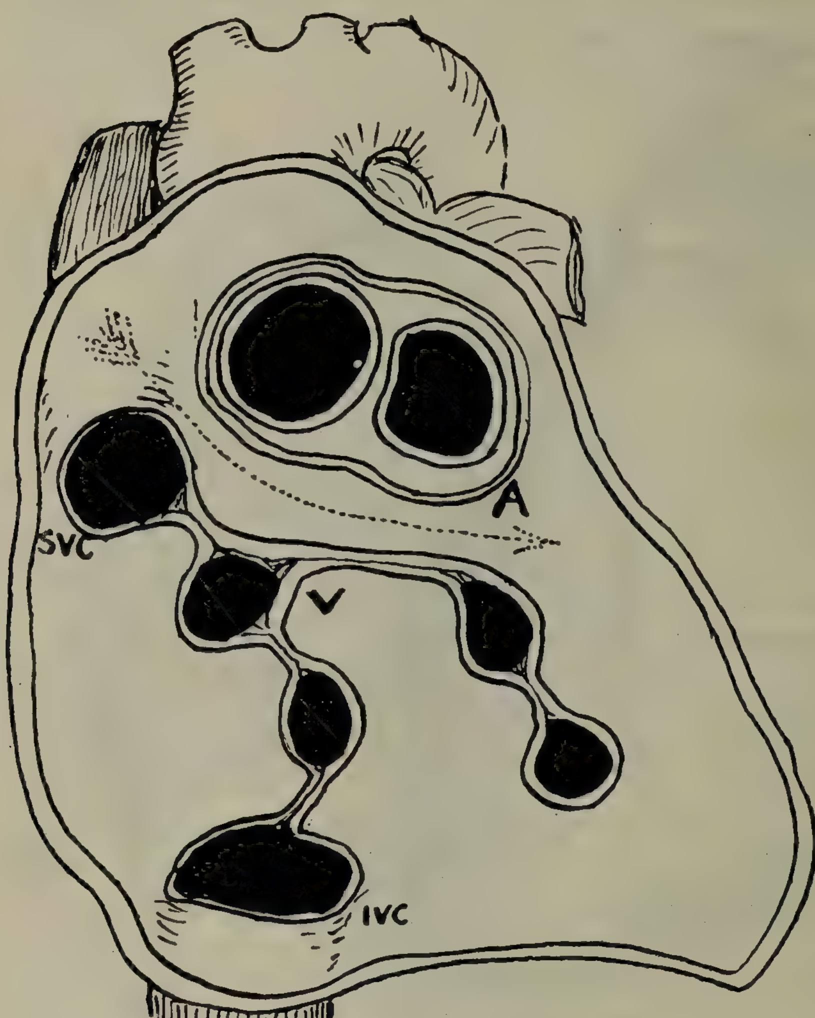


Fig. 594.—Scheme of Disposition of Arterial (A) and Venous Mesocardia (V) on Posterior Wall of Pericardium.

The dotted arrow lies in transverse sinus.

The *parietal portion* li the inner surface of t fibrous part, to which it closely adherent, and a intimately covers the upp surface of the central tend of the diaphragm.

The *visceral porti* known as the *epicardiu* closely invests the heart, a also the great vessels at base more or less complete The continuity between t parietal and serous portio is established inferiorly alo the inferior vena cav Superiorly the continuity established along the gre vessels at the base of t heart about $1\frac{1}{2}$ inches abo it. In this situation t serous portion forms an a terial sheath which enclos within it the ascending aor and pulmonary trunk f about $1\frac{1}{2}$ inches, this bei the only complete shea formed by the serous portic Behind this sheath, with its contents, and in front of the atrial porti of the heart, there is a passage, called the *transverse sinus* of t pericardium, which leads from the right to the left side of the sero sac. The serous portion is also related to the superior vena cava an the pulmonary veins, but it only covers them in front and at t sides.

The serous portion of the pericardium forms a triangular fo called the **ligament of the left vena cava (vestigial fold of Marsha** which is situated between the left pulmonary artery and the upper le pulmonary vein. Its base is directed towards the left, and its surfac

anterior and posterior. Between its two delicate layers there is
nall fibrous cord, a vestige of the left duct of Cuvier; this, like the
apericardial part of the superior vena cava on the right side,
ses down in front of the pulmonary vessels.

The free surfaces of the parietal and visceral layers of the serous
tion are smooth, polished, and lubricated by serous fluid to allow of
movement on the part of the heart. In the course of pericarditis
y become at first dry, and then roughened by deposits of lymph,
s giving rise to the pericarditic friction sound, and, it may be, to
esions. They may also become separated from each other by an
sion into the pericardial sac.

Blood-supply.—The fibrous portion of the pericardium and the
ietal layer of the serous portion receive their arteries from (1) the
icardial and pericardiaco-phrenic branches of the internal mammary,
(2) the descending thoracic aorta. The visceral layer of the
ous portion receives arterial twigs from the coronary arteries of the
rt.

The **veins** pass to the internal mammary, pericardiaco-phrenic, and
gos veins.

Nerve-supply.—The phrenic, vagus, and sympathetic nerves.

Lymphatics.—These pass to the anterior, superior, and posterior
diastinal glands.

Structure.—The fibrous portion of the pericardium is composed of fibrous
ue, and is very dense, but not very extensible. The serous portion consists
a homogeneous, connective-tissue basement membrane containing some
tic fibres, and lined with endothelium. The parietal layer is much thicker
n the visceral; the latter is intimately connected with the cardiac muscular
ue, except along the grooves, which are occupied by adipose tissue and
odvessels.

Development.—The serous portion of the pericardium is developed from
walls of the cœlom, or body-cavity, which is the cleft in the mesoderm
arating the splanchnopleure and somatopleure.

The fibrous walls have various origins; the antero-lateral parts come from
deep layers of the body-wall, split off by the extension of the pleural cavities,
l the lower or diaphragmatic part is derived from the septum transversum.
e cavity is at first continuous with the pleural sacs, but the openings, which
dorsal and medial to the ducts of Cuvier, are closed by the end of the first
nth.

The Thymus.—This is present in the fœtus and young child, and
ms a very conspicuous object in the dissection of a child during
e first year or two of life. It attains its greatest size at puberty,
er which, as a rule, it slowly atrophies, although traces of it are to
found even in advanced age. The atrophic process which it under-
es is, however, extremely variable. In its fully-developed condition
is situated partly in the thorax and partly in the neck. In the
mer situation it occupies the superior and anterior mediastinal
aces, extending as low as about the level of the fourth costal cartilages,
d lying in front of the great bloodvessels and upper part of the peri-
rdium, the upper part of the sternum being in front of it. In the
ck it extends as high as the lower part of the thyroid gland, being

under cover of the sterno-hyoid and sterno-thyroid muscles. In situation it embraces the front and sides of the trachea, complet concealing it from view, and encroaches upon the carotid sheath either side. Its length is ab $2\frac{1}{2}$ inches, and its breadth, wh is greatest inferiorly, is about inches. Its colour is pinkish is soft in consistence; and surface shows indications of lo lation. It consists of two asy metrical lateral lobes, each of wh is pyramidal. In some cases left lobe is the larger, and other cases the right. These lo are in close contact, but are quite distinct. Sometimes a th lobe is present, occupying an termediate position between other two.

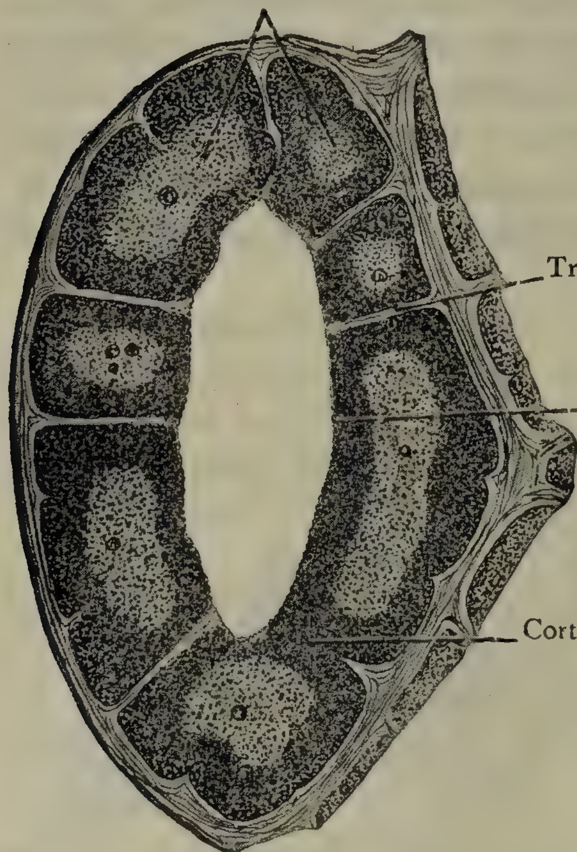


FIG. 595.—TRANSVERSE SECTION OF A LOBULE OF THE THYMUS GLAND OF A KITTEN.

The concentric corpuscles of Hassall are shown in the medulla.

Blood-supply.—The arteries chiefly derived from the inter mammary, inferior thyroid, a superior thyroid.

The **veins** open into the ri and left innominate and thyr veins.

Nerve-supply.—The nerves derived from the sympathetic a vagus.

Structure.—Each lobe has a capsule of fibrous tissue, from which trabec pass into the interior. These trabeculæ map out each lobe into large and sm lobules. Each lobule consists of an outer cortical and an inner medull portion. The *cortex* is composed of lymphoid tissue, the lymphoid elem predominating over the retiform, and it is surrounded by a capillary n work of bloodvessels which contains many lymph corpuscles. The lymph tissue of the cortex is incompletely subdivided into nodules by means trabeculæ.

The *medulla* is more transparent than the cortex, the retiform element the lymphoid tissue is more conspicuous, and the lymph corpuscles are l numerous. In addition, the medulla contains small groups of cells, more less concentrically arranged, which are known as the **concentric corpuscles Hassall.** According to one view, these cells are remains of the diverticula fr which the thymus body is developed; but another view is that they are concern with the formation of bloodvessels and connective tissue.

Development.—The thymus body is developed in two lateral parts from entodermic epithelium of the pharyngeal portion of the primitive gut. epithelium of the *third* visceral cleft on either side becomes evaginated early the second month, and gives rise to dorsal and ventral diverticula. The vent diverticulum, which forms the **thymic growth,** has a thick epithelial wall, bu small lumen, and grows in a downward direction. Its distal end, which ventral to the pericardium, forms a solid enlargement, and the proximal e loses its connection with the third visceral cleft. The enlarged distal end gi

umerous solid epithelial buds, which are invested with mesoderm. This ing gradually extends to the proximal part of the diverticulum. The solid and cords of each side ramify freely, and give rise to the corresponding lobe e thymus. The original diverticulum thus assumes a lobulated appearance, resembles a racemose gland. The buds or acini, however, are solid, and not w, as in racemose or acinous glands. The acini are separated by connective e and bloodvessels, which are developed from the surrounding mesoderm. phoid tissue is also developed from the mesoderm around the acini, and tissue forms the greater part of the adult thymus. The epithelial elements ch lobe are subordinate to the lymphoid tissue, and are ultimately represented ie **concentric corpuscles of Hassall.**

Lungs.—The lungs are two in number—right and left. They are igy in consistence, float in water, and are readily compressed. en pressed between the fingers crepitation is elicited, this being to the displacement of air. When the lung is incised, similar itation is heard, and a muco-serous fluid, mixed with air, exudes. y possess considerable elasticity, their colour is that of a dark slate, they are usually mottled, this being due to carbonaceous matter. arly life, however, the colour is rose-pink.

The lungs occupy the greater part of the thoracic cavity. Normally y are at all times in close contact with the thoracic walls, the pleuræ rvening. Unless adhesions have formed during life between the eral and parietal pleuræ, the surface of each lung is quite free ept in two situations—namely, at the root, which occupies a limited a of the inner surface, and at the attachment of the pulmonary ment. Each lung is conical, the base being directed downwards. presents for consideration an apex, a base, two surfaces, and two lers.

The **apex** is blunt, and rises out of the thoracic cavity into the t of the neck for about $1\frac{1}{2}$ inches. It is here covered by the cupola he pleura, and a little below its highest point it presents a groove its medial and anterior aspects. In the case of the right lung s groove is produced by the innominate and right subclavian arteries, l in the case of the left lung by the subclavian artery of that side. ow this groove there is another groove, produced on either side by innominate and subclavian veins.

The **base** is extensive, semilunar in outline, and concave in adapta- n to the upper arched surface of the diaphragm, upon which it ts, with the intervention of the pleura. The base of the right g is related to the right lobe of the liver, and that of the left lung he left lobe of the liver, the stomach, and the spleen, the diaphragm ervening in each case. The margin of the base is thin and sharp, l it extends into the costo-diaphragmatic recess, reaching lowest iind, but nowhere as low as the line of the costo-diaphragmatic ection of the pleura.

The **costal surface** is extensive and convex, and in health it is sely applied to the inner surfaces of the ribs and of the internal ercostal and subcostal muscles.

The **medial surface** is of much more limited extent than the outer

(Figs. 596 and 597). The greater part of it is concave (P) in adaptat to the heart, enclosed in the pericardium, the concavity being grea in the case of the left lung on account of the projection of the he to the left side. About the junction of the anterior two-thirds a posterior third this surface presents a vertical fissure, called the *hilu* at which the root of the lung is situated. The medial surface of *right* lung, behind the hilum, is related (Œ) to the œsophagus, and corresponding portion of the inner surface of the left lung prese

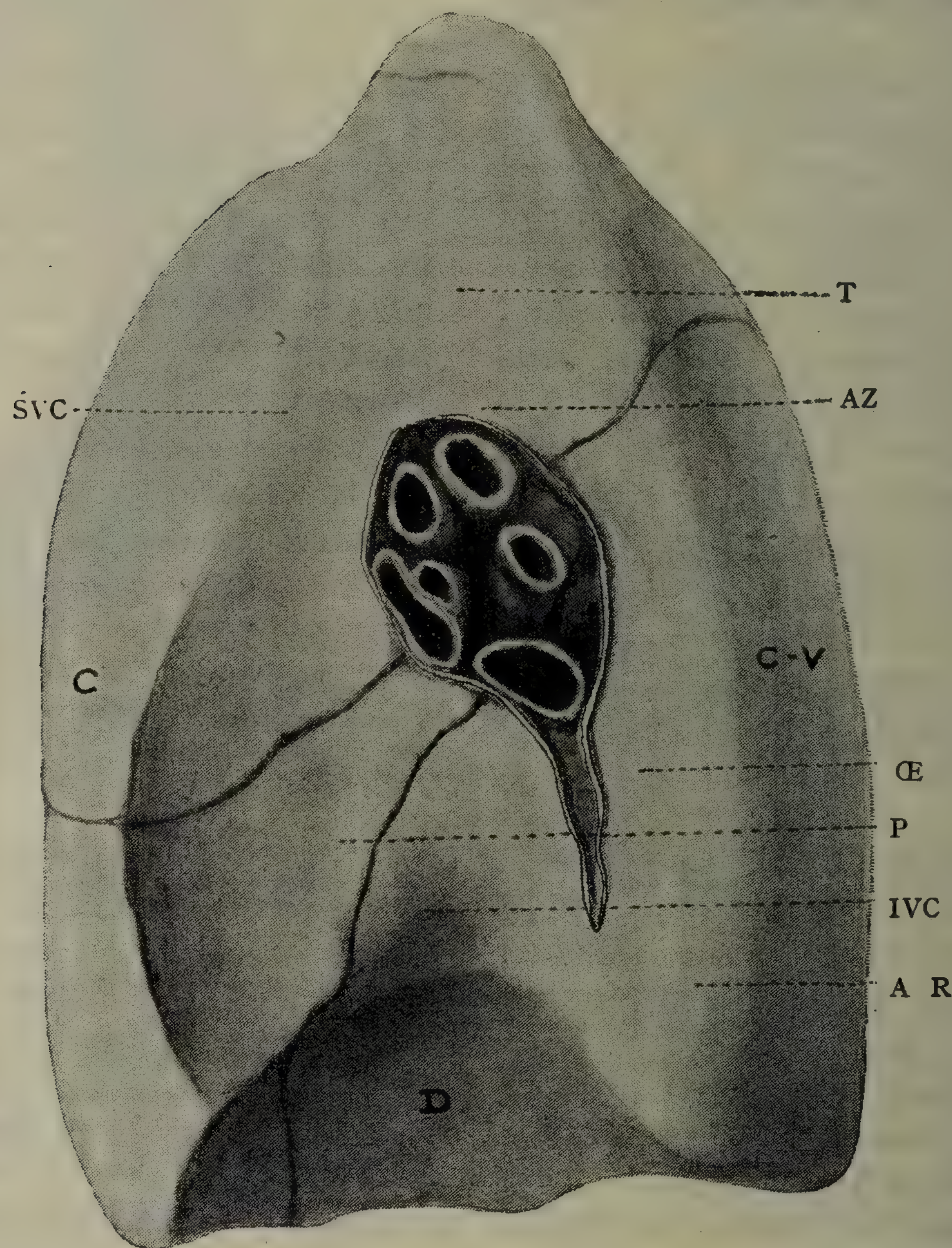


FIG. 596.—MEDIASTINAL ASPECT OF RIGHT LUNG.

part (DA) of the aortic groove, vertically placed and produced b the descending thoracic aorta. Anterior to the lower part of th groove the left lung is related to the œsophagus, but less intimate than the right lung. The inner surface of the *right* lung presen above the level of the hilum grooves for the following structures: th vena azygos (AZ), the superior vena cava (SVC) and right innomina vein, the innominate artery, the trachea (T) and œsophagus. Th inner surface of the *left* lung presents above the level of the hilu grooves for the following: the arch of the aorta (A), the left subclavia

ery (S), the left innominate vein, the œsophagus and thoracic t (Œ).

The **borders** are anterior and posterior. The **anterior border** is 1 and short, and overlaps the pericardium, more so during inspira- 1 than expiration, but leaving an area of the pericardium uncovered, wn as the area of precordial dulness. The anterior border of right lung keeps behind the sternum as low as the sixth right al cartilage. The corresponding border of the left lung, beyond lower border of the fourth left costal cartilage, presents a deep

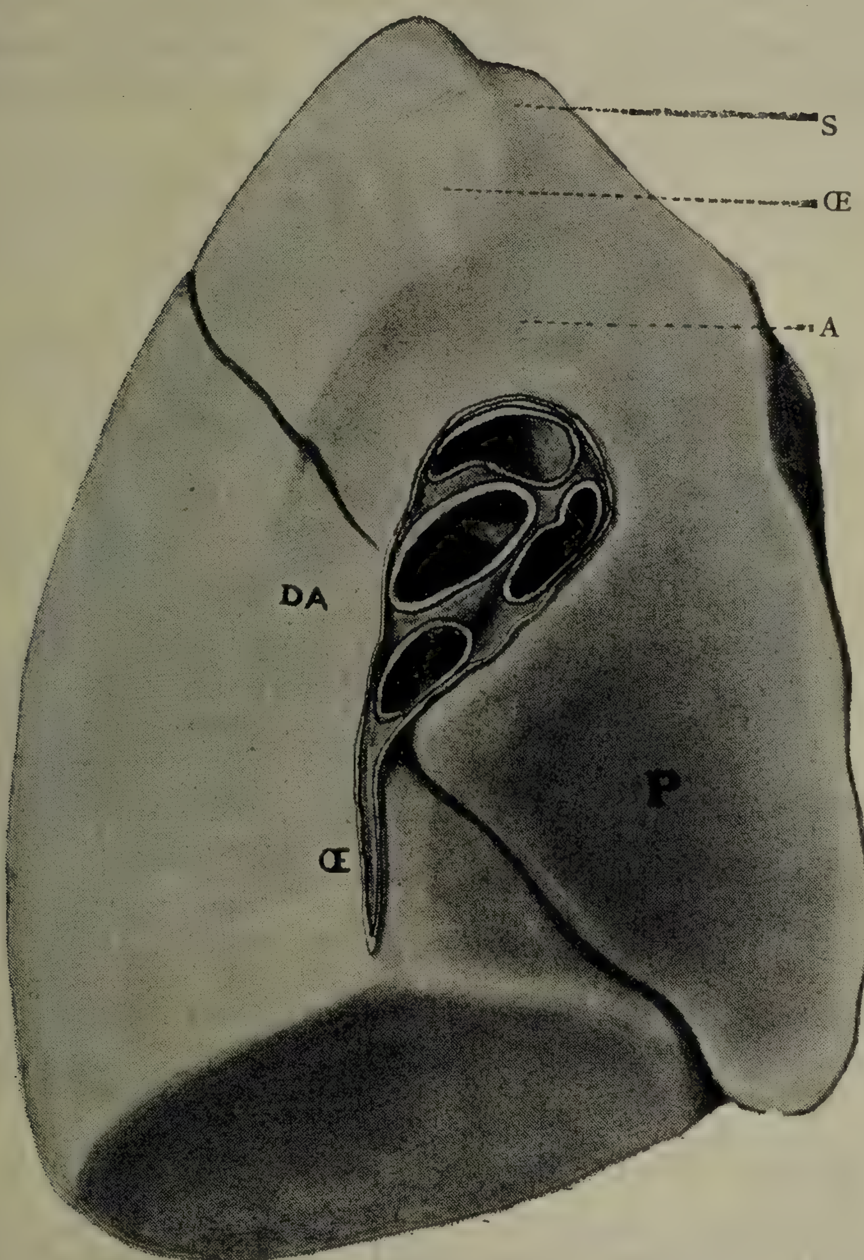


FIG. 597.—MEDIASTINAL ASPECT OF LEFT LUNG.

1aped notch, called the *cardiac notch*, for the reception of the al portion of the heart enclosed in the pericardium. The **posterior ler** is elongated, thick, and round, and occupies the groove by side of the vertebral column.

Each lung is divided into two **lobes,** upper and lower, by an exten- , oblique, and deep fissure, which penetrates to the hilum. So is this fissure that, unless adhesions have formed, the lung appears onsist of two halves. The fissure commences on the inner surface, the posterior border, about 3 inches below the apex. It then

turns round the posterior border, and passes obliquely downwa and forwards over the outer surface to the basal margin. In case of the right lung the fissure joins the basal margin some li distance from the lower end of the anterior border; but in the c of the left lung the fissure joins the basal margin distinctly fart forwards. A good ready guide to this fissure is the lower borde the pectoralis major muscle, as it forms the anterior fold of the axi

The **upper lobe** is comparatively small, and includes the ap about the upper 3 inches of the posterior border, the anterior bor and in the case of the left lung practically all that can be ausculta anteriorly. The **lower lobe** is of large size, and lies behind and be the oblique fissure. It includes the base, the posterior border exc

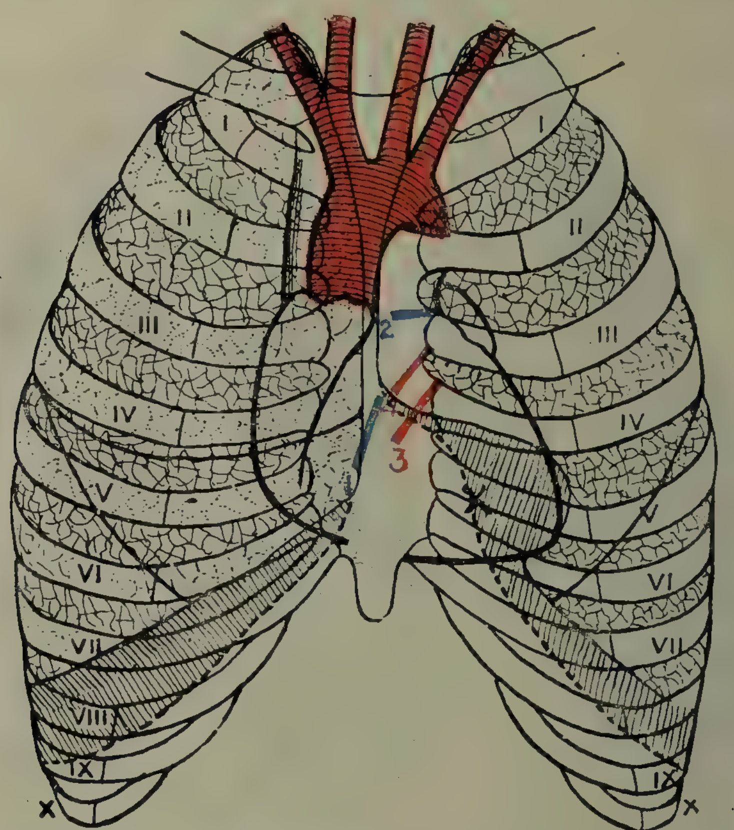


FIG. 598.—DIAGRAM SHOWING THE HEART AND LUNGS IN SITU.

1. Tricuspid Orifice 2. Pulmonary Orifice 3. Mitral Orifice 4. Aortic Orifice X, Region of Latham's Circle

the upper 3 inches, and practically all that can be ausculta posteriorly.

By means of the *oblique fissure* each lung, as stated, is divided i two lobes. In the case of the left lung the division proceeds no fartl In the case of the right lung, however, there is an additional fissu which extends from near the mid-point of the chief fissure at t posterior border horizontally forwards over the outer surface to t anterior border. This additional fissure cuts off from the upper lo a triangular or wedge-shaped portion, which is called the **middle lo**

A fourth or even a fifth lobe may be present on the right side. Th accessory lobes are usually found in the region of the hilum or of the infe vena cava. If in the former position, the accessory lobe appears to be due t lateral displacement of the vena azygos, which in these cases lies in the obli fissure; if in the latter position, the accessory lobe represents the azygos lob many animals.

Differences between the Two Lungs.—(1) The *right* lung has two ...res and three lobes, whilst the left lung has only one fissure and two ...s. (2) The anterior border of the *right* lung is uninterrupted whilst ... of the left lung presents inferiorly the cardiac notch. (3) The *right* ...rger and heavier than the left, the weight of the right being about ...unces and that of the left about 18 ounces. (4) The *right* lung ...orter than the left, this being due to the fact that the liver causes ... right half of the diaphragm to rise higher than the left half. ...The *right* lung is broader than the left, because the heart projects ...e to the left side than to the right.

Vertical Extent of the Lungs.—In the mammary line the *right* lung ...ends as low as the sixth rib; in the mid-axillary line as low as the

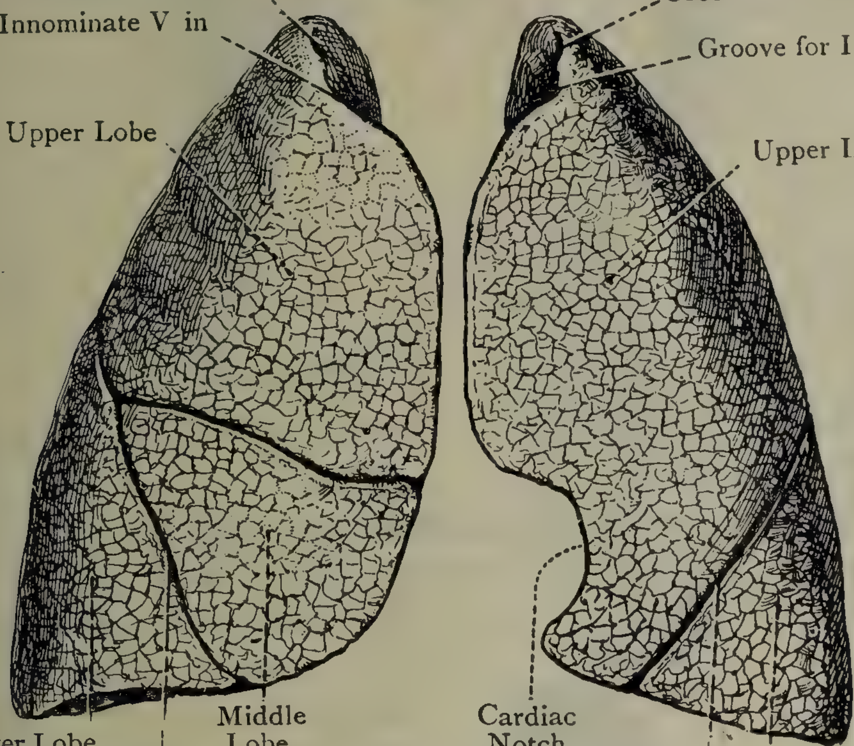


FIG. 599.—THE LUNGS (ANTERIOR VIEW).
A, the right lung; B, the left lung.

...th rib; and in the scapular line (inferior angle of the scapula) as ... as the tenth rib. The lower limits of the *left* lung exceed those ...he right by about the depth of a rib. It should be borne in mind, ...vever, that owing to respiratory changes the vertical extent of the ...gs is extremely variable.

Root of the Lung.—The root is situated at the *hilum* on the inner ...face. Its chief constituents are as follows: (1) the bronchus or ...tube; (2) the pulmonary artery, which conveys venous blood to ... lung; and (3) the two pulmonary veins, which convey the arterial ...oxygenated blood from the lung to the left atrium of the heart. ...addition to these constituents there are (*a*) the bronchial arteries and ...ns, (*b*) the pulmonary lymphatic vessels, (*c*) the pulmonary nerves, ...l (*d*) the bronchial lymphatic glands. All these constituents are

connected by areolar tissue, and the entire root is invested by t pleura.

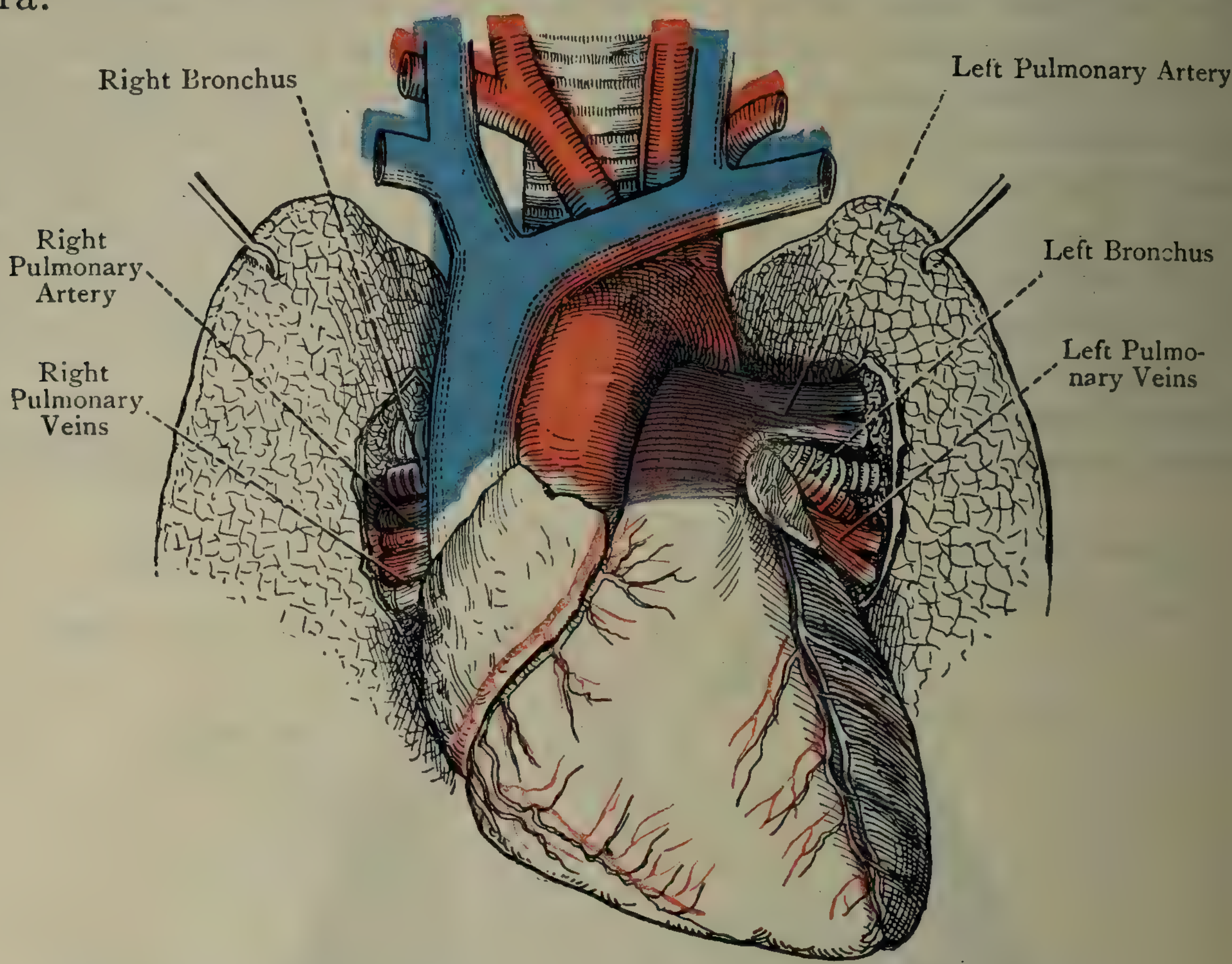


FIG. 600.—THE ROOTS OF THE LUNGS (ANTERIOR VIEW).

Relations.—The following relations are common to both root *in front*, the phrenic nerve, with the pericardiaco-phrenic artery ar the anterior pulmonary plex of nerves; *behind*, the vag nerve and the posterior pu monary plexus of nerves; ar *below*, the pulmonary ligament

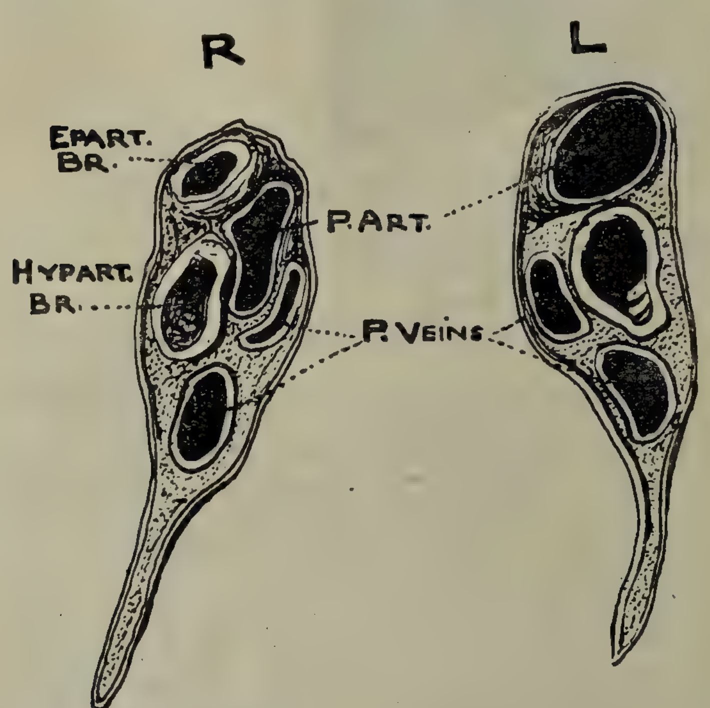


FIG. 601.—MEDIASTINAL VIEWS OF ROOTS OF LUNGS, TO SHOW RELATIONS OF BRONCHI, ARTERIES, AND VEINS.

Special Relations—Right Ro —*Anterior.*—The superior ver cava and the upper part of t right atrium of the heart. *Su perior.*—The vena azygos as arches forwards over the rig bronchus and right vagus open into the superior vena cav *Posterior.* — The vena azygo **Left Root**—*Superior.*—The ar of the aorta. *Posterior.* — T descending thoracic aorta.

Relative Position of the Chi Constituents.—The relation *fro before backwards* is the same on each side, and is as follows: (1) t upper of the two pulmonary veins; (2) the pulmonary artery; ar

the bronchus. The relation *from above downwards* differs on the sides. On the *right side* a division of the bronchus, known as *eparterial* bronchus, occupies the highest position at the hilum, reas on the *left side* a branch of the pulmonary artery is usually highest structure. The inferior angle of the somewhat pear-ped hilum is occupied by the lowest tributary of the pulmonary is.

The larger portion of the right bronchus and the whole of the left nchus are *hyparterial.*

Structure of the Lungs.—The trachea divides into two bronchi, right and left, structure of which is similar to that of the trachea. The right bronchus, at ut $\frac{3}{4}$ inch from its origin, gives off superiorly a branch, called the *eparterial*

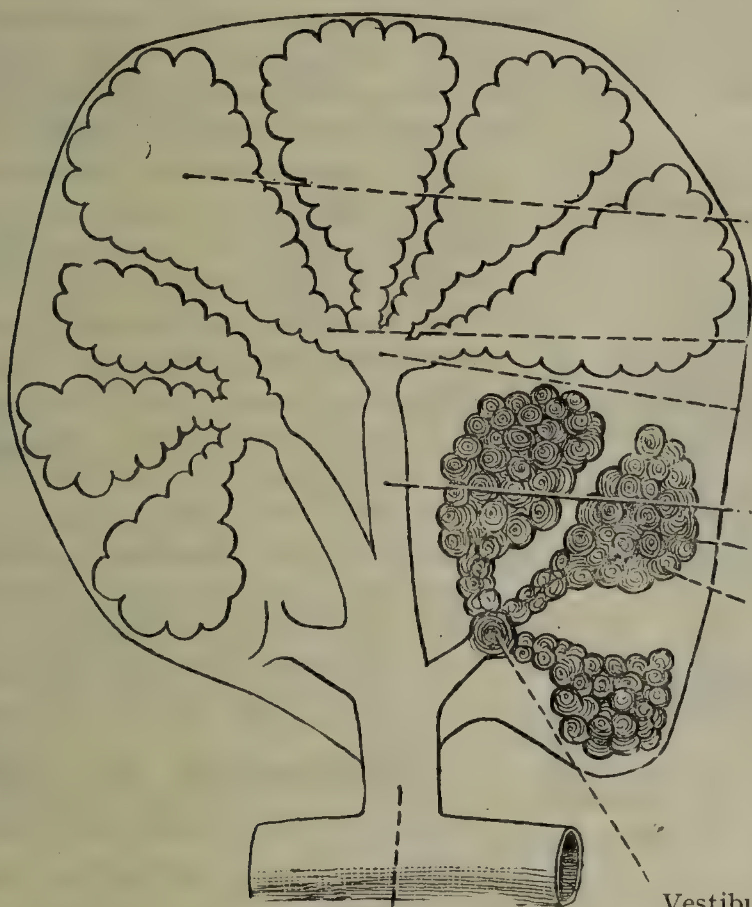


FIG. 602.—SCHEME OF A PULMONARY LOBULE (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

chus, for the upper lobe of the right lung, and beyond this point, where it ow *hyparterial,* it divides into two branches, one for the middle and the other the lower lobe. The left bronchus is entirely *hyparterial,* and divides into branches, one for the upper and the other for the lower lobe of the left lung. structure of these primary divisions of the bronchi is similar to that of the nchi themselves. Within each lung these primary divisions undergo sub-sions to a certain extent dichotomously, but the ramifications are chiefly due ranches being given off laterally, and these never anastomose. The ramifica-s of the air-tubes within the lungs are called the *interpulmonary bronchi,* and r ultimate subdivisions within the lobules are known as the *bronchioles.* h bronchiole transmits air to and from a group of infundibula.

Each lobular bronchial tube, after entering a lobule, divides into as many nchioles as there are groups of infundibula. Each bronchiole, on approaching luster of, say, two or three infundibula, presents a dilatation, called the *ibule,* and from this vestibule reception chambers, known as the *atria,* proceed he infundibula.

An **infundibulum** is an irregular, funnel-shaped passage closed at one e
and having its walls and closed extremity beset with **pulmonary alveoli,** wh
also beset, though more sparsely, the walls of the atria.

The interpulmonary bronchi are destitute of membranous walls posterio
and are cylindrical. This is due to the fact that their irregular plates of cartil
are disposed round the circumference of the wall. The muscular fibres
arranged in complete rings round the bronchi, and the elastic tissue for
longitudinal bundles. The mucous membrane is freely provided with racem
mucous glands, and is covered with stratified ciliated columnar epitheliu
When the branches of the bronchi, by division, have attained a diameter of abo
$\frac{1}{25}$ inch, the cartilaginous plates disappear, and the walls consist of a fibro-elas
membrane and circularly-disposed muscular fibres, with a thin mucous coat des
tute of mucous glands, and covered with simple ciliated columnar epithelium, th
being here and there patches of squamous, non-ciliated cells. The walls of t
vestibule, atria, and alveoli are very thin, and consist of areolar, elastic, a
muscular tissues, the elastic element being specially developed at the marg
of the orifices of the cells. This elastic tissue enables the alveoli to recoil af
distension. The interior of the vestibule, atria, and alveoli is lined with a sin
layer of squamous, non-ciliated epitheliu
which is of extreme delicacy in the alve
Upon the outer walls of the cells there
dense networks of capillary bloodvesse
which also pervade the septa between t
cells, these septa being formed by infoldin
of the contiguous cell-walls. Each septu
contains only one capillary layer. T
venous blood is thus brought into the mo
intimate relation with the air, all that sep
ates the two being the very thin walls
the cells and the very delicate walls of t
capillary bloodvessels. Moreover, there bei
only one capillary layer in each intercellul
septum, the blood in the septal capillaries
exposed to the air on each side.

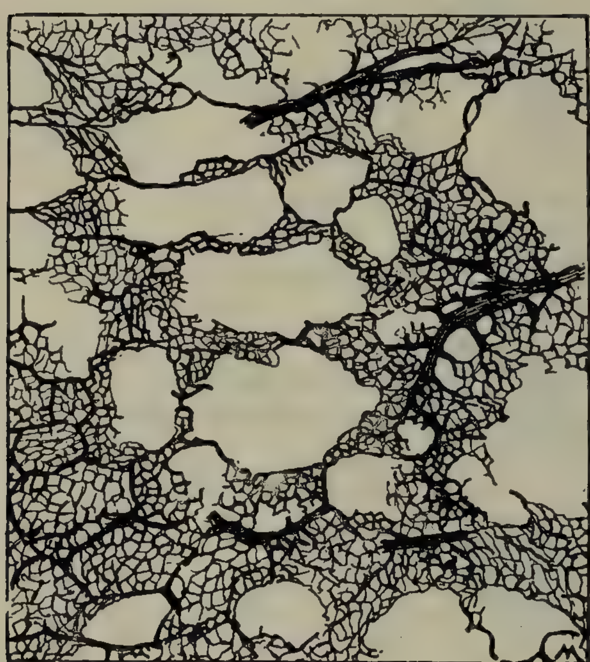


Fig. 603.—Section of Lung (injected).

Bloodvessels of the Lungs.—Tw
sets of arteries are associated wi
each lung—namely, pulmonary a
bronchial, the former having to
with the respiratory function of the organ, and the latter with t
nutrition of its component tissues. The **pulmonary arteries** are tw
in number, right and left. They result from the bifurcation of t
pulmonary trunk, and convey venous blood to the lungs. Each arte
ramifies freely within the lung, its branches closely accompanying t
bronchial tubes, but never anastomosing with one another. Ultimate
they terminate in dense capillary networks which lie upon the walls
the alveoli, and also in the septa between adjacent cells. The arteri
are somewhat more capacious than the veins.

The **pulmonary veins** commence as radicles in the capillary ne
works already referred to, and they pass to the root of each lun
where they give rise to two pulmonary veins, which proceed to t
left atrium of the heart and convey to it arterial or oxygenated bloo
The pulmonary veins and their tributaries are destitute of valve
Unlike the branches of the pulmonary artery, the tributaries of t
pulmonary veins freely anastomose. Within the lung the arteri

ally lie above and behind the corresponding interpulmonary nchi, the veins below and in front. It is to be noted that the nonary arteries carry *venous* blood, whilst the pulmonary veins y *arterial* blood.

The **bronchial arteries** convey arterial blood to the lungs for the rition of their component tissues. They will be described in nection with the descending thoracic aorta, with which they are ociated.

The **bronchial veins** return their blood chiefly into the vena azygos superior vena hemiazygos respectively. They are not so large he corresponding arteries, since some of the blood conveyed by the nchial arteries is returned by the pulmonary veins.

Lymphatics.—The lymphatic vessels of each lung are arranged wo sets—*superficial* and *deep*. At the hilum these two sets open the *interbronchial glands*. The *superficial set* receives the lymtics of the *visceral* or *pulmonary pleura*.

Nerves.—These are derived from the anterior and posterior pulnary plexuses, which are formed by the vagi nerves, aided by nches from the sympathetic. The nerves penetrate as far as alveoli, upon the walls of which they are regarded as terminating arborizations. The anterior and posterior pulmonary plexuses be found described on p. 1044.

Development of the Respiratory Apparatus.

The respiratory apparatus consists of the **larynx, trachea,** and **lungs.** The est indication of it is a median longitudinal groove, appearing in the third k on the *inner* aspect of the *ventral wall* of the **œsophageal part of the fore-** This groove is called the **laryngo-tracheal groove,** and it produces an evaginn of the ventral wall of the œsophagus. It consists of *entoderm* derived n that of the fore-gut, and it is covered by splanchnic *mesoderm.* This groove lually deepens, and gives off the two lung-buds from its caudal end; these then carried caudally by elongation of the recess to form a trachea. The ngo-tracheal tube consists of (1) entoderm derived from that of the fore-gut, (2) mesoderm, which invests it.

The condition of matters now is that there are two tubes, dorsal or pharyngophageal, and ventral or laryngo-tracheal, which communicate freely cephalad.

Larynx.—The larynx is developed from the *cephalic* or *proximal part* of the nonary diverticulum, with coincident modification of the pharyngeal floor the **Larynx**).

Trachea.—The trachea is developed from the *caudal* or *distal part* of the ngo-tracheal tube, the cartilaginous rings, connective tissue, and muscular ie of the trachea being developed from the *mesodermic investment* of the iitive tube and becoming evident after the middle of the second month.

Lungs.—The simple *lung-buds* of early stages (Fig. 604) are hollow club-shaped dermal extensions from the caudal end of the laryngo-tracheal tube, which v into the small rounded mesodermal masses already prepared for them; e project into the upper end of the pericardio-peritoneal channels.

The buds are asymmetrical, and grow rapidly. Various stages of this growth, o the middle of the second month, are given in the figure, also the outward earance of a lung a little older than this, in which the early lobulation is seen. enlarging lung, with its surrounding pleura, gains room for its growth by ding the body-wall and extending (p. 78) in this, splitting it cranially, trally, and to a smaller extent caudally. The *entoderm* of each lung-bud and

of its various ramifications furnishes all the **epithelial elements,** bronchial
alveolar, of the corresponding lung. The *mesoderm* of the bud and of its vari
ramifications gives rise to the **bloodvessels, connective** and **muscular tissues,**
cartilages of the bronchial tubes, as well as to the **visceral pleura.** The pedi
of the lung-buds give rise to the *bronchi.* The *right* lung-bud gives off *t*
processes or *vesicles,* and the *left* lung-bud gives off *two processes,* and in
manner the **three-lobed condition** of the adult *right* lung and the **two-lo**
condition of the adult *left* lung are indicated.

Each of these processes gives rise by budding to secondary processes,
these in turn give rise successively to other processes. This budding goes
very freely, and the ramifications constitute the **pulmonary lobes.** All the b

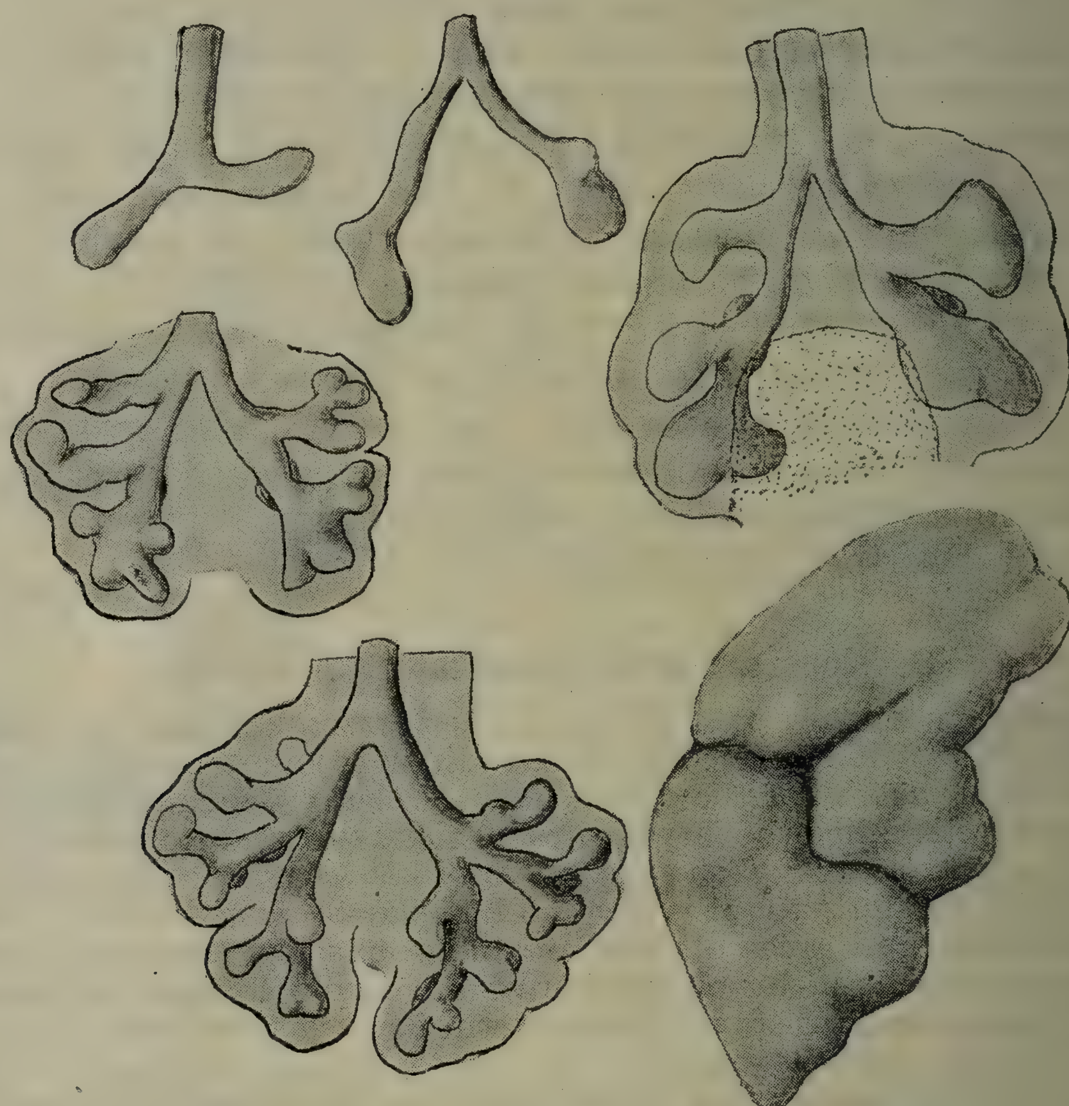


FIG. 604.—ENTODERMAL LUNG-BUDS OF EMBRYOS OF 5·7 AND 8 MM.

Below, at a smaller magnification, the same from embryos of fifth and si
weeks. Also outer aspect of right lung (18 mm.)

or processes, which carry along with them an investment of mesoderm, give
to the ramifying system of **interpulmonary bronchi.** The terminal ramificati
form the **bronchioles** and **infundibula.** The **air-cells** or **pulmonary alveoli**
formed as *hollow sessile buds* or evaginations of the walls of the infundibula, w
the cavities of which they communicate freely.

As stated, the epithelial cells of the lung-buds and of all their ramificatio
as well as the epithelial cells of the pulmonary diverticulum, are developed fr
the entoderm of the fore-gut.

The **eparterial bronchus** is often said to be an additional bronchial outgrow
The condition, however, is due in all probability to the enlargement of a su
sidiary arterial anastomosis; an ordinary epibronchial pulmonary artery devel
and enlarges in the second month, comparable with that on the left side, but wa

lisappears in the latter part of this month, leaving the hypobronchial artery rry on the supply to the lung.

ungs of the Fœtus.—The lungs prior to birth, having been im-ious to air, feel solid, like liver, and at once sink if placed in a el containing water.

uperior Mediastinal or Cardiac Glands.—These glands, which are ierous and important, are situated in the superior mediastinum, g the upper aspect of the arch of the aorta, in front of the lower of the trachea, and along the right and left innominate veins.

They receive their *afferent* vessels from (1) the anterior mediastinal ds, (2) the upper part of the pericardium, (3) the heart, (4) the hea, (5) the œsophagus, and (6) the thymus. Their *efferent* vessels

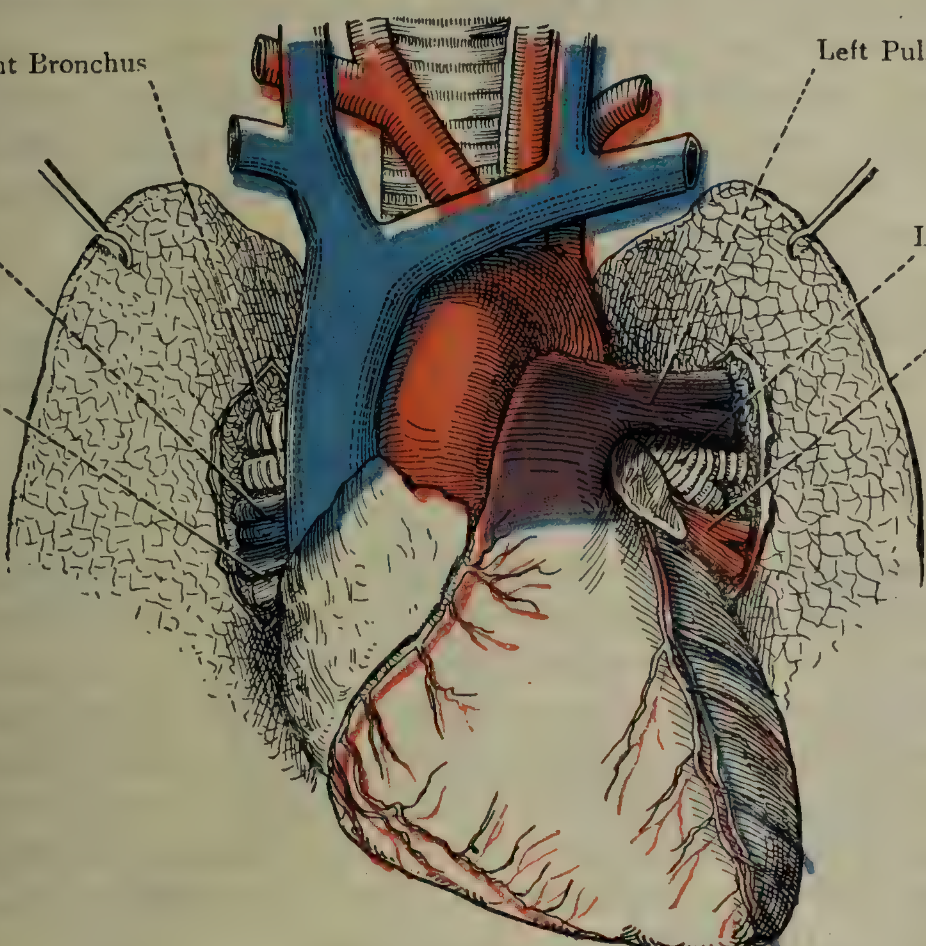


FIG. 605.—THE ROOTS OF THE LUNGS, ETC.

ninate in the *thoracic duct* and in the *right lymphatic duct*, or into of the main vessels opening into or forming these ducts.

Innominate Veins.—These vessels are two in number, right and , and each is formed by the junction of the internal jugular and clavian veins behind the inner end of the clavicle. They both in the superior mediastinum.

The **right innominate vein** is about an inch in length, and passes vnwards with a slight inclination inwards. At the level of the lower der of the first right costal cartilage, close to the sternum, it unites h the left innominate vein to form the superior vena cava. Laterally s closely related to the right phrenic nerve and right pleura; its dial relation is the upper part of the innominate artery, and behind s the right vagus nerve.

The **left innominate vein** is about 3 inches in length, and pas obliquely inwards and downwards from left to right. As stated, joins its fellow of the right side to form the superior vena cava. front of it there are the upper part of the manubrium sterni, origins of the sterno-hyoid and sterno-thyroid muscles, and the rema of the thymus. Behind it are the origins of the innominate, left comm carotid, and left subclavian arteries; the left vagus and left phre nerves; and two superficial cardiac nerves from the cervical porti of the left vagus and left sympathetic. Below it there is the arch of aorta.

There are no valves in the innominate veins.

Tributaries.—Each vein receives the following tributaries: (1) vertebral vein; (2) the inferior thyroid vein; (3) the internal mamm vein; and (4) the first posterior intercostal vein. The last-nam vessel, however, sometimes opens into the vertebral vein, and oc sionally the right inferior thyroid vein opens into the left innomin vein. The *left* innominate vein receives, as an additional tributa the left superior intercostal vein.

Development.—The *right* innominate vein is developed from that port of the right primitive jugular vein which intervenes between the place wh it receives the right subclavian vein and the place where the transverse v joins it.

The *left* innominate vein is developed from the venous network between primitive jugulars.

Superior Vena Cava.—This vessel is formed by the union of the rig and left innominate veins behind the lower border of the first rig costal cartilage close to the sternum. It is about 3 inches in leng and descends almost vertically to the level of the upper border of t third right costal cartilage, where it opens into the postero-super angle of the right atrium of the heart. In its course it pierces t fibrous pericardium. The upper half of the vessel is extrapericardi and lies in the superior mediastinum; but the lower half is intrape cardial, and lies in the middle mediastinum.

Relations—Upper Half—*Lateral.*—The right phrenic nerve a the right pleura. *Medial.*—The lower part of the innominate arte **Lower Half**—*Internal.*—The ascending aorta. *Posterior.*—The root the right lung. The serous pericardium covers the lower part the vessel except over about its posterior fourth.

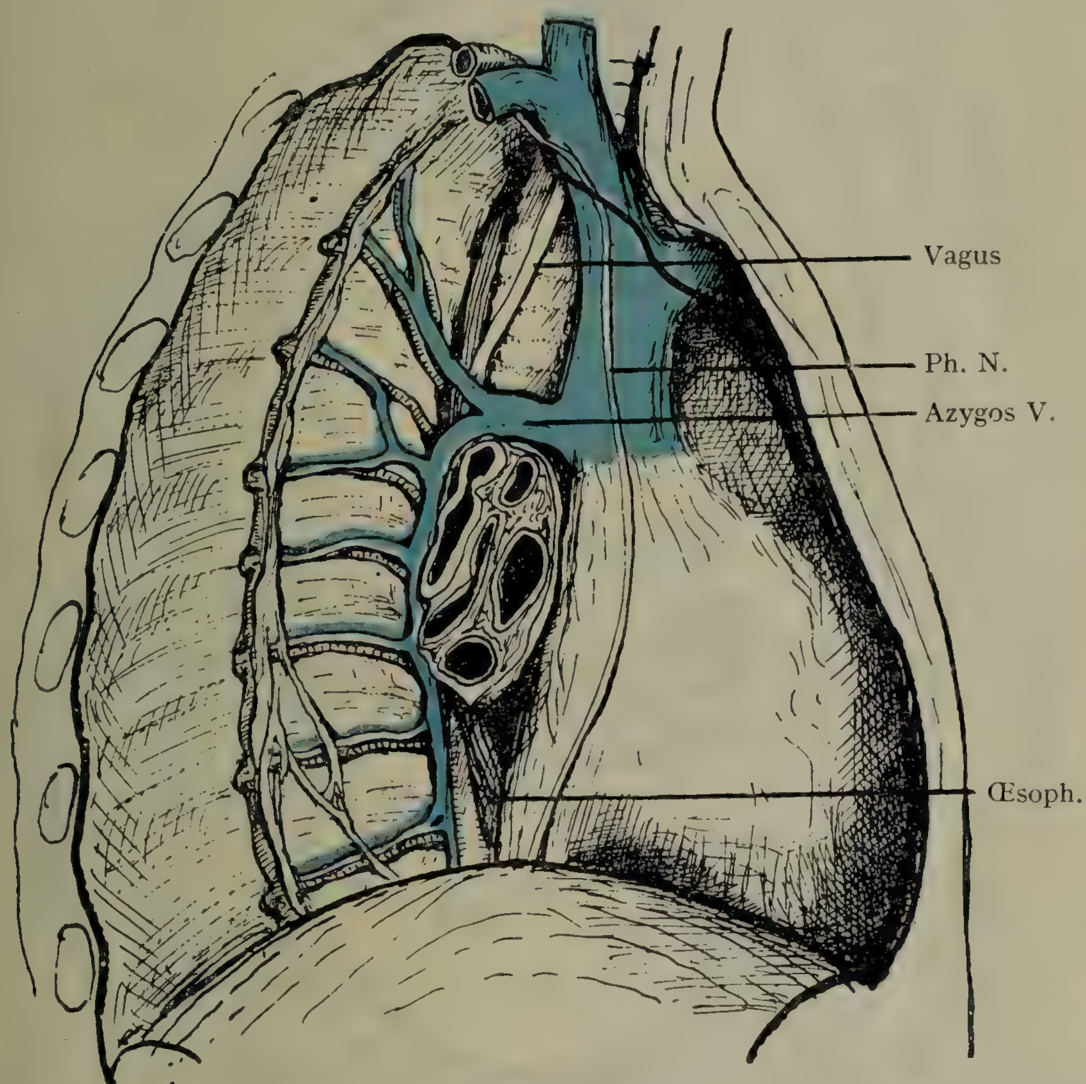
The superior vena cava is destitute of valves.

Tributaries.—The chief tributary is the vena azygos after it h arched forwards over the right bronchus. It opens into the superi vena cava immediately before that vessel pierces the fibrous pe cardium. Other minute tributaries are pericardial and mediastin veins.

Development.—The portion of the superior vena cava *above* the vena azyg is developed from that part of the right primitive jugular vein which lies bel the point where it is joined by the transverse jugular vein; and the portion *bel* the vena azygos is developed from the right duct of Cuvier.

nferior Vena Cava.—This vessel enters the thorax by perforating central tendon of the diaphragm, and immediately afterwards ceived within the fibrous pericardium. Its course in the thorax ractically nil, as it may be said to open at once into the postero-rior angle of the right atrium of the heart.

Thoracic Aorta.—The thoracic aorta extends from the base of the ventricle of the heart to the level of the lower border of the body ne twelfth thoracic vertebra. At this point it passes through the ic opening of the diaphragm, and enters upon the abdominal part ts course. It passes at first upwards and to the right; it then



606.—Vena Azygos and Right Sympathetic Chain, showing Ganglia and the Greater and Lesser Splanchnic Nerves arising from it.

Ph.N., phrenic nerve.

eps in an arched manner upwards, backwards, and to the left, over root of the left lung; and finally descends in close contact with vertebral column, lying at first upon its left side, but subsequently ront of it. It is therefore conveniently divided into three parts—ely, the ascending aorta, the arch of the aorta, and the descending a.

Ascending Aorta.—The ascending aorta commences at the base ne left ventricle of the heart, behind the left border of the sternum, level with the lower margin of the third left costal cartilage, and rminates at a point behind the right border of the sternum on a level

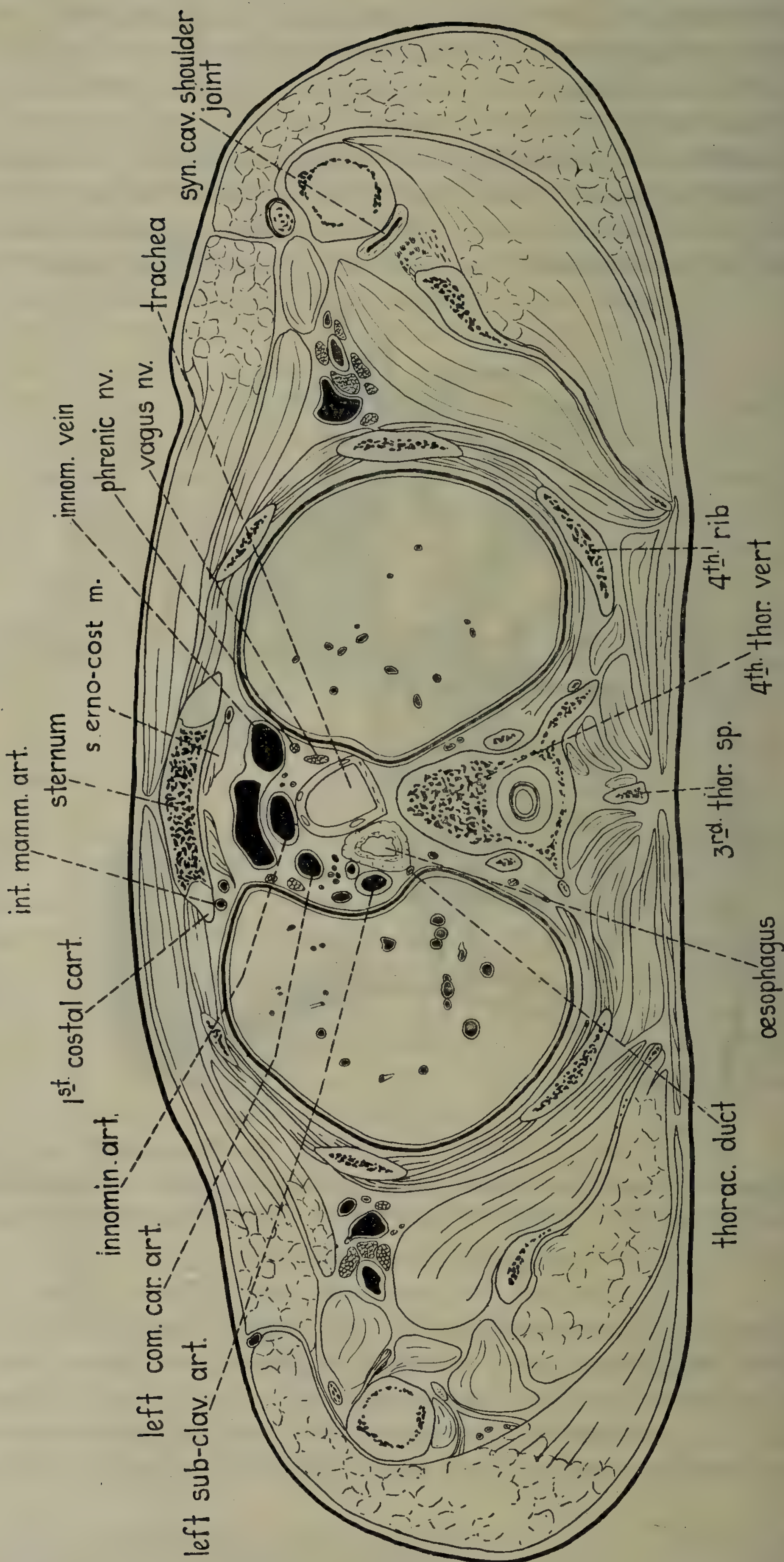


FIG. 607.—TRANSVERSE SECTION THROUGH FOURTH THORACIC VERTEBRA (AFTER SYMINGTON).

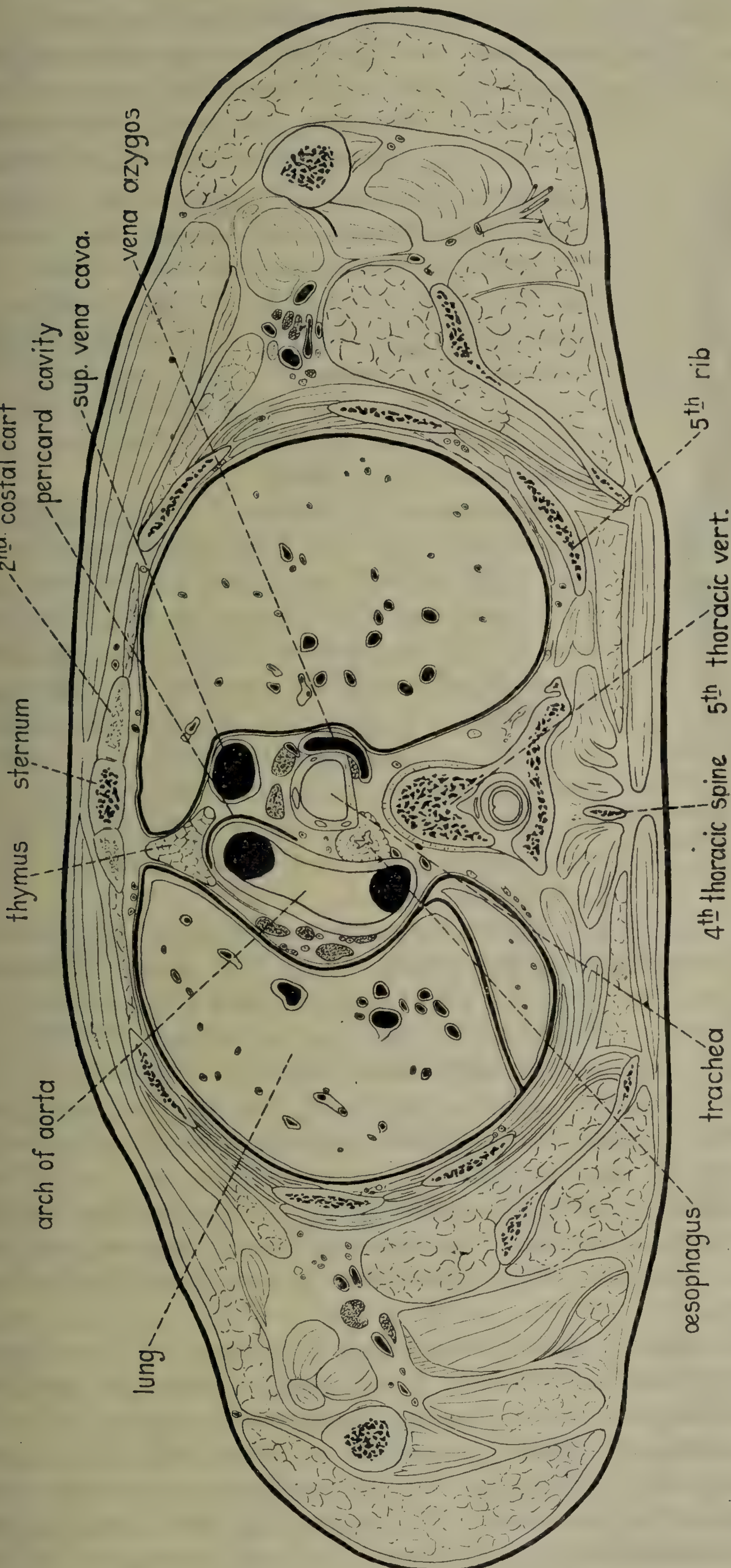


FIG. 608.—TRANSVERSE SECTION THROUGH FIFTH THORACIC VERTEBRA (AFTER SYMINGTON).

with the upper margin of the second right costal cartilage. Its co is upwards and to the right, with an inclination forwards. It lie the middle mediastinum, and within the fibrous pericardium, w ensheathes it, and for about the first $1\frac{1}{2}$ inches of its course it is enclo along with the adjacent portion of the pulmor trunk, in a sheath formed by the serous par the pericardium. The ascending aorta meas about 2 inches in length. At its commencen it presents three dilatations, which corresp to the aortic sinuses in the interior, and opposite the segments of the aortic valve. sinuses are situated one in front and behind. Along the right side of the vessel tl is a somewhat extensive dilatation, called *great sinus of the aorta.*

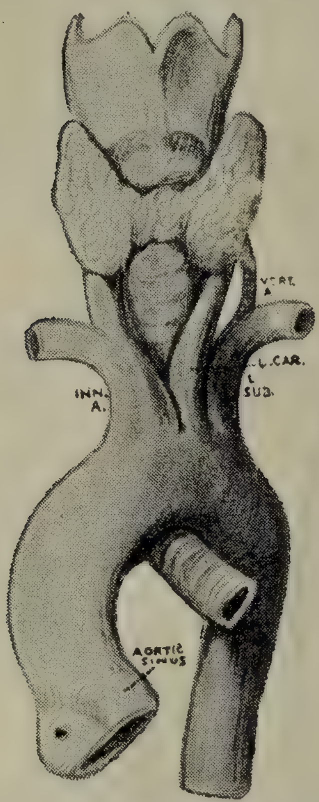


FIG. 609.—ASCENDING (INTRAPERICARDIAL) AORTA AND ARCH, WITH ITS THREE LARGE BRANCHES.

Relations—*Anterior.*—The infundibulum the right ventricle, the pulmonary trunk, the right auricle at first, and subsequently first piece of the body of the sternum, fı which it is separated by the pericardium, ri pleura, and anterior margin of the right lı *Posterior.*—The right pulmonary artery, fı which it is separated by the fibrous pericardi and the left atrium, from which it is separa by the transverse sinus. *Right.*—The supe vena cava and the right atrium. *Left.*—' pulmonary trunk.

Branches.—These are the two coronary arteries, right and left.

The **right coronary artery** arises from the anterior aortic sir Passing forwards between the right auricle and the pulmonary tru it enters the right atrio-ventricular groove, which it traverses fr front to back as far as the commencement of the inferior interv tricular groove. At this point it gives off the inferior interventricu branch. It then enters the posterior part of the left atrio-ventricu groove, in which it anastomoses with a branch of the left coron artery. The *inferior interventricular artery* traverses the inferior int ventricular groove as far as the region of the apex, where it anas moses with the anterior interventricular artery from the left coron artery.

The right coronary artery furnishes branches to the right atri and to both ventricles. One, of large size, called the *right margi artery*, passes along the right border, towards the apex.

The **left coronary artery** arises from the left posterior aor sinus, and is at first concealed by the pulmonary trunk. It pas forward between the pulmonary trunk and the left auricle, and gi off the anterior interventricular branch. It then enters the left atr ventricular groove, which it traverses from front to back, anastomosi posteriorly with a branch of the right coronary artery. The *anter*

ventricular artery traverses the anterior interventricular groove r as the region of the apex, where it anastomoses with the inferior ventricular branch of the right coronary artery.

he left coronary artery furnishes branches to the left atrium and oth ventricles. One, of large size, called the *left marginal artery*, s along the left border, towards the apex.

evelopment.—The ascending aorta, along with the pulmonary trunk, is oped from the **truncus arteriosus,** in which the bulbus cordis teminates. s divided by a spiral septum into aorta and pulmonary trunk.

rch of the Aorta.—The arch of the aorta commences behind the border of the sternum on a level with the upper margin of the d right costal cartilage, and terminates on the left side of the body

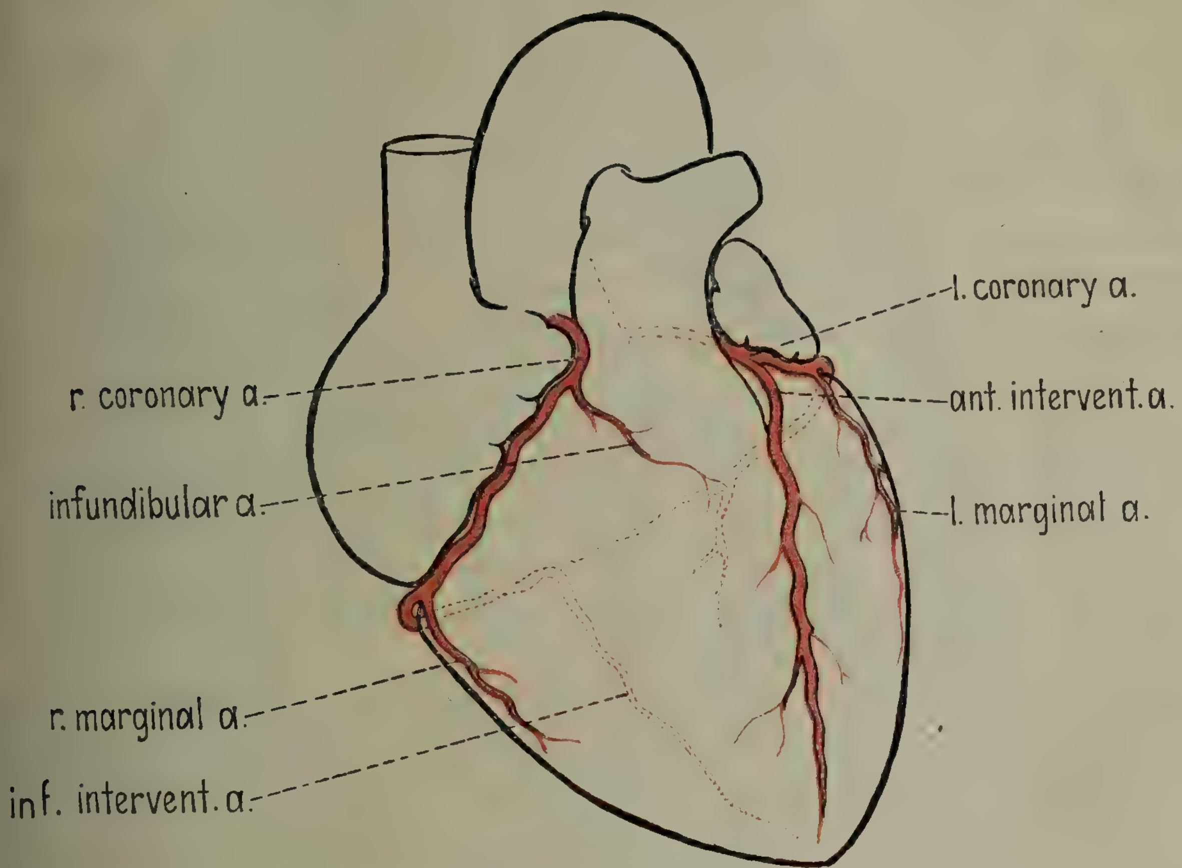


FIG. 610.—THE ARTERIES OF THE HEART SEEN FROM IN FRONT, THE HEART BEING SUPPOSED TO BE SEMI-TRANSPARENT.

e fourth thoracic vertebra, at the lower border of which it becomes descending aorta. It passes upwards, backwards, and to the left, ping over the root of the left lung, and when it reaches the left of the body of the fourth thoracic vertebra it descends. The ht to which the arch reaches corresponds to the centre of the ubrium sterni, which is about 1 inch below the upper border of manubrium. It lies in the superior mediastinum, and its left is in close relation with the left pleura.

Relations—*Anterior.*—The left phrenic and left vagus nerves, the er being anterior to the latter. Between these two nerves are the rior cervical cardiac branch of the left sympathetic, and the inferior ical cardiac branch of the left vagus, both on their way to the super- l cardiac plexus, which they form; and the left superior intercostal

vein on its way to join the left innominate vein. All these structu are overlaid by the left pleura. The remains of the thymus constit an additional anterior relation. *Posterior.*—The trachea, deep card plexus of nerves, œsophagus, thoracic duct, and left recurrent laryng nerve. *Superior.*—The left innominate vein, and the origins of following three great arteries, named in order from right to left, a also from before backwards: the innominate, the left common caro and the left subclavian. *Inferior.*—The left bronchus, the bifurcat of the pulmonary trunk, the superficial cardiac plexus of nerves, left recurrent laryngeal nerve, and the ligamentum arteriosum. T last-named fibrous cord is attached to the back part of the concav of the arch immediately beyond the level of the origin of the l subclavian artery.

The arch presents a constriction immediately beyond the ori of the left subclavian artery, called the *aortic isthmus*, and this succeeded by a short fusiform dilatation, known as the *aortic spin* (of His). These features are best marked in the fœtus.

Branches.—These are three in number—namely, the innomina left common carotid, and left subclavian arteries. They arise in the or named, proceeding from before backwards, and also from right to le

Innominate Artery.—This vessel is the first and largest of the th branches which arise from the arch of the aorta. It springs from upper aspect of the arch rather above the level of the upper bord of the second right costal cartilage, and it terminates behind upper border of the right sterno-clavicular joint by dividing into right common carotid and right subclavian arteries. It is from to 2 inches in length, its direction is upwards and outwards, and lies in the superior mediastinum.

Relations—*Anterior.*—The right half of the manubrium ster with the origins of the right sterno-hyoid and sterno-thyroid muscl the left innominate and the right inferior thyroid veins; the rig sterno-clavicular joint; and some remains of the thymus. *Posterior* The trachea at first, but as the artery ascends obliquely to the rig it leaves the front of the trachea and is placed on the right side. T three cervical cardiac branches of the right sympathetic also lie behi the artery on their way to the deep cardiac plexus. *Right.*—The rig pleura; the innominate vein, with the right vagus nerve behind the superior vena cava; and the right phrenic nerve. *Left.*—The l common carotid artery and the trachea, in this order from bel upwards.

Branches.—These are terminal, and are two in number—name the right common carotid and the right subclavian. The artery, a rule, gives off no branches in its course. Occasionally, however, gives origin to a vessel of variable size, called the *arteria thyroidea i* (lowest thyroid artery). The interest attached to this occasio branch is that, in ascending to the isthmus of the thyroid gland in t neck, it lies in front of the trachea, and would be endangered in t operation of tracheotomy.

arieties.—(1) The innominate artery may be shorter or longer than usual. n cases of high bifurcation the artery may so encroach upon the trachea as endangered in tracheotomy.

Left Common Carotid Artery in the Thorax.—This vessel arises from ipper aspect of the arch of the aorta, just to the left of, and posterior

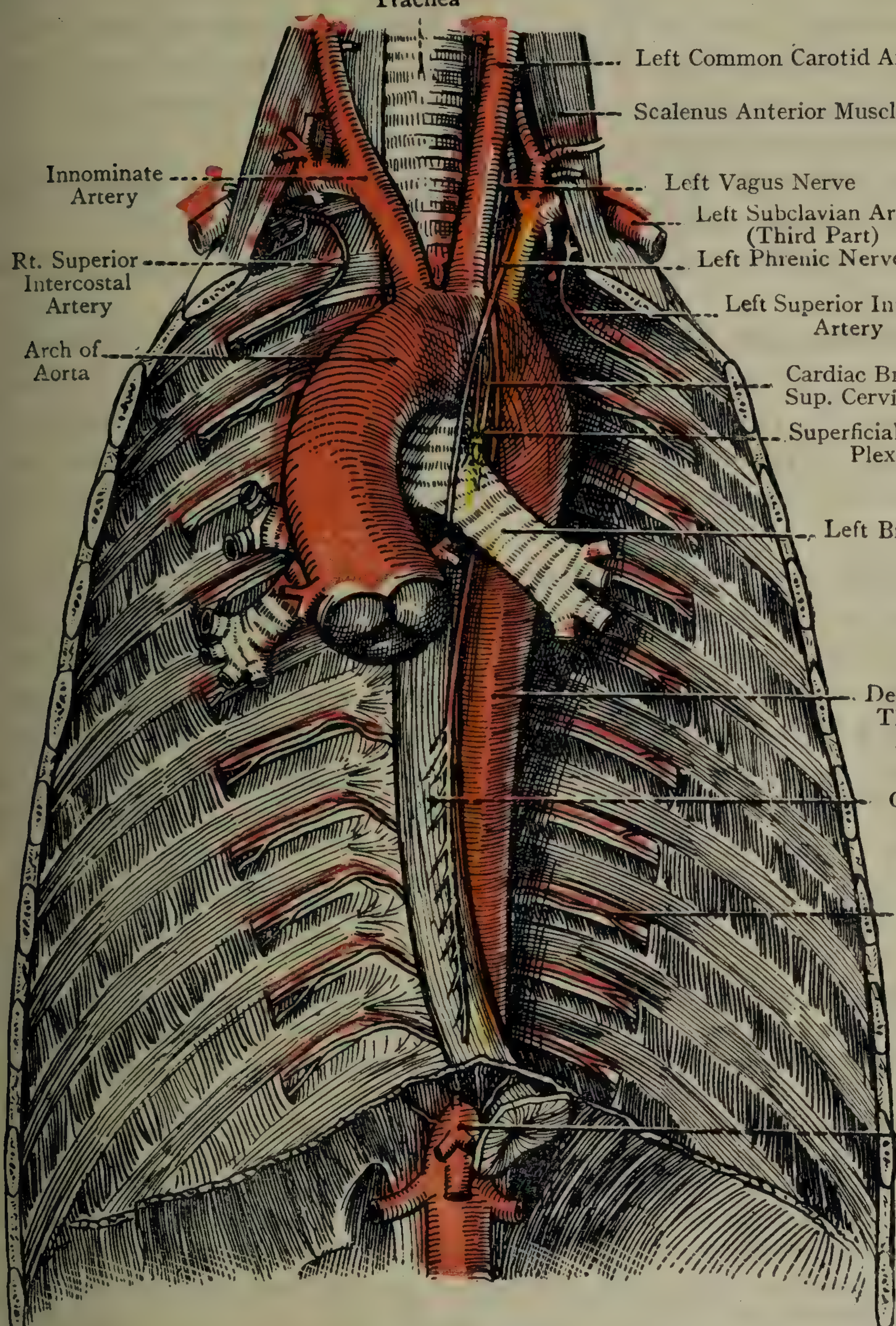


FIG. 611.—DISSECTION OF THE POSTERIOR WALL OF THE THORAX.

the origin of the innominate artery. It lies in the superior mediasım, and its direction is upwards and to the left. Having reached posterior aspect of the left sterno-clavicular joint, it enters upon cervical part of its course.

Relations—*Anterior.*—The left half of the manubrium sterni, the origins of the left sterno-hyoid and sterno-thyroid muscles,

but these structures lie at a little distance from the vessel; the l
innominate vein; and some remains of the thymus. *Posterior.*—T
trachea at first, and subsequently the left recurrent laryngeal nerv
the œsophagus (which here deviates slightly to the left of the trache
and the thoracic duct. *Right.*—The innominate artery at first, a
later the trachea. *Left.*—The left vagus and left phrenic nerves, wi
the superior cervical cardiac branch of the left sympathetic and t
inferior cervical cardiac branch of the left vagus; the first and the le
superior intercostal veins as they pass to the left innominate vei
and the left pleura and lung.

The thoracic portion of the left subclavian artery is on the left
and posterior to, the vessel, but at a little distance from it.

The thoracic portion of the left common carotid artery gives
no branches.

First Part of the Left Subclavian Artery in the Thorax.—This ves
arises from the upper aspect of the arch of the aorta a little to the le
of, and posterior to, the origin of the left common carotid artery.
lies deeply in the superior mediastinum, and is almost parallel to t
thoracic portion of the left common carotid, its course being nea
vertical.

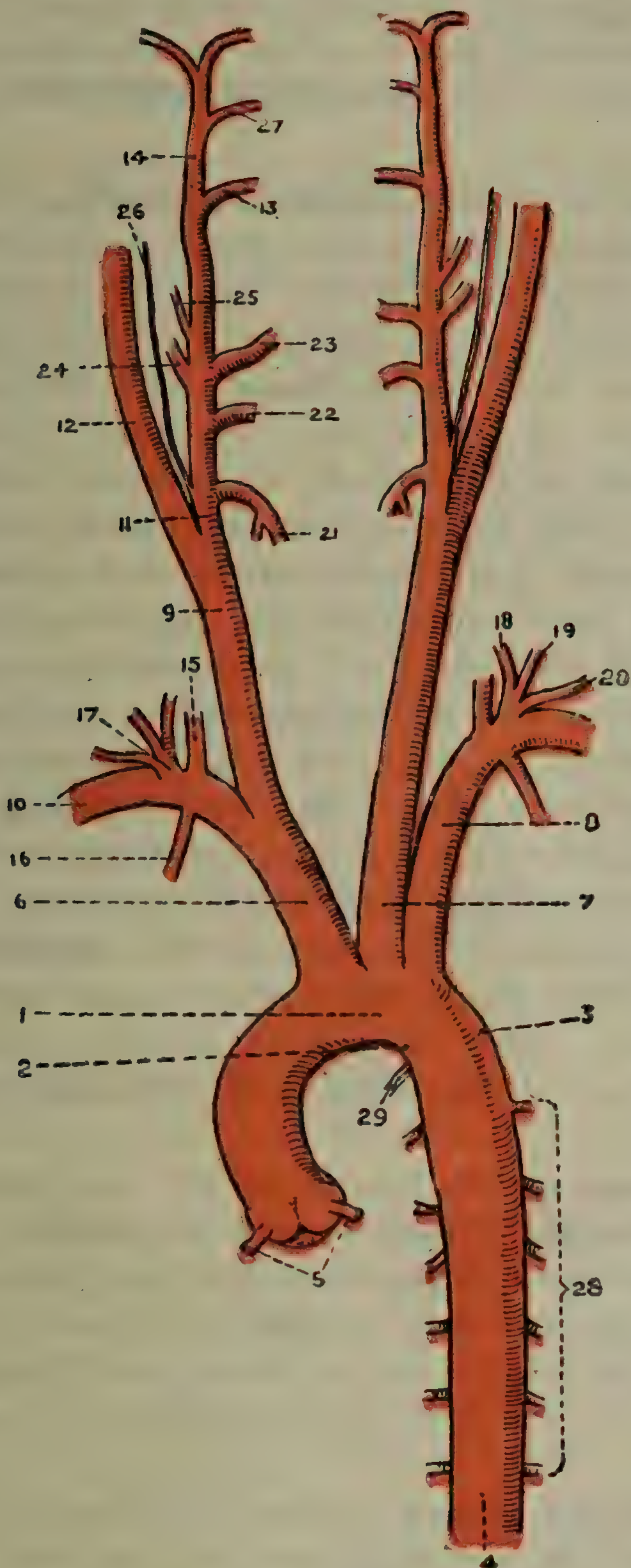
Relations—*Anterior.*—The left common carotid artery; the left vag
and left phrenic nerves, with the superior cervical cardiac branch of t
left sympathetic and the inferior cervical cardiac branch of the le
vagus, all these nerves lying between it and the left common carot
artery; and the left innominate vein. *Posterior.*—The œsophagus a
the thoracic duct. *Right.*—The trachea and the left recurrent larynge
nerve. *Left.*—The left pleura and the inner aspect of the left lun
the latter being grooved by the vessel.

The thoracic portion of the left subclavian artery gives off
branches.

Varieties of the Aorta—1. **Position.**—(*a*) The arch of the aorta may rise
high as the upper border of the manubrium sterni, or it may stop short of t
level of the centre of the manubrium. (*b*) It may have been derived from a rig
aortic arch instead of a left.

2. **Branches of the Arch and their Positions.**—Varieties in these respects a
very numerous. The normal number of branches arising from the arch is thr
There may be, however, only one branch, or, on the other hand, there may
as many as six. When there is a reduction in the number of branches, it
usually due to the left common carotid arising with the innominate from a comm
trunk. The most common additional branch is the **left vertebral artery,** its pla
of origin being between the left common carotid and left subclavian arteri
The right vertebral artery sometimes arises from the arch, but this is somewh
rare. An **arteria thyroidea ima** may arise from the arch between the innomin
and left common carotid arteries. In rare cases the **internal mammary arte**
or the **inferior thyroid,** may spring from the arch. The innominate artery m
be absent, in which cases the right subclavian and right common carotid ha
independent origins. Under these circumstances the **right subclavian art**
may be the last of the branches from the arch, and, when this is so, in order
reach the right side of the neck, it crosses in front of the vertebral colur
lying behind the œsophagus, or more rarely between the trachea and
œsophagus.

velopment of the Arch of the Aorta and its Branches.—The **arch of orta,** between the innominate artery and the left subclavian, is the ed *fourth aortic arch* of the embryo. It is thus of the same develop-



IG. 612.—THE AORTA IN THE THORAX, AND THE PRINCIPAL ARTERIES OF THE HEAD AND NECK.

rch of the Aorta
ortic Isthmus
ortic Spindle
escending Aorta
oronary Arteries (from Ascending Aorta)
nnominate Artery
eft Common Carotid
eft Subclavian
ight Common Carotid
10. Right Subclavian
11. External Carotid
12. Internal Carotid
13. Maxillary
14. Superficial Temporal
15. Vertebral
16. Internal Mammary
17. Thyro-cervical Trunk
18. Inferior Thyroid
19. Transverse Cervical
20. Suprascapular
21. Superior Thyroid
22. Lingual
23. Facial
24. Occipital
25. Posterior Auricular
26. Ascending Pharyngeal
27. Transverse Facial
28. Posterior Intercostals
29. Lig. Arteriosum

l value as the **innominate** and **first part** of the **right subclavian.** Beyond ft subclavian origin it is formed from a part of the *left dorsal aorta.* The inate, as said above, is a portion of the right fourth aortic arch, and the

left common carotid is a forward-running branch from this fourth arch, as i
common carotid on the right side; these two vessels, although their actual v
is in doubt, are frequently said to represent the *ventral aortæ* of lower form
interpretation of some practical value even if not absolutely correct (see p.
et seq.). The **left subclavian** is an intersegmental artery, enlarged because o
relation to the limb; its origin was from the dorsal aorta opposite to the entr
of the fourth aortic arch. The **ligamentum arteriosum** is the remnant o
sixth aortic arch.

For the description of the **descending aorta,** see p. 1089.

Pulmonary Trunk.—This is the great vessel which, by mean
its right and left divisions, carries the venous blood from the r
ventricle of the heart to the lungs. It is therefore an exampl
an artery which conveys venous blood, and in this respect resem
the umbilical arteries of the fœtus. It arises from the infundibu
of the right ventricle of the heart, on a level with the upper ma
of the third left costal cartilage at its junction with the stern
It is directed upwards and backwards, and after a course of al
2 inches breaks up into two divisions, right and left, within the
cavity of the arch of the aorta. The vessel lies in the middle med
tinum, and along with the ascending aorta it is contained within
pericardium, the serous portion of which forms one common sh
for the two arteries over about the first $1\frac{1}{2}$ inches of their cours

Relations—*Anterior.*—The sternal extremity of the second
intercostal space and second left costal cartilage, and the left pl
and left lung. *Posterior.*—The root of the ascending aorta; the c
mencement of the left coronary artery; and the left atrium of
heart. *Right.*—The right coronary artery; the right auricle
the ascending aorta. *Left.*—The left coronary artery and the
auricle.

The only **branches** of the trunk are the two terminal divisions.

The **right pulmonary artery** passes outwards to the right, be
the ascending aorta and superior vena cava, to the root of the r
lung, where it divides into two branches, upper and lower. The u
branch is distributed to the upper lobe, and the lower branch, w
is the larger of the two, is distributed to the middle and l
lobes.

The **left pulmonary artery** passes outwards to the left, in f
of the left bronchus and descending aorta, to the root of the left l
where it divides into two branches, one for the upper and the c
for the lower lobe. The ligamentum arteriosum is attached to
upper aspect of its root.

The *right* pulmonary artery is larger and longer than the left.

Development.—The **pulmonary trunk,** along with the ascending aor
chiefly developed from the *truncus arteriosus,* but a small portion of it is fo
by the *commencement of the sixth left arterial arch,* which remains connected
that portion of the truncus which becomes partitioned off to form the pulmo
trunk.

The **right** and **left pulmonary arteries** are developed as branches fron
sixth left aortic arch near its commencement, the remainder of that arch g
rise to the ductus arteriosus of the fœtus.

igamentum Arteriosum.—This is a fibrous cord which is the remains important vessel peculiar to fœtal life, called the *ductus arteriosus.* :tends from the upper aspect of the root of the left pulmonary y to the under surface of the arch of the aorta immediately nd the level of the origin of the left subclavian artery. Its tion is upwards, backwards, and slightly to the left.

uring fœtal life the right and left pulmonary arteries are of small size, and uctus arteriosus conveys the greater part of the venous blood from the ventricle of the heart into the aorta at a point *beyond* the origin of the left avian artery. None of this blood, therefore, can pass into the great vessels 1 spring from the upper aspect of the arch of the aorta.

evelopment.—The ductus arteriosus is developed from the dorsal part of xth left aortic arch.

'ulmonary Veins.—These vessels carry the arterial or oxygenated 1 from the lungs to the left atrium of the heart. Though they called veins, they contain arterial blood, and in this respect re- ole the umbilical vein of the fœtus. They are four in number, right and two left, and at the root of each lung the upper of the is on a more anterior plane than the lower. The *right veins* pass nd the superior vena cava and the right atrium, and the *left* ; pass in front of the descending aorta. All four vessels open into eft atrium on its posterior aspect. On leaving the roots of the lungs veins are said to receive small bronchial tributaries from the cent interpulmonary bronchi and glands.

The *right* pulmonary veins are larger and longer than those of the side.

/agus Nerves in the Thorax.—These nerves, right and left, differ nuch from each other in their course and relations as to require rate descriptions.

The **right vagus nerve,** having descended in front of the first part he right subclavian artery, and having given off its recurrent ngeal branch at the lower border of that vessel, enters the thoracic ty. It then descends in the superior mediastinum behind the minate vein, and, inclining backwards, it reaches the right of the trachea, along which it courses to the *posterior aspect* of the of the right lung. Behind the root of the right lung the nerve omes flattened out and breaks up into numerous branches, which disposed in a plexiform manner, and constitute the *right posterior nonary plexus,* from which branches are given off to the right lung. m the lower part of this plexus the nerve issues in the form of two ls, which descend in the posterior mediastinum upon the right side he œsophagus, or gullet, and communicate freely with the corre- nding cords of the left side. In this manner a plexus is formed, ch is called the *œsophageal plexus.* Subsequently the two cords he right side unite to form a single nerve, which descends on the *'erior surface* of the œsophagus, and enters the abdomen through œsophageal opening of the diaphragm to be distributed to the *'erior surface* of the stomach.

The **left vagus nerve** enters the thoracic cavity between the common carotid and left subclavian arteries, and descends in superior mediastinum behind the left innominate vein. It passes in front of the arch of the aorta, having the left phrenic n on its right side and anterior to it, with the intervention of the sup cardiac nerve from the left superior cervical sympathetic gang and its own inferior cardiac branch. At the lower border of the it gives off its recurrent laryngeal branch, and then passes to *posterior aspect* of the root of the lung. Behind the root of the lung the nerve, as on the right becomes flattened out and br up into numerous branches, w are disposed in a plexiform man and constitute the *left posterior monary plexus*, from which bran are given off to the left lung. F the lower part of this plexus nerve, as on the right side, is in the form of two cords, w descend in the posterior mediasti upon the left side of the œsopha or gullet, and communicate fr with the corresponding cords of right side. In this manner, as sta a plexus is formed, which is ca the *œsophageal plexus*. Subseque the two cords of the left side u to form a single nerve, which scends on the *anterior surface* of œsophagus, and enters the abdo through the œsophageal opening the diaphragm to be distributed the *anterior surface* of the stomac

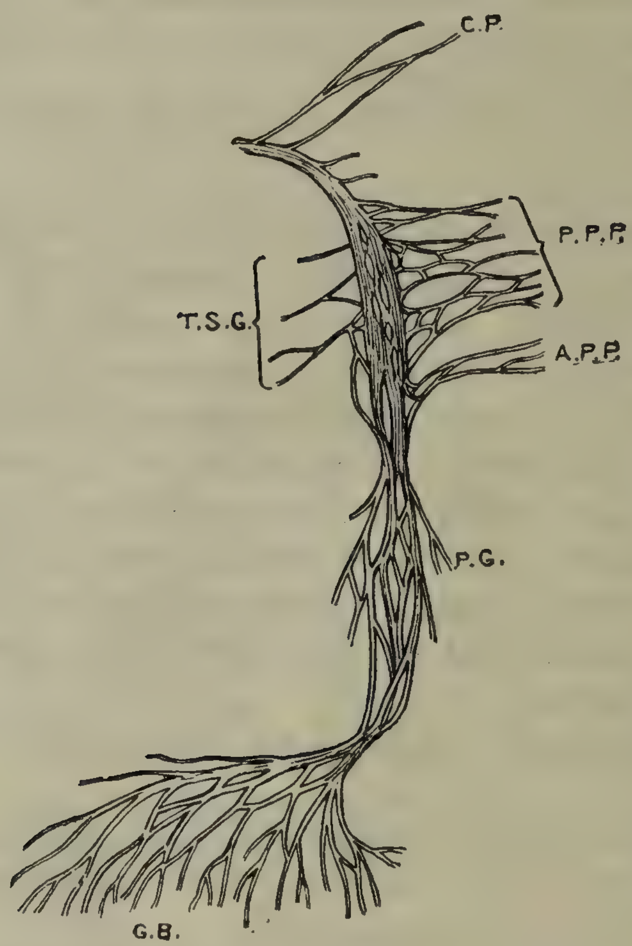


Fig. 613.—Scheme of Vagus Nerve in Thorax and Abdomen (Flower).

C.P. Branches to Cardiac Plexus
P.P.P. Branches to Posterior Pulmonary Plexus
A.P.P. Branches to Anterior Pulmonary Plexus
T.S.G. Branches from Upper Thoracic Ganglia of Sympathetic
P.G. Œsophageal Plexus
G.B. Gastric Branches

Branches.—These are as follo the left recurrent laryngeal; card from the right nerve; pulmona pleural; œsophageal; and p cardial.

The *left recurrent laryngeal nerve* arises from the left vagus in fr of the arch of the aorta on a level with its lower border. It pas backwards within the arch at the place of attachment of the li mentum arteriosum, and then turns upwards behind the arch. Hav reached the groove between the trachea and the œsophagus, it asce therein to the neck, where its subsequent course and distribution will described. In the thorax the nerve, which contains fibres derived fr the cranial root of the accessory nerve, furnishes a few cardiac branc to the deep cardiac plexus as it winds round the arch of the aorta.

ıe *right recurrent laryngeal nerve* is extra-thoracic, inasmuch as ses from the right vagus at the root of the neck, and it winds the first part of the right subclavian artery.

e *left* recurrent laryngeal nerve turns round the ligamentum arteriosum se this structure is the remnant of the arterial arch within the sixth al arch, of which the recurrent laryngeal is the nerve. Among the visceral in front of this the nerves are in the anterior parts of their arches, *in of the arterial stems,* but in the **sixth** visceral arch the vessel, having to ack to reach the arch, lies in it *in front of the nerve.* Thus the nerve is t round the ligament when the heart and large vessels assume a more l position with reference to the head and neck. *On the right* the sixth al arch disappears early, and as the fifth artery is a very short-lived ure, the nerve catches against the **fourth** artery, the first part of the right avian. It is interesting to observe that in those cases in which the right avian arises from the left end of the arch of aorta, and passes to the right d the œsophagus, there is no right fourth aortic arch; the nerve consequently es against the **third** arch, internal carotid, running thus *directly to the r.*

he *cardiac branches* of the **right** vagus are two or three in number, they descend upon the trachea to the deep cardiac plexus. (The ac branches on the left side are derived, as stated, from the recurrent laryngeal nerve as it winds round the arch of the a.)

he *pulmonary branches* are arranged in two sets, anterior and erior. The *anterior pulmonary branches* are two or three in ber, and arise from the parent trunk before it disappears behind root of the lung. They pass to the anterior aspect of the root, being joined by sympathetic twigs, they form the **anterior pul-ary plexus,** which is reinforced by twigs from the deep cardiac us, and in the case of the left anterior pulmonary plexus by twigs the superficial cardiac plexus. The branches of the anterior nonary plexus enter the lung, and accompany the ramifications he interpulmonary bronchi.

The *posterior pulmonary branches* arise from the vagus nerve nd the root of the lung. They are larger and more numerous the anterior branches, and, being joined by twigs from the nd, third, and fourth thoracic sympathetic ganglia, they form **posterior pulmonary plexus.** The branches of this plexus, like those he anterior, enter the lung, and accompany the ramifications of interpulmonary bronchi. The *pleural branches* are distributed to mediastinal and visceral pleuræ, particularly in the region of the m.

The *œsophageal branches* arise chiefly from the œsophageal plexus ow the level of the roots of the lungs, and they are distributed to the tion of the œsophagus which occupies the posterior mediastinum ıer œsophageal branches, however, arise above the level of the ts of the lungs, and are distributed to the portion of the œsophagus ich occupies the superior mediastinum.

The *pericardial branches* arise from the œsophageal plexus, and are tributed to the pericardium, which they enter from behind.

Cardiac Plexus.—The cardiac plexus is one of three large preve bral plexuses associated with the sympathetic system, the other —namely, the cœliac and the hypogastric—being situated in abdominal cavity. The plexus is situated partly in the conca of the arch of the aorta, and partly upon the trachea above the bifu tion and behind the aortic arch. It is formed by branches of vagi and sympathetic nerves, and consists of two portions, superf and deep, which communicate with each other.

The **superficial cardiac plexus,** which is comparatively smal situated in the concavity of the arch of the aorta between the mentum arteriosum and the right pulmonary artery. It is for by (1) the superior cardiac nerve from the *left* superior cervical s pathetic ganglion, and (2) the inferior cervical cardiac branch of left vagus nerve. These two nerves descend over the arch of aorta, lying between the left phrenic and left vagus nerves. At place where the two nerves join there may be a small ganglion, w is known as the *cardiac ganglion* (*ganglion of Wrisberg*).

Branches.—The plexus gives branches to the left anterior monary plexus, and, having received a considerable accession of fi from the right half of the deep cardiac plexus, it is prolonged into *right* coronary plexus.

The **deep cardiac plexus,** of larger size than the superficia situated upon the trachea immediately above the bifurcation behind the arch of the aorta. It is formed by (1) all the car branches of the *right* cervical sympathetic ganglia—namely, supe middle and inferior—and of the *right* vagus—namely, superior inferior; (2) one or two cardiac branches from the *right* recur laryngeal nerve; (3) one or two cardiac branches from the *right* va in the thorax; (4) the middle and inferior cardiac branches of the cervical sympathetic trunk; (5) the superior cervical cardiac bra of the *left* vagus; and (6) the cardiac branches of the *left* recur laryngeal nerve. It is arranged in two halves, right and left, w communicate with each other. Each half receives the follov branches:

Right Half.	Left Half.
1. The three cardiac branches of the right cervical sympathetic.	1. The middle and inferior ca branches of the left cer sympathetic.
2. The two cardiac branches of the right vagus, in the neck.	2. The superior cardiac branc the left vagus, in the neck.
3. The cardiac branches of the right recurrent laryngeal.	3. The cardiac branches of the recurrent laryngeal.
4. The cardiac branches of the right vagus, in the thorax.	

Branches.—The *right half* of the deep cardiac plexus gives (1) branches to the right anterior pulmonary plexus; (2) branc to the right coronary plexus. The *left half* of the deep cardiac ple gives off (1) branches to the left anterior pulmonary plexus; (2) branc to the left coronary plexus.

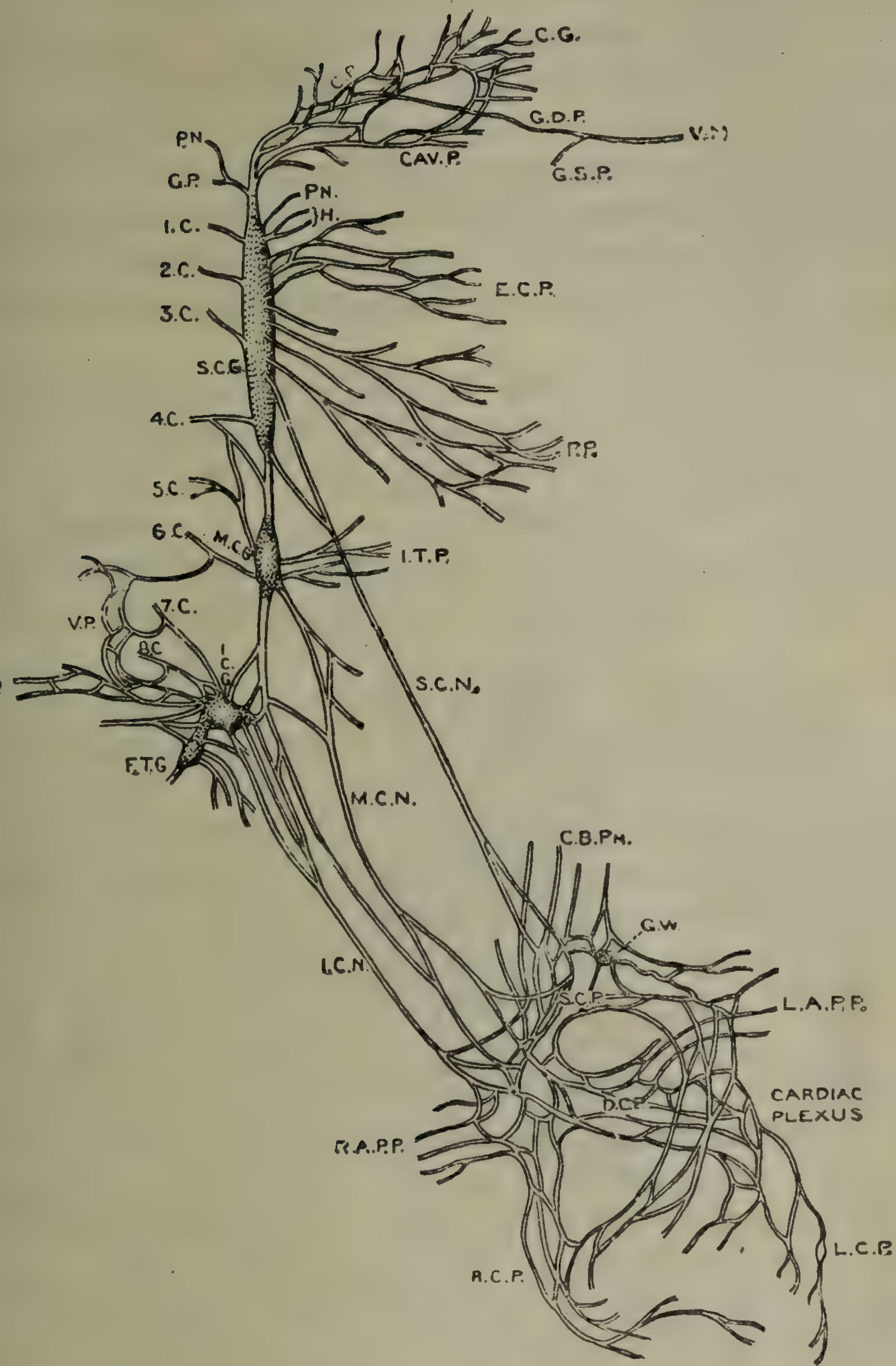


FIG. 614.—SCHEME OF THE SYMPATHETIC TRUNK IN THE NECK, AND OF THE CARDIAC PLEXUS (FLOWER).

S.C.G. Superior Cervical Ganglion.

nd G.P. Branches to Vagus and Glosso-pharyngeal
, 3c, 4c. Branches to Upper Four Cervical Nerves
.P Carotid Plexus
P. Cavernous Plexus
.G. Branch to Ciliary Ganglion
.P. Deep Petrosal
.P. Greater Superficial Petrosal
.N. Nerve of Pterygoid Canal
.N. To Inferior Ganglion of Vagus
H. To Hypoglossal
.P. To External Carotid Plexus
.P. To Pharyngeal Plexus
.N. Superior Cardiac Nerve

M.C.G. Middle Cervical Ganglion.

5c. To Fifth and Sixth Cervical Nerves
.P. To Inferior Thyroid Plexus
.N. Middle Cardiac Nerve

I.C.G. Inferior Cervical Ganglion.

7c, 8c. To Seventh and Eighth Cervical Nerves
V.P. To Vertebral Plexus
S.P. To Subclavian Plexus
I.C.N. Inferior Cardiac Nerve

F.T.G. First Thoracic Ganglion

Cardiac Plexus.

C.B.PN. Cardiac Branches of Vagus
S.C.P. Superficial Cardiac Plexus
G.W. Cardiac Ganglion
D.C.P. Deep Cardiac Plexus
R.A.P.P. Right Anterior Pulmonary Plexus
L.A.P.P. Left Anterior Pulmonary Plexus
R.C.P. Right Coronary Plexus
L.C.P. Left Coronary Plexus

Coronary Plexuses.—These are two in number, right and left.

The **right coronary plexus** is formed by branches from (1) superficial cardiac plexus, and (2) the right half of the deep card plexus. It accompanies the right coronary artery, and furnis branches to the right atrium and right ventricle of the heart.

The **left coronary plexus** is formed by branches which are deri chiefly from the left half of the deep cardiac plexus. It accompar the left coronary artery, and furnishes branches to the left atrium left ventricle of the heart.

Ganglia are met with in the coronary plexuses, and in the cou of the fibres which supply the walls of the auricles. They are present on the fibres which supply the walls of the ventricles the region of the atrio-ventricular groove, but nowhere else. In heart of the calf the nerves are easily recognized beneath the visce pericardium, as they pass across the muscular fibres in an oblic manner.

Heart.—The heart is a hollow muscular organ, which, enclo within the pericardium, is situated in the middle mediastinum, wh it lies obliquely between the two lungs. It is conical in shape, is free to move within its pericardial sac, except at the base, wh it is connected with the great bloodvessels. Its relation to the thora wall during life is influenced by posture and by the respiratory mo ments. When a person lies upon the left side, or when the pr position is assumed, the organ is more intimately related to the thora wall than in the opposite postures; and during inspiration it is l intimately connected with the thoracic wall than during expiration.

General Relations and Topography.—The heart lies obliqu behind the lower three-fourths of the body of the sternum. Ab two-thirds of the organ are contained in the left half of the thora cavity, and about one-third in the right half. The *base* is direct upwards, backwards, and to the right, and lies opposite the bod of the middle four thoracic vertebræ—namely, the fifth, sixth, seven and eighth. The *apex* is directed downwards, forwards, and to left, and during life it strikes the thoracic wall in the fifth left int costal space $1\frac{1}{2}$ inches below the left nipple, and about $\frac{3}{4}$ inch witl the left mammillary line. This point represents the apex-beat, and about $3\frac{1}{2}$ inches from the median line of the sternum. The *stern costal surface*, which is convex, lies behind the lower three-fourths of t body of the sternum and the corresponding costal cartilages, right a left—namely, the third, fourth, fifth, and sixth—more particularly th of the left side. This surface is encroached upon by the pleuræ a the thin anterior margins of the lungs. Opposite the cardiac not on the anterior margin of the left lung there is a small portion which uncovered by lung, unless during deep inspiration, and this cor sponds with the *area of precordial dulness*. **Latham's circle** is tak as defining this area, and the directions for describing the circle as follows: 'Make a circle of 2 inches in diameter round a point mi way between the left nipple and the end of the sternum.' Strict

king, the area of precordial dulness is triangular in conformity to V-shaped cardiac notch on the anterior margin of the left lung, it may be mapped out by the following lines: one drawn from the tion of the apex-beat to the median lines of the sternum on a level the fourth left costal cartilage; another drawn from the position he apex-beat to the median line of the sternum at the junction he body and xiphoid process; and a third connecting the inner s of these two lines, and extending along the middle of the sternum.

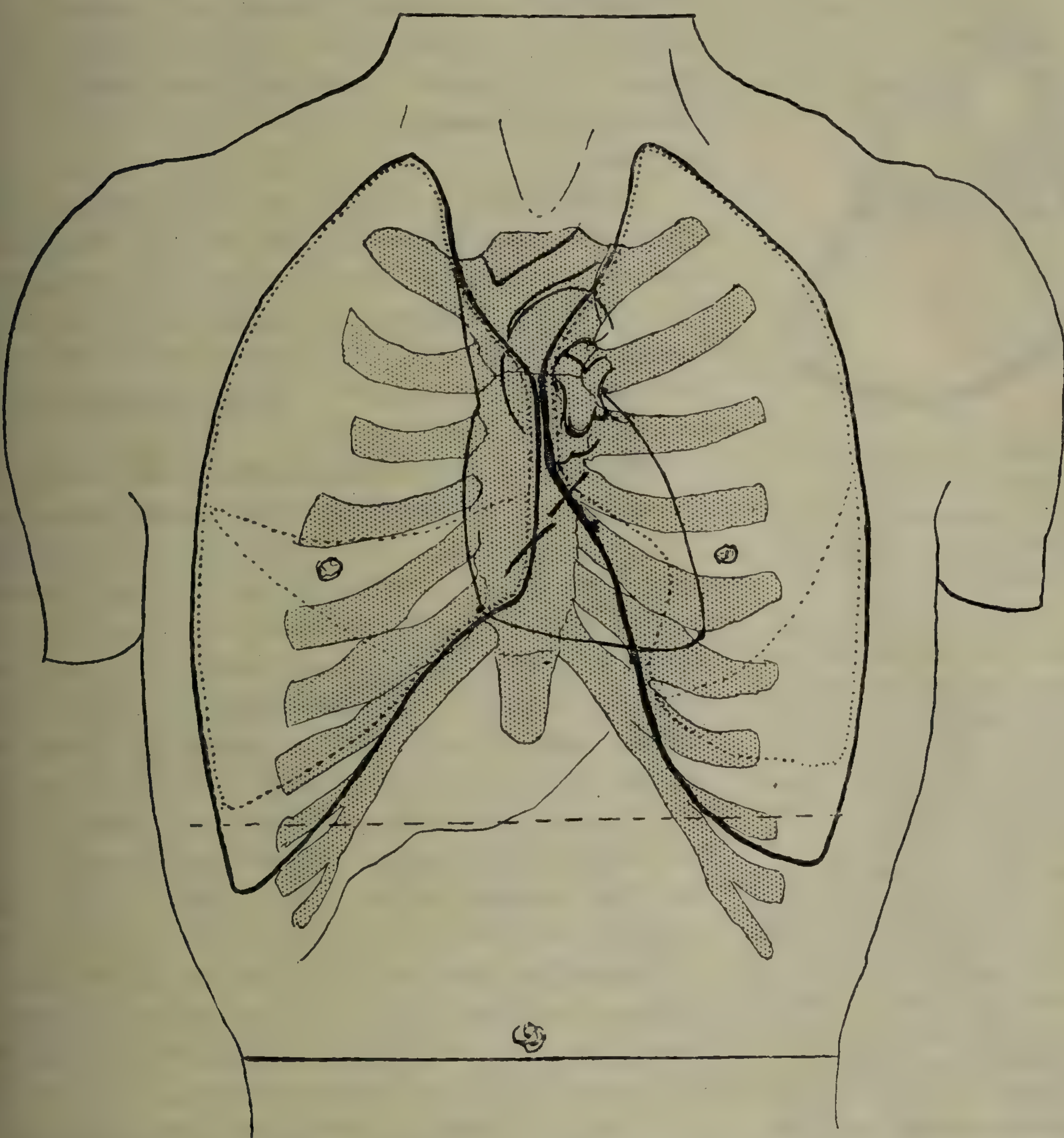


FIG. 615.—SURFACE MARKING OF THORAX FROM THE FRONT.

e *inferior* or *diaphragmatic surface*, which is flat, is directed downrds, and rests upon the upper surface of the central tendon of the phragm, covered by the serous pericardium.

The outline of the heart, in reference to the anterior wall of the rax, may be indicated with approximate accuracy in the following nner:

Base.—Draw a line across the sternum on a level with the upper rder of the third right and the lower border of the second left costal

cartilages, and prolong this line for ½ inch to the right of the sternu and 1 inch to the left of it.

Inferior Border, or Acute Margin.—Draw a line from the stern end of the sixth right costal cartilage to the position of the apex-be This line corresponds to the lower limit of the heart.

Right Limit.—Draw a line from the upper border of the third rig costal cartilage, ½ inch from the sternum, to the sternal end of t sixth right costal cartilage. This line shou be curved outwards to such an extent th its greatest convexity will be 1½ inches dista from the median line of the sternum. corresponds with the right limit of the rig atrium.

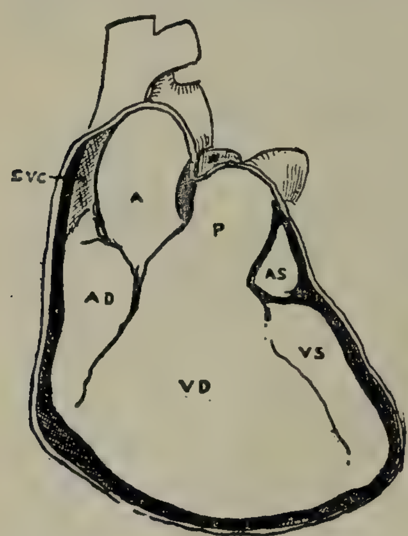


Fig. 616.—To show the Parts of Heart as seen from the Front, when Pericardium is removed.

VD is the right ventricle, narrowing upwards (infundibulum) to reach pulmonary artery (P). The prominent anterior part of left ventricle (VS) is seen along its left border, and forms the actual apex; the left auricle (AS) shows just above this. The ascending part of aorta (A) comes from the left ventricle, and therefore appears from behind P. AD is the anterior aspect of the right auricle.

Left Border, or Obtuse Margin.—Draw line from the lower border of the second l costal cartilage, 1 inch from the sternum, the position of the apex-beat. This line shou be slightly curved outwards, but it must n include the left nipple. It corresponds to t left limit of the heart.

Course of the Circulation.—The interior the heart is divided by two septa (atrial a ventricular) into two halves, right and le and each half is subdivided by a transve constriction into two chambers, an upper atrium, and a lower or ventricle, right a left respectively. The atria, except in t fœtus, are completely separated from ea other by a septum, and so also are t ventricles; but the atrium and ventricle each side communicate freely with each oth by the atrio-ventricular orifice. The rig atrium receives the venous blood chiefly fro the superior and inferior venæ cavæ and t coronary sinus. From the right atrium t blood passes into the right ventricle, a thence into the pulmonary trunk. The rig and left pulmonary arteries convey it to t lungs, and in passing through the pulmona capillaries it is oxygenated and becom arterial blood. It is then taken up by the pulmonary venous radicle and conveyed to the pulmonary veins, which carry it to the left atriu of the heart. From the left atrium it passes into the left ventric whence it is driven into the aorta. The aorta and its various ran fications convey the arterial blood to the different parts of the bod and thereafter it is returned as venous blood to the right atrium the heart.

Exterior of the Heart.—The exterior of the heart presents distin

cations of its division internally into four chambers. These take form of grooves—namely, atrio-ventricular, interatrial, and inter-tricular.

The *atrio-ventricular groove*, which is deep, divides the heart into al and ventricular portions, and surrounds the organ except in it, where the root of the aorta and the pulmonary trunk are situated. e atrial portion is posterior and superior in position, whilst the tricular portion is anterior and inferior. The *right half* of the io-ventricular groove contains (1) the right coronary artery, and the small cardiac vein, which latter lies chiefly in its posterior t. The *left half* of the atrio-ventricular groove contains (1) the coronary artery; (2) the right coronary ery, which lies in its posterior part; a portion of the great cardiac vein, ich lies in its anterior part, and also ghtly in its posterior part; and (4) the onary sinus, which lies in its posterior rt.

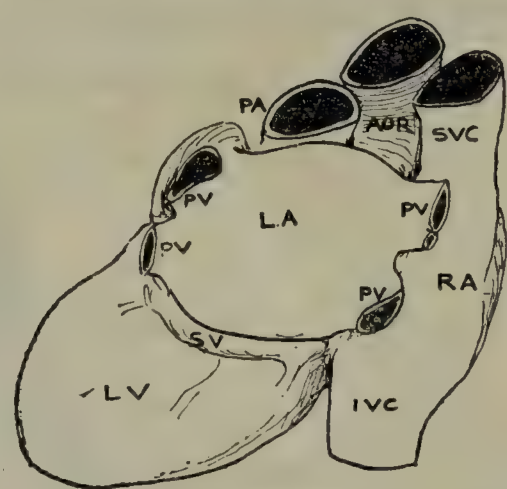


Fig. 617.—A Posterior View of the Heart, showing Left Atrium (LA) receiving Pulmonary Veins (PV).

This is the highest and most posterior cavity. The right atrium (RA) is seen beside it, and the left ventricle (LV) is visible below and in front on its left side. The coronary sinus (SV) runs transversely between the atrium and the ventricle.

The **atrial portion** of the heart has the m of a crescent, the horns of which present the auricles, and are directed wards. The concavity of the crescent also directed forwards, and lodges the ot of the aorta and the pulmonary ink, the latter being the more anterior the two. Its walls are thin, and it is vided into two atria, right and left. The ternal indication of this division is the *teratrial groove*, which is situated verti-lly on the posterior surface to the left the openings of the superior and inferior enæ cavæ. This groove corresponds to e posterior attachment of the atrial ptum in the interior. The greater part the posterior surface of the atrial portion formed by the left atrium. Projecting forwards from the anterior id upper part of each atrium is the *auricle (auricular appendix)*. The vo auricles embrace between them the root of the aorta and the ulmonary trunk.

The **right atrium** (**right auricle**) forms the anterior and right part f the base of the heart, and is triangular in outline as seen from ie front. The superior vena cava enters its atrium at the postero-iperior angle, and the inferior vena cava at the postero-inferior ngle. Near the latter vein the coronary sinus also opens into the trium. The *right auricle* (*auricular appendix*) is prolonged forwards rom the antero-superior angle of the atrium, and inclines to the left 1 front of the root of the ascending aorta. It is shorter, broader, and ess curved than the left auricle, and its margin is notched, but not so

much so as is that of the left auricle. The right atrium is travers
by a groove, called the *sulcus terminalis*, which extends from the fro
of the termination of the superior vena cava to the front and rig
side of the termination of the inferior vena cava. This groove sho
where the *sinus venosus* of embryonic life meets the primitive atrium.

The **left atrium (left auricle)** forms the posterior part and left
the base of the heart. It is quadrilateral, and the greater part
it lies flattened behind the ascending aorta and the pulmonary trun
The pulmonary veins, two right and two left, open into the posteri
part of the atrium. The *left auricle* (*auricular appendix*) is prolong
forwards from its left aspect, and inclines to the right over the le
side of the pulmonary trunk. It is longer, narrower, and more curv

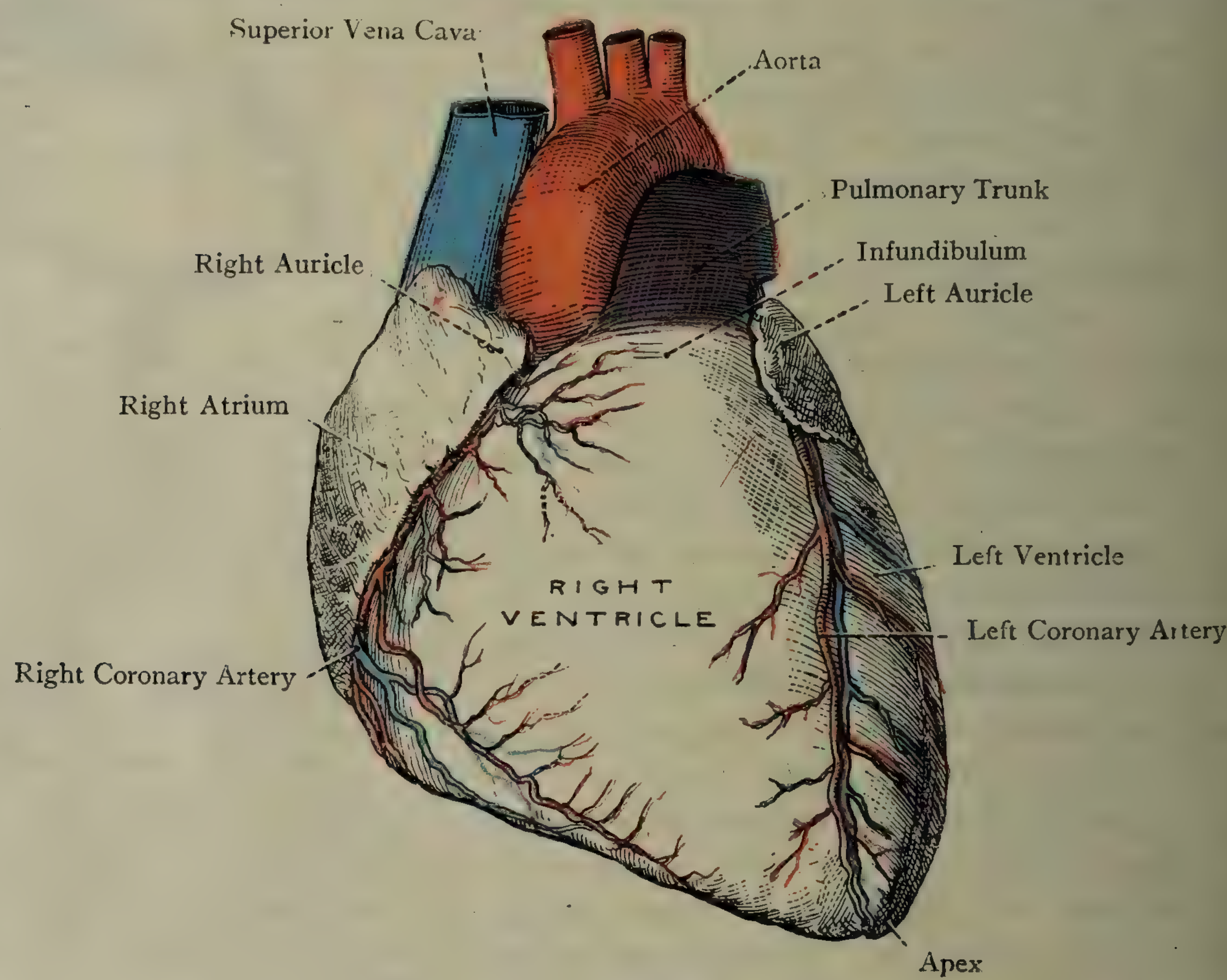


FIG. 618.—THE HEART (STERNO-COSTAL SURFACE).

than the right auricle, and its margin is more deeply notched. T
back of the left atrium is related to the œsophagus, with the inte
vention of the pericardium; the small *oblique vein of left atrium* (*ve
of Marshall*) passes downwards and inwards upon it, to open into t
coronary sinus.

The **ventricular portion** of the heart is conical, its walls are thic
and it is divisible into two ventricles, right and left. The extern
indication of this division is the interventricular groove, which co
responds to the attachment of the ventricular septum in the interio
This groove consists of two parts, anterior and posterior. The *anteri
interventricular groove* extends over the sterno-costal surface of t
heart from the left side of the pulmonary trunk to the inferior bord

:he right of, and near, the apex. At this point it becomes continuous h the inferior interventricular groove. It contains, besides fat, the anterior branch of the left coronary artery, and (2) a part of great cardiac vein. The *inferior interventricular groove* is situated the inferior surface of the heart, and, as stated, is continuous with preceding. It contains, besides fat, (1) the inferior interven- :ular branch of the right coronary artery, and (2) the middle cardiac n.

The ventricular portion of the heart presents an apex, a base,) surfaces, and two borders. The **apex** is directed downwards, wards, and to the left, and forms the apex of the heart. The *left*

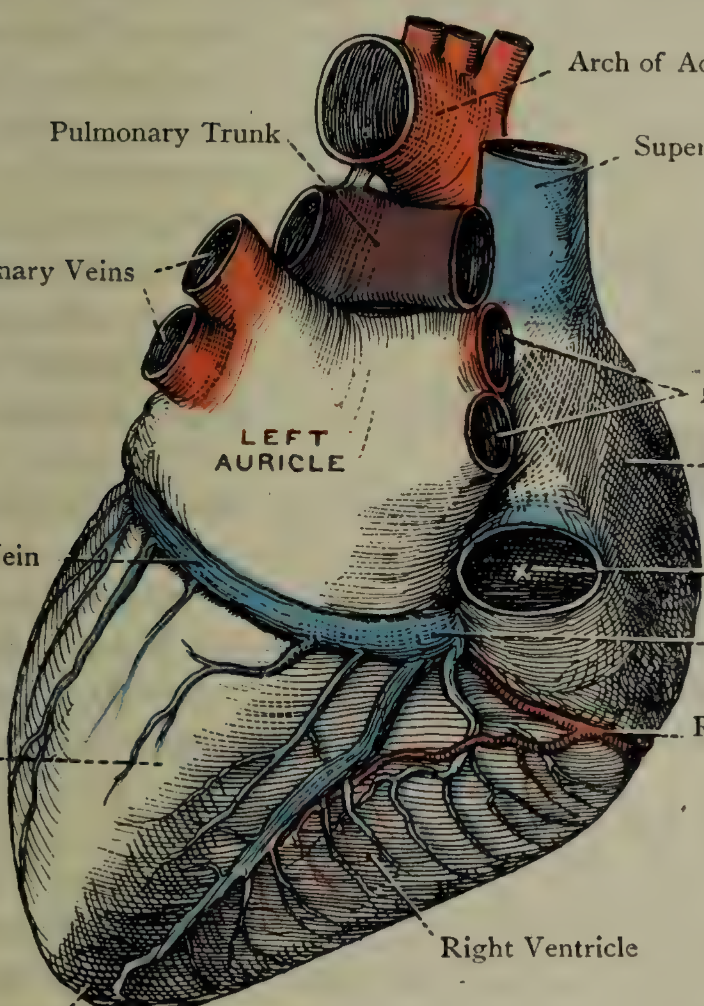


FIG. 619.—THE HEART (POSTERIOR VIEW.)

ıtricle alone enters into its formation. The **base** is directed upwards, :kwards, and to the right, and is connected with the atria and the gins of the aorta and pulmonary trunk, the former being behind l the latter in front.

The **surfaces** are sterno-costal and diaphragmatic. The *sterno- tal surface* is convex, and is traversed by the anterior interventricular ɔove. As this groove lies near the left border, the greater part of s surface (about two-thirds) is formed by the right ventricle, and : remainder by the left ventricle. In *post-mortem* examinations, :refore, when the pericardium is opened, the **right** ventricle is chiefly ɔosed for inspection. On this aspect of the right ventricle there : the anterior cardiac veins. Its upper and left part is somewhat

conical, and is called the *infundibulum* (*conus arteriosus*). It gi origin superiorly to the pulmonary trunk. The *diaphragmatic surf* is flat, and is traversed by the inferior interventricular groove. this groove lies near the inferior border, the greater part of this surf (about two-thirds) is formed by the left ventricle, and the remain by the right ventricle. On this aspect of the left ventricle there the posterior cardiac veins.

The **borders** are inferior (right) and left. The *inferior border* comparatively long, and extends from right to left. It is formed the right ventricle, and is sharp in outline, from which circumsta it is known as the *acute margin*. The marginal branch of the rig coronary artery and one of the anterior cardiac veins lie along

FIG. 620.—DIAGRAMMATIC SECTION ALONG RIGHT SIDE OF HEART.

AV, atrio-ventricular valve; C, trabeculæ carneæ; E, valve of IVC; FO, fossa ovalis; P, papillary muscle; SV, supraventricular crest; T, opening of coronary sinus.

The *left border* is shorter th the inferior, and is blunt a round, from which circu stances it is known as *obtuse margin*. The margi branch of the left coron artery lies along it.

Interior of the Hear Right Atrium (Right Auric —The wall of the auricle marked by a number muscular elevations arran as closely-set, vertical, par lel bands, like the teeth a comb, from which circu stance they are called *musculi pectanati*. Th bands, relatively to e other, are more or less icular. They are also pres on the right wall of atrium, being more comb-l here than in the auric and they terminate posteriorly at a vertical ridge, called the *cri terminalis*. This crest corresponds in position to the sulcus termin externally, and it has the same significance. Internally and posterio the walls of the atrium are destitute of musculi pectinati, and p sent a smooth appearance. The right atrium presents the follow **openings**: the opening of the superior vena cava; the opening of inferior vena cava; the opening of the coronary sinus; the openings the venæ cordis minimæ; and the tricuspid orifice.

The **orifice of the superior vena cava,** which is destitute of a val is situated at the postero-superior angle of the atrium. It is direc downwards and forwards, and the upper part of the crista termin is continuous with its anterior margin.

The **orifice of the inferior vena cava** is situated at the poste

erior angle of the atrium, and is directed upwards and inwards. front of the orifice, and to a certain extent overlapping it, there a crescentic fold of endocardium, which is the remains of the *valve the inferior vena cava* (*Eustachian valve*) of fœtal life. The con-xity of the crescent is continuous with the anterior margin of the fice of the vein, and the inner horn of the crescent is continuous th the anterior limb of the annulus ovalis, to be presently described. e fold is a somewhat indefinite structure in the adult, being subject much variety as regards size, and sometimes presenting several all openings. During fœtal life, however, the valve is of the utmost portance, inasmuch as it directs the blood entering by the inferior na cava through the foramen ovale into the left atrium.

The **orifice of the coronary sinus** is situated between the valve of e inferior vena cava and the tricuspid orifice. It is guarded by a licate semicircular fold of the endocardium, called the *valve of the onary sinus* (*Thebesian valve*), which, however, is functionally competent.

The **foramina venarum minimæ** (foramina Thebesii) represents eral minute openings on the wall of the atrium. Some of these are nply blind recesses, whilst others are the orifices of minute veins, led the *venæ cordis minimæ*, which return the blood from the wall the atrium.

The **atrio-ventricular** or **tricuspid orifice** is situated in the lower d anterior part of the atrium in front of the orifice of the inferior na cava, with the intervention of that of the coronary sinus. It is al and in health will admit three fingers. Through this opening e blood passes from the right atrium into the right ventricle, its urn being prevented by the tricuspid valve, which will be described connection with the right ventricle.

The posterior wall of the atrium corresponds to the *atrial septum,* d presents for consideration the fossa ovalis and the annulus ovalis.

The **fossa ovalis** is an oval depression which is situated upon the ver part of the atrial septum a little above and to the left of the fice of the inferior vena cava. It indicates the position of the *amen ovale* of the fœtal heart, which is a communication between e two atria through which the blood entering the right atrium by e inferior vena cava passes into the left atrium. The floor of the sa ovalis is very thin, and is bounded above and at the sides by a minent crescentic margin, called the **annulus ovalis.** The annulus leficient below, and the concavity of the crescent is directed down-rds. Its anterior limb is continuous with the valve of the inferior na cava. In some cases a minute oblique communication between e two atria persists in the adult, being situated under cover of the per portion of the annulus ovalis.

Interior of the Right Ventricle.—When exposed to view in the linary way, the interior of the right ventricle is pyramidal, the e being directed backwards and to the right, and the apex forwards, the left, and a little downwards. It is completely separated from

the left ventricle by the ventricular septum, which forms the poster wall of the ventricle, and bulges into it so as to be convex towards In transverse section, therefore, the right ventricle is semilunar. wall, which is about three times thinner than that of the left ventri is thickest at the base, and becomes thinner towards the apex. T

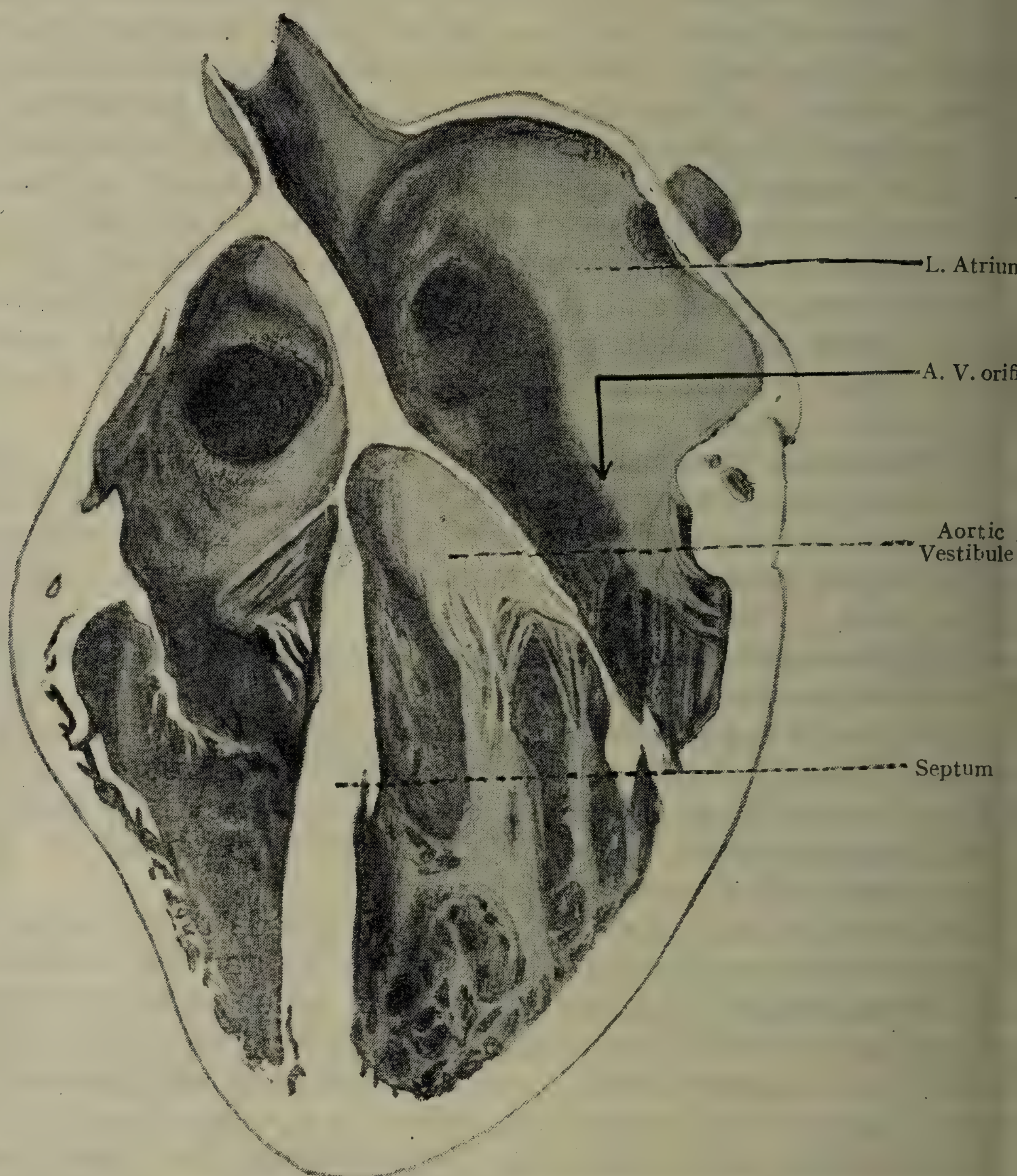


FIG. 621.—LONGITUDINAL SECTION THROUGH HEART, OPENING THE FOUR CAVITIES.

Shows the deep situation of the aortic vestibule, between the left A.V. openi and the interventricular septum. The thin upper part of this septum the pars membranacea, which is partly between the aortic vestibule a each of the right-sided cavities. Based on a section given by Tandler.

capacity of the ventricle is about 4 ounces. Its upper and left pa form the *infundibulum* (*conus arteriosus*), from the upper part of whi the pulmonary trunk springs. The walls of the infundibulum a smooth, but elsewhere the walls of the ventricle are elevated in muscular bands, called *trabeculæ carneæ*. These project into t

y, and from their reticular arrangement they render the wall irregular. According to the manner in which the trabeculæ eæ are attached to the wall, they are arranged in three sets: (1) some simple elevations, which are attached to the wall by their entire th, as well as by their extremities; (2) some are attached to the only by their extremities, being free elsewhere; and (3) others ttached only by one extremity. These latter are called *papillary les.* They are conical, and their bases are attached to the wall ie ventricle. Their free extremities are connected with a number liform processes, called *chordæ tendineæ,* which pass to the margins ventricular surfaces of the segments of the atrio-ventricular e. When the ventricle contracts, the papillary muscles also ract, and by tightening the chordæ tendineæ they prevent the s of the atrio-ventricular valve from being swept back into the im. The cusps are therefore maintained in contact during the ricular systole, and no regurgitation of blood from the ventricle the atrium is allowed in health. The papillary muscles are nged in three groups—anterior, inferior, and septal—and their s are attached to the walls of the ventricle in the region of the x of the cavity. The anterior papillary muscle is of large size, inferior is usually broken up into two or more secondary papillary cles, while the septal muscles are variable both in number and

In most hearts a fleshy column, called the *moderator band,* is met 1 in the right ventricle, which extends from the ventricular septum he base of the anterior papillary muscle. The term *moderator band* applied to this bundle in the mistaken belief that it moderated ension of the right ventricle. It is now known to serve for the sage of an important slip of the atrio-ventricular bundle. (The d was noted and drawn by Leonardo da Vinci more than four hun- d years ago, and the name of *bundle of Leonardo* has been suggested it.)

The **openings** connected with the right ventricle are two in number amely, the tricuspid and pulmonary. They are situated at the e of the cavity, and are guarded by most important valves. The uspid orifice is situated on the right and posteriorly, whilst the monary orifice is situated on the left and anteriorly, being also on igher level than the other. *Venæ minimæ cordis* are said to open the right ventricle.

The **right atrio-ventricular** or **tricuspid orifice** is oval, and admits passage of three fingers. It allows the venous blood to flow from right atrium into the right ventricle, and in order to prevent urgitation of blood from the ventricle into the atrium during the tricular systole it is guarded by an important valve, called the ht **atrio-ventricular** or **tricuspid valve.** This valve is composed of ee segments or *cusps,* which are covered with endocardium. These ject into the cavity of the ventricle, and are triangular. The bases the cusps are continuous with one another, and form a ring, which

is attached to the margin of the tricuspid orifice. The largest cus
situated in front and to the left of the tricuspid orifice. It interv
between that orifice and the infundibulum, and is known as the *ante*
cusp. Another cusp is situated behind the tricuspid orifice, and i
contact with the ventricular septum. It is called the *medial c*
The third cusp is situated to the right near the acute margin, an
called the *inferior cusp*. In the angular intervals between the b
parts of the three large cusps there are usually three small cusps.

Each cusp consists of two layers of endocardium, with fib
tissue between them, especially at their central parts. The mi
portion of each cusp is therefore thicker than the marginal porti
these latter being thin and transparent. The margins themse

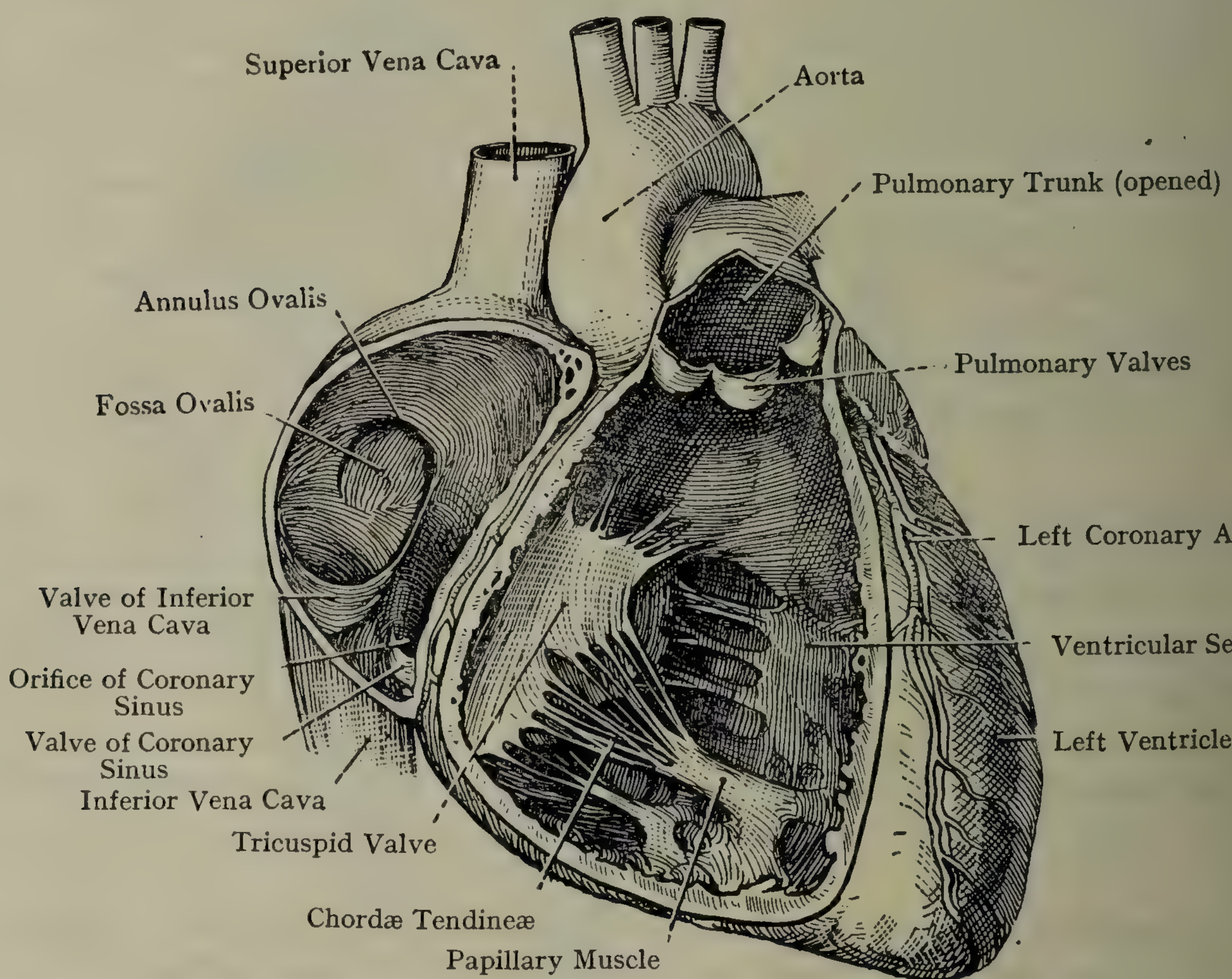


FIG. 622.—THE INTERIOR OF THE RIGHT AURICLE AND RIGHT VENTRIC

are notched. The atrial surfaces of the cusps are smooth, but t
ventricular surfaces are roughened by the chordæ tendineæ, w
are also attached to the margins.

The **chordæ tendineæ** are filiform, fibrous processes which
connected on the one hand with the wall of the ventricle, and
the other with the cusps of the tricuspid valve. Most of them sp
from the anterior and inferior papillary muscles, but a few of t
arise from the ventricular septum and from the small papillary e
nences upon it. Those which are connected with the anterior papil
muscle pass to the interval between the anterior and inferior cu
those which are connected with the inferior papillary muscle and
subdivisions pass to the interval between the medial and infe

ps; and those which are connected with the ventricular septum ; to the interval between the anterior and medial cusps. The nection of the chordæ tendineæ with the cusps of the valve is of reefold nature as follows: (1) most are connected with the marginal ts of the cusps; (2) others are connected with the thickened central tion of each cusp; and (3) a few pass to the basal portion of each p, where they are connected with the fibrous ring around the uspid orifice.

The **pulmonary valve** guards the orifice of the pulmonary trunk, prevents regurgitation of blood from the trunk into the right tricle during the elastic recoil of the arterial wall. It is composed three semilunar cusps, and the wall of the artery opposite each

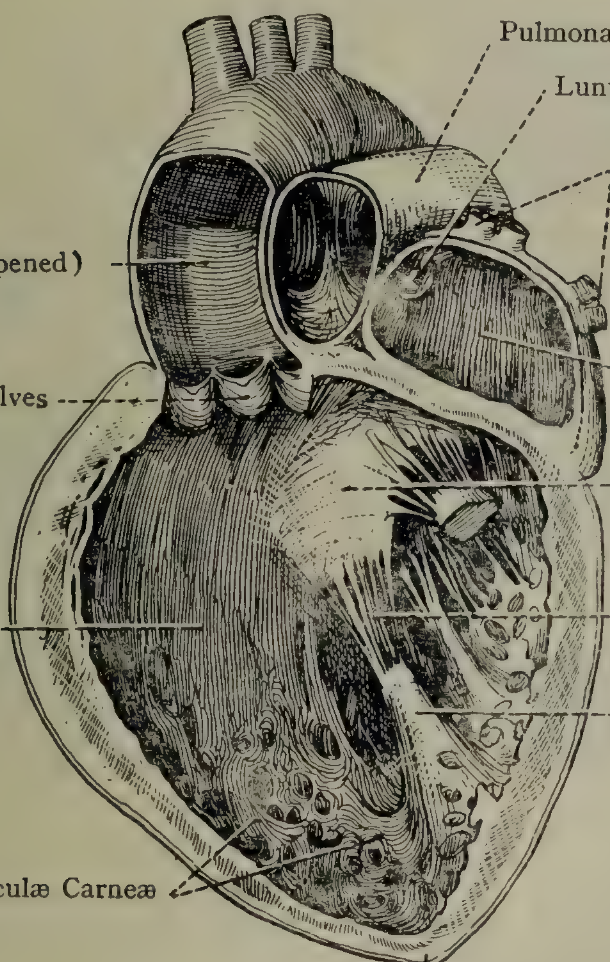


FIG. 623.—THE INTERIOR OF THE LEFT ATRIUM AND LEFT VENTRICLE.

ment presents a recess, these recesses being called **sinuses.** The ve and the sinuses are similar to corresponding structures in nection with the aortic orifice, and will be fully described along h that orifice.

Interior of the Left Atrium.—The musculi pectinati are present y in the auricle, whereas in the right atrium they are present both the auricle and on the right wall of the atrium. The wall of the left ium is entirely smooth. The atrium presents five **openings**—nely, the openings of the four pulmonary veins, and the mitral ice.

The **orifices of the four pulmonary veins** are situated on the posterior ll of either side, two right and two left, and are destitute of valves.

The **auriculo-ventricular** or **mitral orifice** is situated in the anter part of the floor of the atrium. It is oval, and in health admits passage of two fingers.

Venæ minimæ cordis are said to open into the left atrium.

The *atrial septum* presents a slight depression, limited inferio by a faint crescentic ridge, the concavity of which is directed upwar These indicate the position of the foramen ovale of the fœtal heart

Interior of the Left Ventricle.—The cavity of the left ventri extends quite to the apex of the heart, and is longer and narrov than that of the right ventricle. It is somewhat conical, the base bei directed backwards and upwards. The ventricular septum rece from the cavity, and is conca towards it. In transverse secti therefore, the left ventricle is ov or nearly circular. The wall of left ventricle is about three tin thicker than that of the right, difference being readily account for by the fact that the left ventri is concerned with the systemic c culation, whilst the right ventri has to do with the pulmonary c culation, the latter involving a mu shorter circuit. The wall of left ventricle attains its maxim thickness about the junction the upper fourth and lower thr fourths, and is thinnest in region of the apex. The capac of the ventricle is about 4 ounc The portion of the cavity imme ately below the aortic orifice known as the **aortic vestibule,** walls of which are *fibrous.*

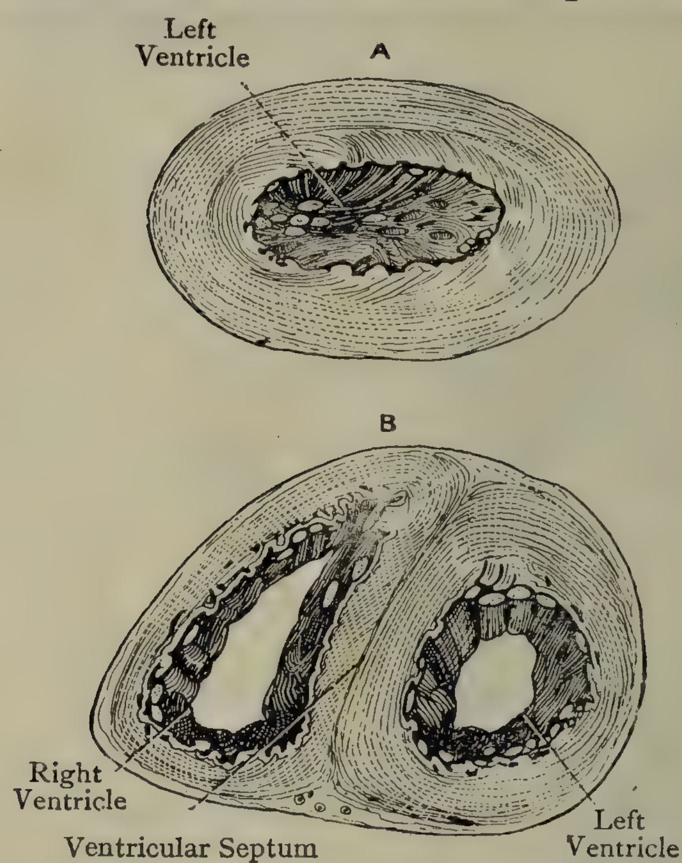


FIG. 624.—TRANSVERSE SECTIONS OF THE HEART.

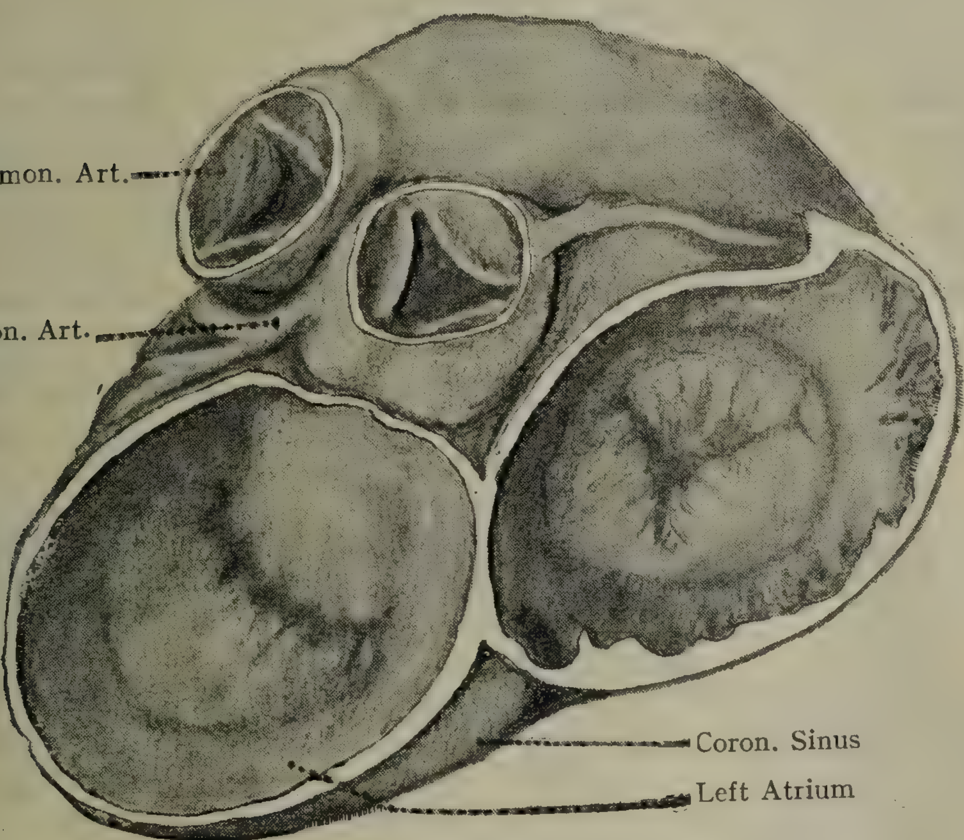
A, through apex (superior view).
B, through ventricles (inferior view).

The left ventricle, like the right, is provided with trabeculæ carn They are arranged in a very intricate manner, more particularly the region of the apex and over the posterior wall. The aor vestibule and the ventricular septum, at least over its upper pa are destitute of trabeculæ carneæ, and present a smooth appearan The papillary muscles are much larger than those in the right ventric they are two in number, anterior and posterior, and they are attacl by their bases to the respective walls of the ventricle, whilst th free ends are connected with the chordæ tendineæ.

The **openings** connected with the left ventricle are two in num —namely, mitral and aortic. They are situated at the base of ventricle in close proximity to each other, and are guarded by import valves. The mitral orifice is situated on the left and posterior whilst the aortic orifice is situated on the right and anteriorly. T

:ic orifice is also considerably the higher of the two. *Venæ minimæ lis* are said to open into the left ventricle.

The **auriculo-ventricular** or **mitral orifice** is oval, and in health nits two fingers. It allows the arterial blood to flow from the left um into the left ventricle, and in order to prevent regurgitation blood from the ventricle into the atrium during the ventricular tole it is guarded by an important valve. This valve is called the **auriculo-ventricular, mitral,** or **bicuspid valve.** It is composed two large segments or *cusps*, with two small cusps in the angular ervals between their basal parts. The cusps are similar in shape



'IG. 625.—DISSECTION (VIEWED FROM ABOVE) OF THE BASAL PART OF THE HEART.

e two arterial stems have been removed close to their origins, exposing their valves, while the atria have been cut away a little distance above the atrio-ventricular valves. The coronary arteries are thus exposed for some extent after their origins, the aortic sinuses are partly visible, the coronary sinus is seen opening into the right atrium, and the atrio-ventricular valves, mitral and tricuspid, are seen closed.

d structure to those of the tricuspid valve, but on account of e nature of their work they are thicker and stronger. They e disposed obliquely, and are of unequal size. The larger of e two is placed in front and to the right of the orifice. It inter-nes between the mitral and aortic orifices, and is known as the *terior cusp*. The smaller cusp is placed behind and to the left of e orifice, and is known as the *posterior cusp*.

The **chordæ tendineæ** are attached to the cusps, as in the case of e tricuspid valve. They are, however, fewer in number, and of eater thickness and strength than on the right side.

Function of the Tricuspid and Mitral Valves.—These valves serve to prev regurgitation of blood from the ventricles into the atria during the ventric systole. Whilst the ventricle is being filled, some of the blood gets beh the segments of the atrio-ventricular valve—that is to say, between each segm and the wall of the ventricle—and the segments are thus carried towards atrio-ventricular orifice. When the ventricle is filled with blood the segme are in contact, and the ventricular systole now takes place. At the same t the papillary muscles contract. Blood is forced against the segments of the va but it cannot in health enter the atrium, because the segments are maintai in close contact, and are prevented from being swept back into the auricle by chordæ tendineæ, which are under the control of the papillary muscles. If th were no papillary muscles, in which case the chordæ tendineæ would spr directly from the wall of the ventricle, then the segments of the valve would be held tight, but would, under the pressure of the blood, be driven back into atrium, and regurgitation of blood would of necessity occur. The explanat of this lies in the fact that when the ventricle contracts a kind of screwing or wringing movement takes place in its wall, as, so to speak, in wringing a towel. The effect of this peculiar action is to approximate successive parts the ventricular wall to the atrio-ventricular orifice, and this would have effect of relaxing the chordæ tendineæ, and so allowing the segments of the va to be driven back into the atrium. The chordæ tendineæ, however, spring fr papillary muscles, and these are elevations of the wall of the ventricle direc

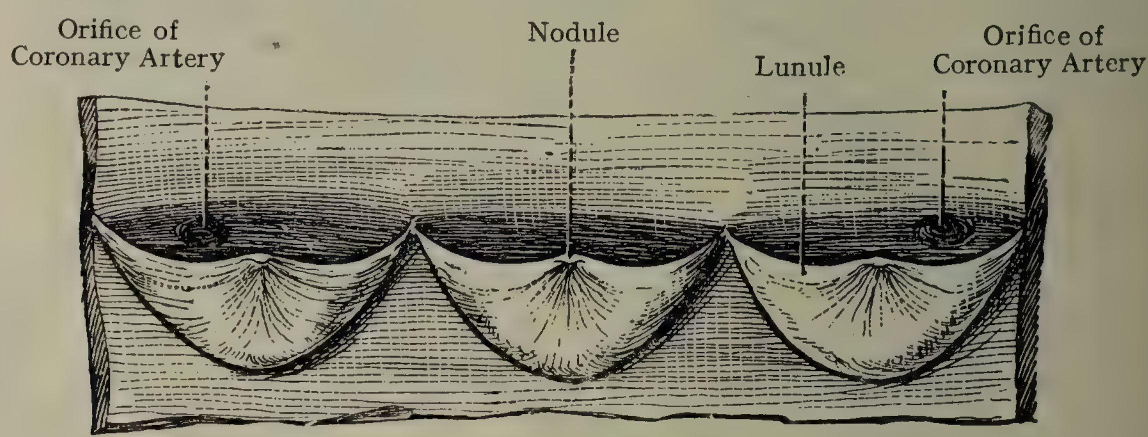


FIG. 626.—CUSPS OF THE AORTIC VALVE.

towards the atrio-ventricular orifice. During the wringing movement, theref of the ventricular wall in systole the papillary muscles, as stated, contract, so maintain the chordæ tendineæ taut, or tightly drawn.

When the mitral valve opposes the entrance of blood into the left ventr the cardiac affection is known as mitral obstruction (stenosis). When mitral valve is incompetent, and allows regurgitation of blood to take place fr the left ventricle into the left atrium, the cardiac affection is known as mi regurgitation (incompetence).

The **aortic orifice** is circular, and is separated from the mitral ori by the anterior cusp of the mitral valve. It is guarded by the **ao valve,** which by means of its cusp prevents regurgitation of bl from the aorta into the left ventricle during the elastic coil of arterial wall. It is composed of three semilunar cusps or segmen consisting of fibrous tissue, covered on their ventricular surfaces endocardium, and on their arterial surfaces by the endothelial lin of the artery. Each cusp is attached by its convex border to wall of the artery at the place where it springs from the ventri The other border of the cusp is free, and is directed away from ventricle. Each cusp, therefore, is so disposed as to allow the bl

pass freely into the aorta from the left ventricle. The free border each cusp is strengthened by a band of fibrous tissue, and at the tre of the border there is a small swelling, called the *nodule* (*corpus ntii*). This gives rise to a slight projection, and on either side of he border is concave. The attached convex border of each cusp lso strengthened by fibrous tissue. In addition to these fibrous kenings, fibrous tissue pervades each cusp from the nodule to the ched border, with the exception of the portions immediately w the lateral concave parts of the free border. These portions in h cusp are semilunar, and are called the *lunules*. They are the nnest parts of the cusp, and are transparent, consisting practically ndocardium and the endothelial lining of the artery.

The interior of the wall of the aorta presents three well-marked esses, each of which is placed opposite a segment of the valve. These esses are called the **aortic sinuses (sinuses of Valsalva)**, and they are dis-ed as *anterior*, *left posterior*, and *right posterior* respectively. The erior sinus presents the orifice of the right coronary artery, and the posterior sinus presents the orifice of the left coronary artery. Each is, together with the corresponding cusp of the aortic valve, forms nall pocket, and the three pockets open away from the left ventricle hat is to say, in a direction corresponding to the normal blood-flow.

Function of the Aortic Valve.—This valve serves to prevent regurgitation of od from the aorta into the left ventricle during the elastic recoil of the arterial l close to the heart. During the ventricular systole, when the blood is being en through the aortic orifice, the aortic valve assive, and its three segments are applied to arterial wall. During the elastic recoil of the rial wall, however, the valve is in action. The effect of the elastic recoil is to force sufficient od backwards towards the left ventricle to close aortic valve. This blood enters the pockets ned by the aortic sinuses and the cusps of the ve. The cusps are pressed towards the centre of aortic orifice, and they come into contact in following manner: the three nodules come into e contact at the centre of the aortic orifice, and lose what would otherwise be a small space, and respective lunules are closely pressed against another. In this manner the aortic orifice is npletely closed, and regurgitation of blood into left ventricle is in health effectually guarded inst. It will be evident that the strain of the kward pressure of blood must be borne by those tions of the segments which are strengthened fibrous tissue extending from each nodule to attached border of each cusp. Though the ules are thin and weak, nevertheless, being, so to speak, doubled up against another, the more they are pressed upon the more closely they fit together.

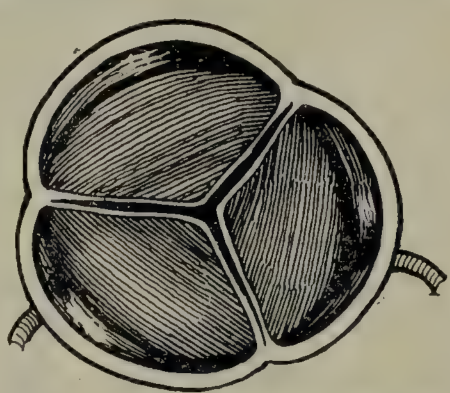


Fig. 627.—The Aortic Sinuses and the Aortic Valves, seen from above.

The right coronary artery (left in figure) is seen coming from the anterior sinus; the left artery is arising from the left posterior sinus.

When the aortic valve offers opposition to the entrance of blood into the ta, the cardiac affection is called aortic obstruction (stenosis). On the other d, when the aortic valve is incompetent, and allows regurgitation of blood ake place into the left ventricle, the cardiac affection is called aortic regurgi-ion (incompetence).

The **pulmonary valve,** which guards the orifice of the pulmona trunk, is similar to the aortic valve, and the preceding descripti is for the most part applicable to it. The cusps of the pulmona valve are, however, weaker than those of the aortic valve, and t **sinuses** are destitute of any arterial orifices. These sinuses are dispos as *posterior, right anterior,* and *left anterior* respectively.

The function of the pulmonary valve is similar to that of t aortic valve.

Ventricular Septum.—This septum completely separates the rig and left ventricles. The external indications of its attachments a the anterior and inferior interventricular grooves. It is thick, and for t most part fleshy. It is thickest in the region of the apex, and becon thinner towards the base of the ventricles. It bulges into the rig ventricle, so as to be convex on that aspect, whilst it recedes from t left ventricle, so as to be concave towards it. The upper or ba part of the septum presents anteriorly a small portion which is destitu of muscular fibres. This portion is thin (see Fig. 621) and consi of fibrous tissue, covered on either side by endocardium.

It is known as the *membranous part* of the septum, and is develop from the fused A.V. cushions of embryonic life. It forms the rig and posterior part of the wall of the aortic vestibule immediat below the aortic valves. Its upper part separates the cavity of t vestibule from the *right atrium,* while its lower part is *between* *ventricles*; these relations can be seen in Fig. 621.

Topography of the Orifices of the Heart.—The **pulmonary orif** is situated on a level with the upper margin of the third left cos cartilage at its junction with the sternum. The **aortic orifice,** whi is more deeply placed than the pulmonary, is situated behind the l border of the sternum on a level with the lower margin of the th costal cartilage.

The **tricuspid orifice** lies behind the body of the sternum oppos the fourth intercostal spaces and fourth and fifth costal cartilag The **mitral orifice,** which is placed very deeply, is situated behind t left border of the sternum on a level with the fourth left costal cartila The anterior atrio-ventricular groove corresponds with a line dra from the third left to the sixth right costal cartilage, and it is on t line that the two atrio-ventricular orifices are necessarily found.

Cardiac Bloodvessels—Arteries.—The nutrient vessels of the he are the coronary arteries, right and left, which arise from the root the ascending aorta. For a description of these vessels, see p. 1036

Veins.—The cardiac veins are as follows: the great cardiac ve the coronary sinus; the posterior cardiac veins; the middle card vein; the small cardiac vein; the anterior cardiac veins; the oblic vein of left atrium; and the venæ cordis minimæ or smallest card veins. With the exception of the last-named cardiac veins (ve cordis minimæ), all the others are seen upon the exterior of the hea

The **great cardiac vein** commences at the apex of the heart, a ascends in the anterior interventricular groove alongside of the anter

ventricular branch of the left coronary artery. In this part of its se it is more properly called the *anterior interventricular vein.* of large size, and receives tributaries from both ventricles and the ventricular septum. On reaching the atrio-ventricular ve it enters the left division of that groove, in which it courses g with the left coronary artery. Having turned round the left gin of the heart, it joins the left extremity of the coronary sinus, which it is continuous. The name *coronary*, which was sometimes n to this vessel, is strictly applicable to it only where it lies in the atrio-ventricular groove.

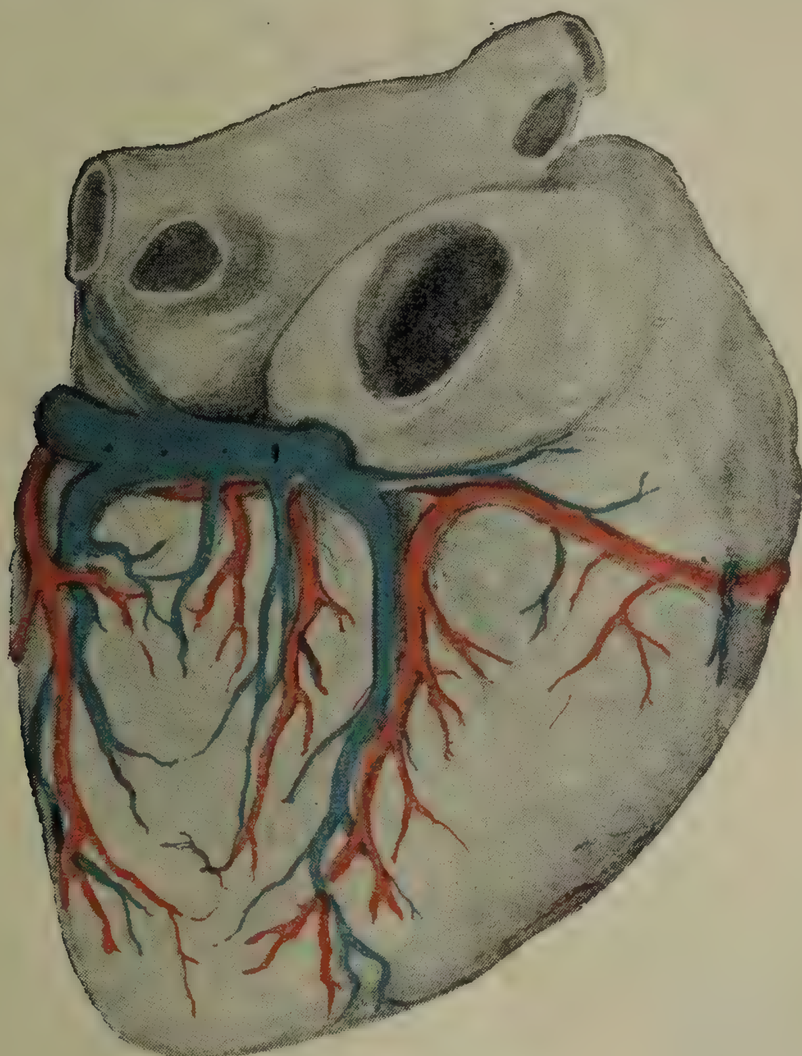


FIG. 628.—HEART VIEWED FROM BELOW AND BEHIND, SHOWING THE ARTERIAL AND VENOUS DISTRIBUTIONS HERE.

The **coronary sinus** is the dilated terminal part of the great cardiac n. It is about 1 inch in length, and occupies a portion of the terior part of the left atrio-ventricular groove. Its left extremity ontinuous with the great cardiac vein, and its right extremity opens the right atrium between the valve of the inferior vena cava and tricuspid orifice, the opening being guarded by the valve of the onary sinus. At the place where the coronary sinus is continuous h the great cardiac vein there is a valve, which is composed of two ments.

The coronary sinus is the persistent left horn of the sinus venosus.

The **posterior cardiac veins** ascend upon the posterior surface of left ventricle, and open partly into the coronary sinus, and partly

into the contiguous portion of the great cardiac vein. One of t
is known as the *left marginal vein.*

The **middle cardiac vein,** which is of large size, commences at
apex of the heart, and passes along the inferior interventric
groove with the inferior interventricular branch of the right coro
artery. It receives tributaries from the adjacent surface of the r
ventricle and from the ventricular septum, as well as a few f
the left ventricle, and opens into the right extremity of the coro
sinus.

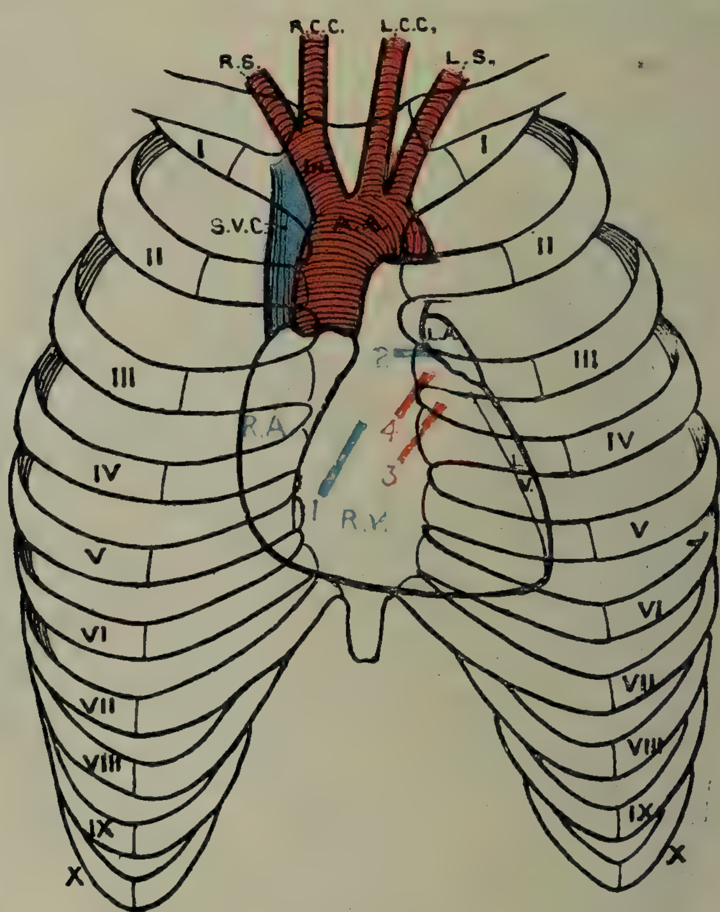


FIG. 629.—DIAGRAM SHOWING THE POSITION OF THE HEART AND ITS VALVU
ORIFICES IN RELATION TO THE ANTERIOR WALL OF THE THORAX.

R.A. Right Atrium
R.V. Right Ventricle
L.A. Left Atrium
L.V. Left Ventricle
A.A. Arch of Aorta
IN. Innominate Artery

R.S. Right Subclavian Artery
R.C.C. Right Common Carotid Artery
L.C.C. Left Common Carotid Artery
L.S. Left Subclavian Artery
S.V.C. Superior Vena Cava

NUMBERS ON STERNUM.

1. Tricuspid Orifice
2. Pulmonary Orifice
3. Mitral Orifice
4. Aortic Orifice

The **small cardiac vein** occupies the right atrio-ventricular gro
in company with the right coronary artery, and opens into the ri
extremity of the coronary sinus. It is subject to some variat
but it usually receives tributaries from the contiguous parts of the ri
atrium and right ventricle, including the anterior cardiac veins.

The **anterior cardiac veins** ascend on the front of the right ventri
and open into the small cardiac vein. One of them is known as
right marginal vein.

The **oblique vein of left atrium** (**oblique vein of Marshall**), whic
a persistent part of the *left duct of Cuvier,* passes downwards and inw

the posterior aspect of the left atrium, and opens into the left emity of the coronary sinus, its orifice being destitute of a valve.

evelopment.—The oblique vein of left atrium represents the terminal portion e *left* duct of Cuvier.

Tributaries of the Coronary Sinus.—These are as follows: (1) the t cardiac vein; (2) some of the posterior cardiac veins, others of e veins opening into the great cardiac vein; (3) the middle cardiac ; (4) the small cardiac vein; and (5) the oblique vein of left atrium. h the exception of the last-named tributary, all the others are vided with valves at their terminal orifices, but elsewhere they destitute of valves.

FIG. 630.—THE VEINS OF THE HEART AS SEEN FROM IN FRONT.

The heart is supposed to be semi-transparent.

The **venæ cordis minimæ** (**smallest cardiac veins**) are not visible n the exterior of the heart. They are very minute, and they open the right atrium, their orifices constituting some of the foramina arum minimarum. Similar minute veins are said to open into the atrium, and also into both ventricles.

Lymphatics.—The lymphatic vessels of the heart form two net-ks—subendocardial and subpericardial. The vessels are ulti-tely collected into two trunks, right or posterior, and left or erior. The **right trunk** receives the lymphatics of the right side he heart, and the **left trunk** takes up those of the left side. Each nk accompanies the corresponding coronary artery, and both pass kwards on either side of the pulmonary trunk. Having pierced pericardium, they terminate in the *superior mediastinal* or *cardiac nds.*

Nerves.—The nerves of the heart are derived from the super and deep cardiac plexuses, and through these from the vagus sympathetic nerves. The branches to the atria are derived p from the deep cardiac plexus, and partly from the coronary plex They form a gangliated plexus on the surface of each atrium ber the epicardium, and from this plexus branches proceed to the mus wall. The branches to the ventricles are derived from the right left coronary plexuses. These branches lie upon the surface of ventricle beneath the epicardium, and in the heart of the calf the readily recognizable as delicate, thread-like streaks. Minute ga are met with at intervals on these nerves in the region of the ba the ventricles, but none on those nerves which lie over the lower thirds of each ventricle. The branches which enter the mus substance of the ventricular walls form plexuses, but are dest of ganglia.

Structure of the Heart.—The cardiac wall is composed of muscular t which is known as the **myocardium.** This is intimately covered by the vi layer of the serous pericardium, this layer being called the **epicardium,** an cavities of the heart are lined with a mem which is known as the **endocardium.**

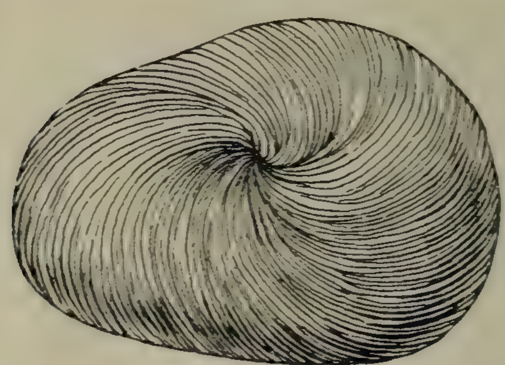


FIG. 631.—THE SUPERFICIAL MUSCULAR FIBRES OF THE HEART IN THE REGION OF THE APEX (C. GEGENBAUR).

The whorled arrangement is well shown.

The **epicardium** resembles a serous mem in structure, and is covered by endothe Beneath the epicardium there is a va amount of fat, which is chiefly met with atrio-ventricular and interventricular groov

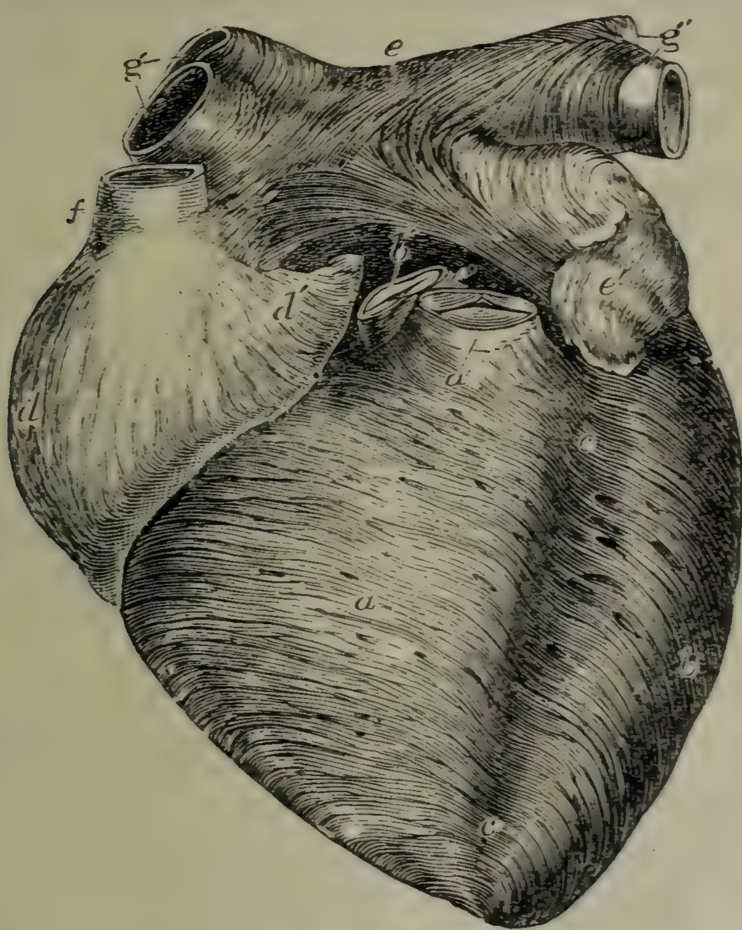
The **endocardium** is a smooth, delicate brane, destitute of bloodvessels, and cover its internal surface by endothelium. It co of a connective-tissue basement membrane taining elastic fibres, and is continuous th the arterial and venous orifices with the *intima* of the vessels. It enters into the f tion of the segments of the atrio-ventricula semilunar valves.

Fibrous Tissue.—The atrio-ventricular arterial orifices of the heart are each surrou by a ring of fibrous tissue, and these rings, case of the atria and ventricles, connect them together. The fibrous tiss these rings furnishes that which is met with in the segments of the various v In the triangular interval between the aortic and the two atrio-ventr orifices there is a collection of dense fibrous tissue, of the consistence of cartilage, which is connected with the fibrous rings just referred to, and represents the os cordis of the ox. When a heart is boiled the fibrous tis dissolved, and the atrial portion can be separated from the ventricular por

Myocardium.—The muscular tissue of the auricles is mostly distinct that of the ventricles, the fibrous rings at the atrio-ventricular orifices vening between the two, and serving to connect them.

Atria.—The muscular fibres of the atria are arranged in a superfici common to both atria, and a deep set confined to each atrium. The *supe fibres* are disposed transversely, and some of them enter the atrial septum. are best marked in front. The *deep fibres* are arranged in two sets, loope circular. The *looped fibres* arch vertically over the atrium, their extre being attached to the ring of fibrous tissue which surrounds the atrio-ventr orifice. The *annular fibres* are present in the auricle around the venous or and around the fossa ovalis. The walls of the atria, though muscular, are

ntricles.—The muscular fibres of the ventricles are, as stated, mostly ct from those of the atria, and are disposed in a very complicated manner. spring for the most part from the rings of fibrous tissue which surround trio-ventricular orifices. The *superficial fibres* descend obliquely towards pex, where they are disposed in a twisted or whorled manner, after which pass on to the inner surface of the left ventricle. Some of them become uous with the papillary muscles of that ventricle, whilst others ascend as ical layer on the inner surface of the ventricle to be attached to the left



632.—Anterior View of Heart of a Young Subject dissected after Long Boiling, to show the Superficial Muscular Fibres (Allen Thompson). $\frac{2}{3}$. (From Quain's 'Anatomy.')

figure is planned after one of Luschka's, but its details were chiefly taken from an original preparation. The aorta, *b'*, and pulmonary trunk, *a'*, have been cut short close to the arterial (semilunar) valves, so as to show the anterior fibres of the atria; *a*, superficial layer of the fibres of the right ventricle; *b*, that of the left; *c*, *c*, anterior interventricular groove; *d*, right atrium; *d'*, its auricle, both showing chiefly perpendicular fibres; *e*, upper part of the left atrium; between *e* and *b'*, the transverse fibres which behind the aorta pass across both auricles; *e'*, auricle of left atrium; *f*, superior vena cava, around which, near the atrium, circular fibres are seen; *g*, *g'*, right and left pulmonary veins with circular bands of fibres surrounding them.

)-ventricular fibrous ring. The superficial fibres are common to both ricles.

The remaining fibres are very numerous, and must be described separately each ventricle. The principal fasciculi of the *left* ventricle spring from the atrio-ventricular fibrous ring, and they pass more or less obliquely towards apex. In their course they turn inwards, and enter the front part of the tricular septum inferiorly. Some of them now pass upwards to the base of ventricle to be attached to the collection of dense fibrous tissue, of the con-ence of fibro-cartilage, already described; others pass across to the postero-rior wall of the right ventricle, where they partly end in a papillary muscle,

and partly pass to be attached to the right atrio-ventricular fibrous ring; w
a third set pass to the postero-inferior wall of the left ventricle, where
become circular in direction. The principal fibres of the *right* ventricle are
the superficial fibres, continuous with those of the left ventricle, and spring
the fibrous rings around the atrio-ventricular and pulmonary orifices. T
on the postero-inferior surface of the right ventricle pass into the ventri
septum, and having traversed it obliquely forwards and upwards, they
from it, and become continuous with the deep fibres of the left ventricle. T
on the sterno-costal surface of the right ventricle also pass into the ventri
septum, and having traversed it obliquely backwards and downwards, they
on to the postero-inferior wall of the left ventricle. Those from the in
aspect of the right ventricle enter the lower part of the ventricular septum

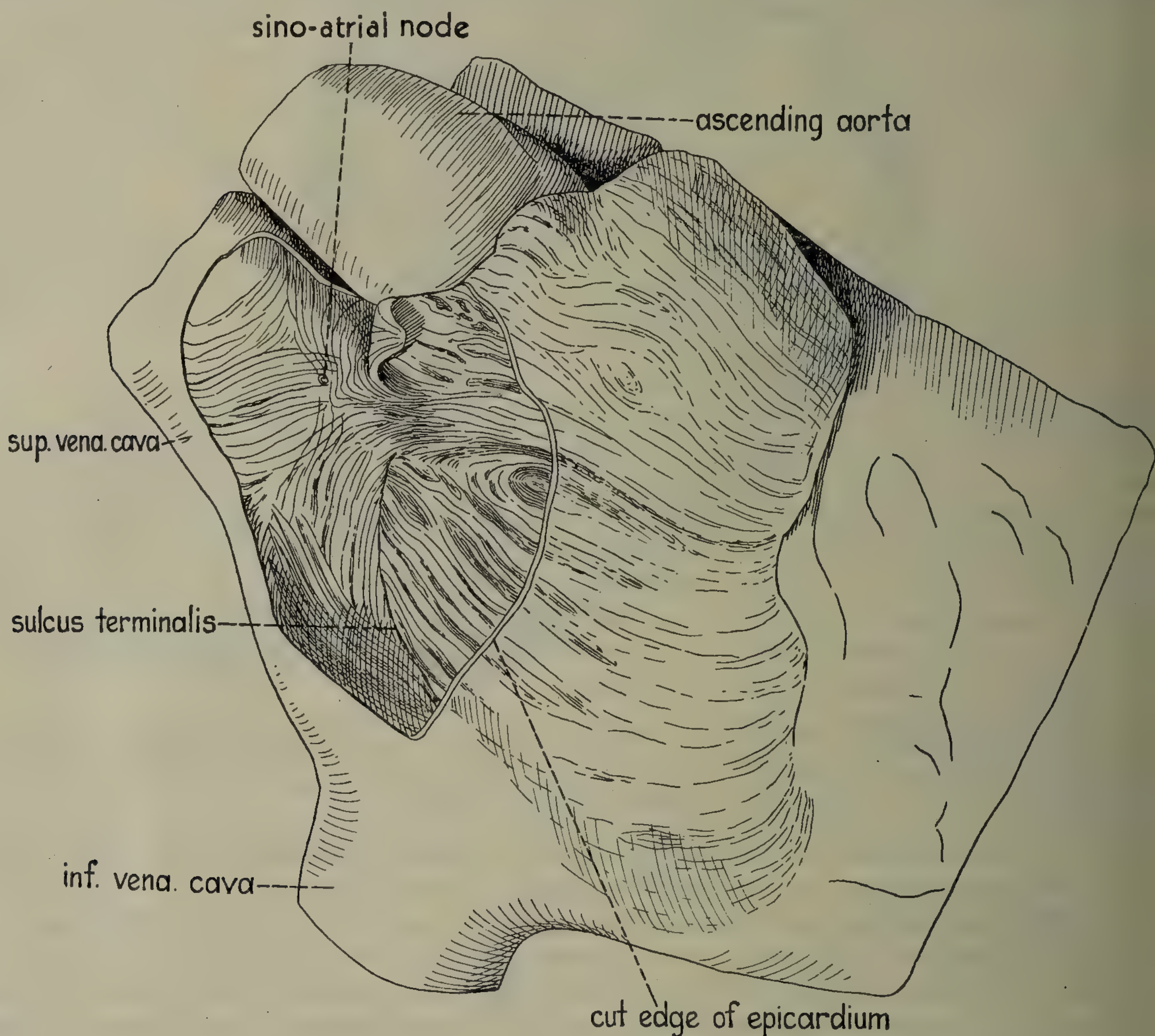


FIG. 633.—THE SINO-ATRIAL JUNCTION (AFTER TANDLER).

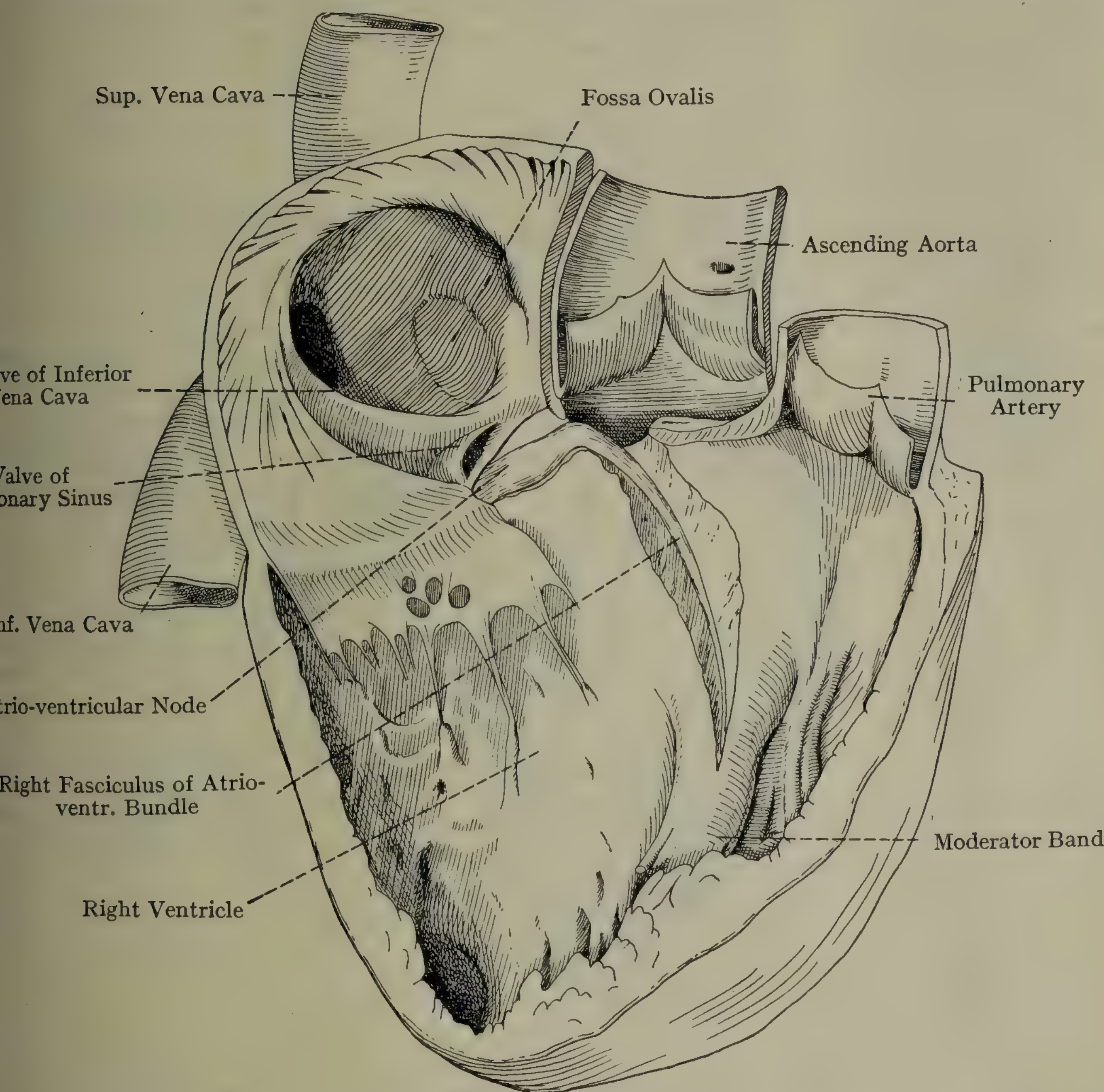
ascend in the septum to the collection of dense fibrous tissue of the consisten
fibro-cartilage at the base. Although the ventricular muscular fibres are disp
for the most part obliquely, there are some annular fibres, but these are con
to the thickest part of each ventricular wall.

Fibres of Purkinje.—These fibres are situated between the endocardium
the cardiac muscular tissue. They consist of elongated cells united at their
so as to form chains. The central part of each cell contains granular protopl
within which there are two nuclei; and the peripheral part presents trans
striations. These cells are probably vestiges of an early condition of ca
muscular fibres.

Sino-atrial Node.—In the region of the sulcus terminalis is a small oval
(Fig. 633) measuring about 10 mm. in length and from 3 to 5 mm. in w
where the muscular fibres are arranged so as to form a delicate network-

-atrial node or the **node of Keith and Flack.** It is believed to be the spot
re the contraction of the heart begins and from where the wave of contraction
eeds over the heart.

trio-ventricular Bundle (Figs. 634 and 635).—This bundle constitutes the atrio-ventricular muscular connection, and functionally is of a conducting re. It begins in the *atrio-ventricular node,* which is situated in the central us body of the heart a little below the opening of the coronary sinus into right ventricle. The node consists of an intricate network of muscular fibres rmingled with, and embedded in, fibrous tissue. Entering the node are



. 634.—The Atrio-ventricular Node and the Right Fasciculus of the Atrio-ventricular Bundle as seen from the Cavity of the Right Ventricle (after Tandler).

es of an indefinite but probably atrial origin. From it proceeds a *single dle,* which represents the **main stem** of the atrio-ventricular bundle. This n passes forwards along the upper margin of the *muscular portion* of the tricular septum, lying immediately below the *membranous part,* and beneath anterior part of the base of the medial cusp of the tricuspid valve. In this ation the main stem breaks up into two fasciculi—right and left. Each of these iculi enters the septal wall of the corresponding ventricle, and divides into nches which ramify beneath the endocardium, where they form part of the tem of Purkinje's fibres. Ultimately the terminal ramifications blend with muscular fibres of the ventricles and *papillary muscles.* A slip from the

right fasciculus passes to the anterior papillary muscle of the right ventr within the moderator band. To open this band and discover the slip is perh the simplest way of exposing the bundle.

The fibres of the atrio-ventricular bundle are pale, and are furnished nerve-fibres and ganglia. The clinical significance of the bundle has refer to Stokes-Adams disease, or **heart-block.**

Structure of the Cardiac Valves.—Each segment of the tricuspid and m valves consists of two layers of endocardium, enclosing between them fib tissue which is derived from the fibrous ring around the corresponding a ventricular orifice. Each segment of the aortic and pulmonary valves

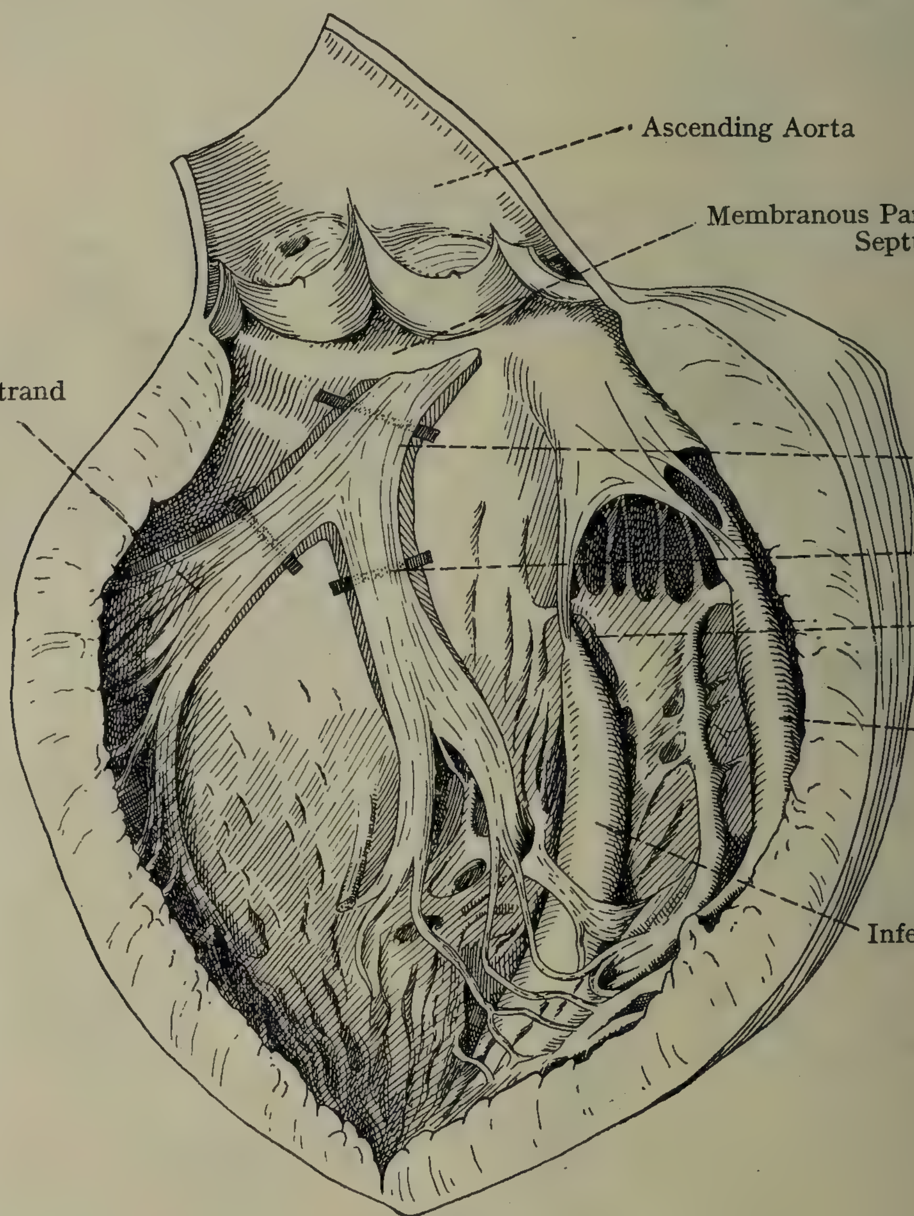


FIG. 635.—THE LEFT FASCICULUS OF THE ATRIO-VENTRICULAR BUNDLE SEEN ON THE VENTRICULAR SEPTUM FROM THE CAVITY OF THE L VENTRICLE (AFTER TANDLER).

consists of two layers of endocardium, enclosing between them fibrous tis which is derived from the fibrous ring around the corresponding arterial orif The segments of all the valves are destitute of bloodvessels.

Minute Structure of the Myocardium.—Cardiac muscle is composed of tra versely striated fibres, but these differ so much from ordinary striated volunt muscular fibres as to require a special description. They possess no sarcolemr they branch freely, and adjacent branches unite, so that an intricate netw is formed by them, and the transverse striæ are fainter and less regular t those of voluntary muscle. Each fibre and its branches are broken up int series of short quadrangular *muscle corpuscles*, arranged in rows or chains, a separated from one another by cross-marks. Each muscle corpuscle conta

ucleus, which occupies *the centre* of the corpuscle, and the corpuscle presents tudinal striæ as well as transverse. A cardiac muscular fibre, as well as anches, is therefore a chain of muscle corpuscles, each of which has a nucleus centre, and there is an absence of sarcolemma.

Veight of the Heart.—The average weight of the of the adult male is 10½ ounces, and of the adult le 8½ ounces.

ize.—The size of a normal heart has been compared e closed hand of the individual person.

evelopment of the Heart.—In the absence of definite mation, the human heart must be considered as ng primarily from the fusion of vessels in the edges e advancing mesoderm in the protocardiac area of embryonic plate. Moreover, these vessels must be ned to lie in the *visceral* portion of this mesoderm, ugh the presence of a pericardial split at such an stage is doubtful; thus the heart would be in asso- on with the *roof of the yolk-sac*, and, when reversal s place, with the *floor of the fore-gut*, to which it would tached by its mesodermal covering. The single tube ting from the fusion enlarges rapidly, standing away the roof of the pericardium, and drawing after it oing so a **dorsal mesocardium,** which 'suspends' it the roof. The existence of a ventral mesocardium ery doubtful; if it does occur, it disappears at an edingly early stage.

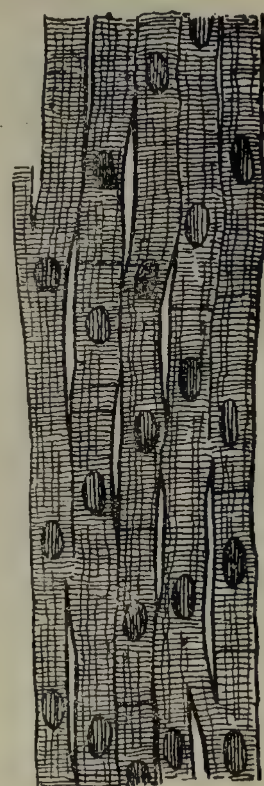
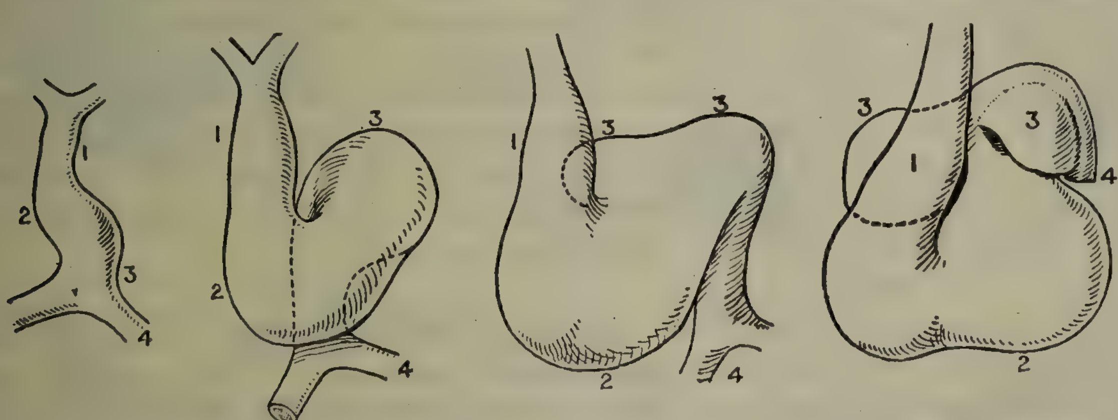


FIG. 636. — CARDIAC MUSCULAR FIBRES, SHOWING THEIR TRANSVERSE STRIÆ, DIVISIONS, JUNCTIONS, AND POSITION OF THE NUCLEI.

The single-looped cardiac tube formed in this way nds forward from the septum transversum, where its *er end is continuous with the sinus venosus*, which s into it. Its anterior end turns up as the **aortic** or **ial stem** or **truncus arteriosus,** entering the meso- al floor of the fore-gut, where it divides. The true iac tube, lying between these two fixed extremities, shows three primary dilatations, or **primitive** (single) chambers—the **atrium** Fig. 638), into which the sinus venosus opens directly; the **ventricle** (V); the **bulbus cordis** (B), from which the aortic stem issues. The dorsal meso- ium, seen in the figure, disappears in its central area very quickly, thus



. 637.—SCHEME SHOWING FOUR SUCCESSIVE STAGES IN THE DEVELOPMENT OF THE HEART (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Arterial Bulb. 2. Ventricle. 3. Atrium.
4. Veins opening into the Sinus Venosus.

ving a passage from one side to the other dorsal to the heart, and between arterial and venous ends; this is the *transverse sinus* of the adult peri- lium.

Sections through the heart show at this and succeeding stages that an inner **ocardial tube** forms a cellular structure, separated by a **subendocardial**

space from an outer **myocardial tube** of contractile mesoderm cells. The sp is occupied by subendocardial fluid, probably contained in greatly disten cells; it is invaded later by the growing myocardium, on which the endocar layer is then laid, the result being the intracardiac network characteristic of true cardiac tube. The three parts of the cardiac tube enlarge rapidly, atrium and ventricle particularly, the result being, as shown in the sec diagram in the figure, that the bulbus is now directed backwards as well upwards, the large atrium is beginning to lap round it on each side from behi and the ventricle is situated ventrally between the two. Other results also fol this rapid growth; the sinus venosus is *gradually drawn into the pericardial ca* at the venous end, and the truncus arteriosus—though not nearly to so gr a degree—at the arterial end.

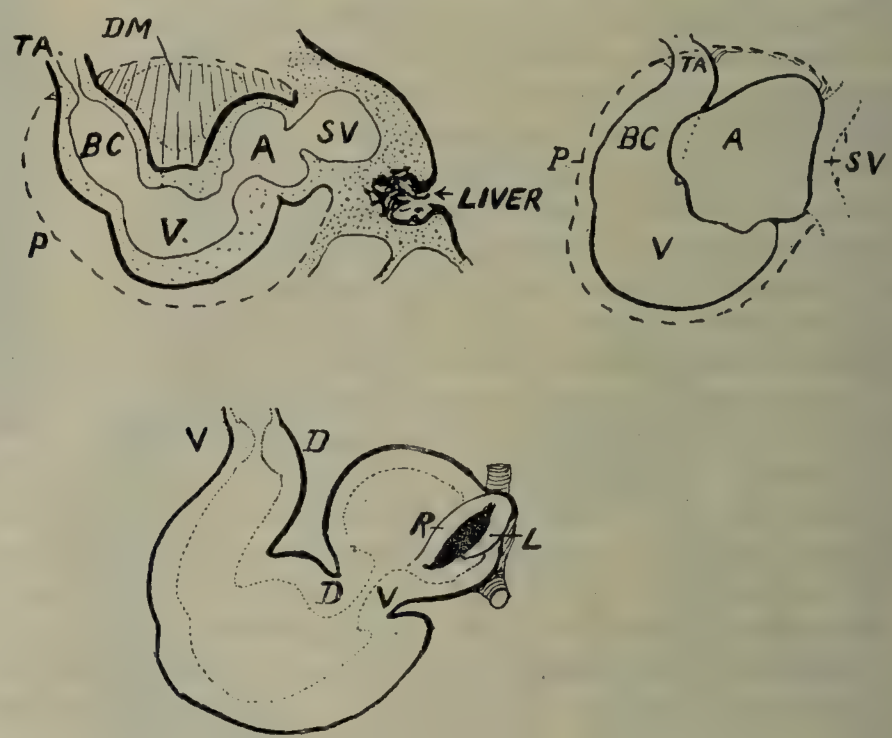


FIG. 638.—SCHEMATIC FIGURES OF EARLY HEART.

In the *first* the heart tube is shown from the left in the pericardium (P), and a single atrium (A), ventricle (V), and bulbus (BC). Opening into it behi is the sinus venosus (SV) embedded in the septum transversum above a in front of the liver-bud. A complete dorsal mesocardium (DM) is prese this quickly breaks through and disappears in the dotted area. The *sec* figure shows the effect of growth of the tube without corresponding increa in distance between its terminal attachments. The *third* diagram illustra the positions in the bent tube assumed by the dorsal (D) and ventral (cushions in the A.V. and arterial regions. R, L, are right and left ven valves beside the opening of the sinus venosus.

The tube is narrowed into an **atrio-ventricular* canal** between the dila atrium and ventricle, and here **endocardial cushions** (*A.V. cushions*) are ma (by the subendocardial tissue), which partly block the passage of the A.V. can **dorsal** and **ventral** cushions are formed first, **right** and **left,** smaller ones being add later. At the aortic orifice **arterial cushions** are similarly produced rather m slowly. All these structures are concerned in the development of *valves.*

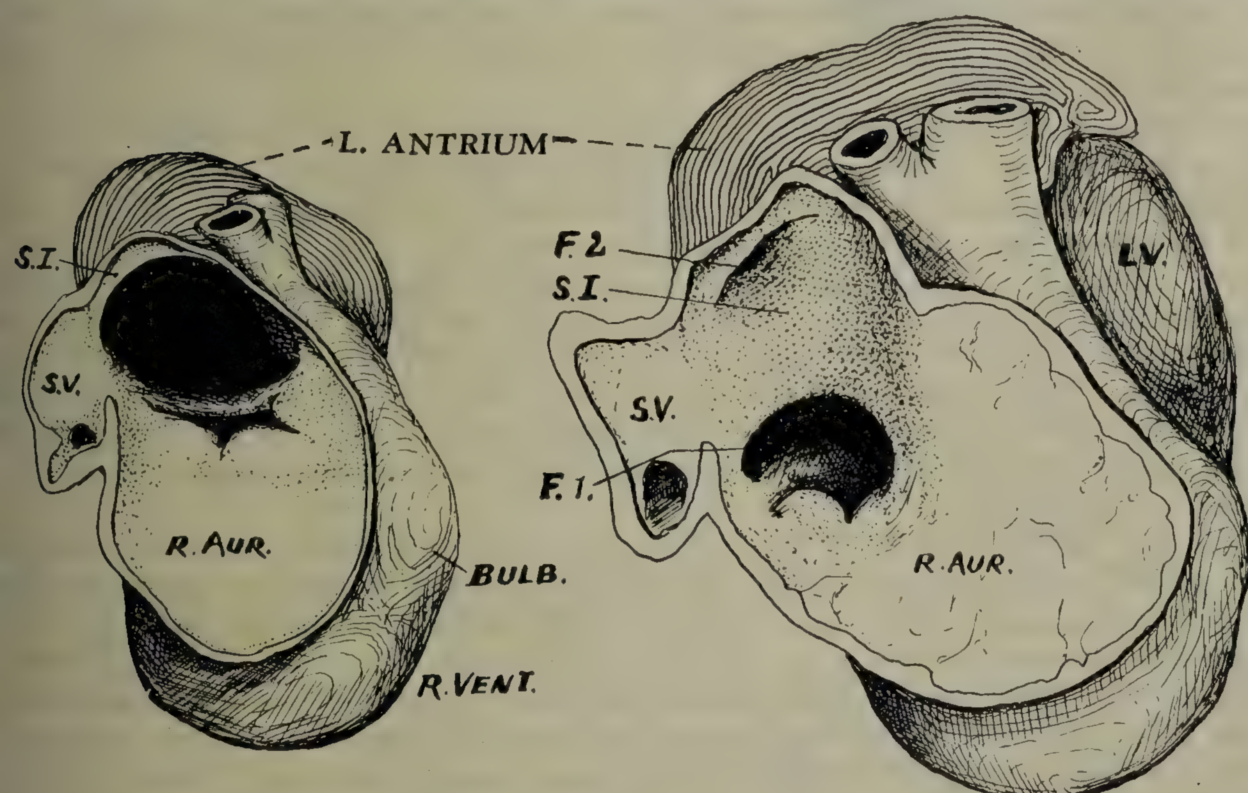
In the fourth week the heart, seen from the front, presents a surface appe ance such as is shown in Fig. 642. Some of the parts of the adult heart can recognized here in a rudimentary state, but the cavity within is still undivid being a single passage from venous to arterial end. The division into ri and left passages must now be described; it is convenient to take the cavit

* Frequently written A.V. for brevity.

tely, but it should be under- that the division goes on in rious parts more or less at the time.

Atrial Septa and Atria.—As nus venosus is drawn out into ericardium from the septum ersum, its opening into the n is found to be no longer n, but *on the right* of the e line; this is probably due ferences in growth-rate of the des of the atrium. The open- to the atrium is guarded by s valves, right and left. As the n enlarges, a **septum primum** rs as a falciform edge (Fig. 640) ng round the upper wall of the a little to the left of the left s valve. It quickly extends the front and back walls, ng in this way the upper and A.V. endocardial cushions. large interatrial opening en- l by this septum above the ons is the **foramen primum.** septum becomes deeper (Fig. and the foramen primum is ately *closed by the meeting of the free edge of the septum with the A.V. cushions*; efore this occurs a **foramen secundum** appears as the result of breaking

FIG. 639.—SECTION THROUGH CARDIAC TUBE IN 2·5 MM. EMBRYO, SHOWING ENDOCARDIAL TUBE (E), SUBENDOCARDIAL SPACE (S), AND MYOCARDIAL TUBE (M).



G. 640.—HEARTS OF EMBRYOS OF 4·5 MM. AND 10 MM. RESPECTIVELY.
t wall of right atrium cut away in each case to show deepening of septum orimum (S. I.); F.1, foramen primum; F.2, foramen secundum; S.V., sinus venosus. Venous valves are not shown.

gh of the upper part of the septum. This is seen at an early stage in the d figure in Fig. 640.

The **septum secundum*** develops as a low, falciform, and fairly thick e on the upper wall a little distance to the right of the first septum, and after foramen secundum has appeared. Its lower and posterior end runs into left venous valve—which is not shown in Fig. 640—and its anterior end is on the upper and front wall. It overhangs the foramen secundum on the ri It increases very slightly in height, but its anterior end, extending round front wall, reaches the dorsal A.V. cushion here, and becomes continuous the lower end of the joined venous valves; it will be noticed again with th and it is only necessary to say here that it forms the *annulus ovalis.*

The opening of the sinus venosus, guarded by its two venous valves, li little to the right of the septal structures low down on the posterior wall. two valves, projecting into the atrial cavity, are joined above and prolonge the wall as an upper fornix; owing to the shortness of the left valve, the no proper lower fornix. The upper fornix, large and developed early, t forward along the upper wall, and is lost on the upper front wall; it mak prominent edge, sometimes referred to as the 'septum spurium.'

The lower fornix, or, more truly, the lower end of the right valve, reaches hinder or ventral† A.V. cushion. The space on the back and upper walls, betw the septum primum and the sinus valves and upper fornix, is known as **intersepto-valvular space ;** the **septum secundum** projects into this from abo

The dorsal and ventral A.V. cushions fuse during the sixth week, divi the A.V. canal into right and left channels. When this occurs, the lower fo extends and reaches the lower front end of the septum secundum, which has b seen to have reached the dorsal cushion.

The opening of the sinus into the atrium gets larger, the right valve stre ing out towards the right, the left coming against the septum primum obliterating the lower part of the intersepto-valvular space; it degener here, but some remnants of it may be found on the septum. The right va forms the **valve of the inferior vena cava,** attached below and in front to remnant of the septum secundum, and being lost above and behind as the remn of the upper fornix, the *crista terminalis.* The enlargement is associated the increasing size of the opening into the sinus of the inferior vena cava schemes in Fig. 641).

It is really the **right horn** of the sinus venosus that is engaged in this enla ment, which makes it become a *part of the right atrium,* that part into wh the venæ cavæ open; the original atrial cavity on this side is pushed outw by its enlargement, and forms only the *auricle.* The **left horn** of the si venosus, forming the *coronary sinus,*, becomes descriptively only a second vessel opening into the large right horn, and the spur between the opening the two horns, at first some distance from the atrium, comes up (Fig. 641 its level, and finally becomes the *part of the valve of the inferior vena cava* lies between the openings of the coronary sinus and inferior vena cava; corresponding part of the right venous valve makes the *valve of the coron sinus,* as in the figure.

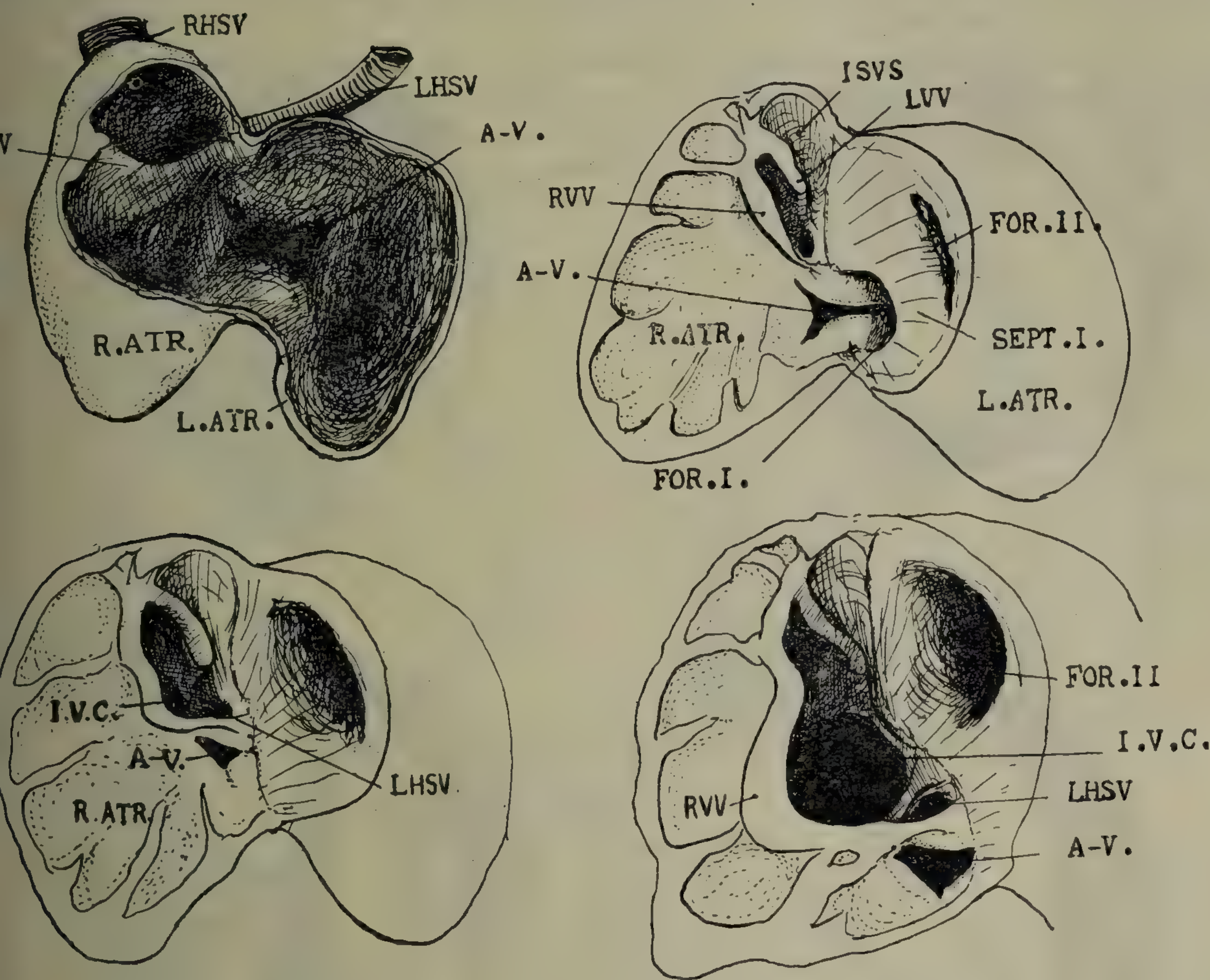
Thus the **right** atrium of the adult heart is developed from the right h of the sinus venosus so far as its *atrium* is concerned, the original atrium forming the *auricle.* The *valve of the inferior vena cava* is formed from right venous valve and the spur between the horns, the *valve of the coronary si* from the lower part of the right valve, and the *septum* is a compound of sep primum (septum ovale) and septum secundum (annulus or limbus ovalis).

The foramen ovale (foramen secundum) usually remains patent to a sm extent for many years.

* Two distinct structures seem to be confused in the descriptions give this septum. One is apparently only the upper remnant of the septum prim above the secondary foramen; the other is the one described here, and app to be in reality the proper septal structure between the left and right sides.

† The nomenclature of these cushions, as seen from the auricular aspect, be understood from the third diagram in Fig. 638.

e cavity of the **left** atrium is produced in a somewhat similar manner. A **common pulmonary vein,** made by junction of right and left branches, nd opening into the left atrium at the end of the first month close to the n primum. It gradually enlarges, increasing in diameter, but not pro- nately in depth. Thus its right and left branches come to open into a which, by its increase in diameter, is pushing the original atrium away ds the left. Still enlarging, the venous cavity takes up its right and left hes into itself, thus leading to their next two branches on each side coming



. 641.—First Figure: Atrial Cavities exposed by Removal of the Upper and Front Wall in an Embryo of 4·5 Mm.

atrio-ventricular opening; RVV, right venous valve, marking off sinus enosus, into which common cavity open the right and left horns of the inus (RHSV, LHSV). The left venous valve is not yet formed. The emaining figures, semi-diagrammatic, show the taking up of the sinus nto the atrium; the right atrial wall only is removed, leaving the septum rimum (SEPT. I.) in position, with the foramina (FOR. I. and II.) above nd below it. ISVS, intersepto-valvular space; LVV, left venous valve; VC, opening of inferior vena cava.

en directly into the cavity. In this way the *atrium* is made from **dilated nary veins,** the *auricle* representing the original **true atrium.**

e **A.V. canal,** as already said, is divided into right and left A.V. openings e fusion of the dorsal and ventral endocardial cushions. The persisting ires are guarded by right and left cushions, with the corresponding ends fused central pair. The fusion occurs about the sixth week, and about me time the *foramen primum closes* on their atrial aspect, and the ven- ar septum is nearing its completion on their other side.

Ventricles and Bulbus Cordis.—In Fig. 642 the 4·5 mm. heart is viewed the front, and the common ventricle is seen to bulge somewhat to the ying to the left of the bulbus, and on the whole rather below it. The

companion drawing shows this heart with the front wall removed fror ventricle and bulb; the cavities of these two parts are seen to be separated p by a prominent **bulbo-ventricular 'spur'** or **angle,** which, by its presence, c the opening into the bulb to lead out of the right extremity of the ventr cavity to the right, in front of, and rather below the atrio-ventricular ape This aperture is seen guarded by its endocardial cushions.

The ventricular cavity is already showing an early state of division right and left ventricles, for a low **septum** is visible extending back to the in

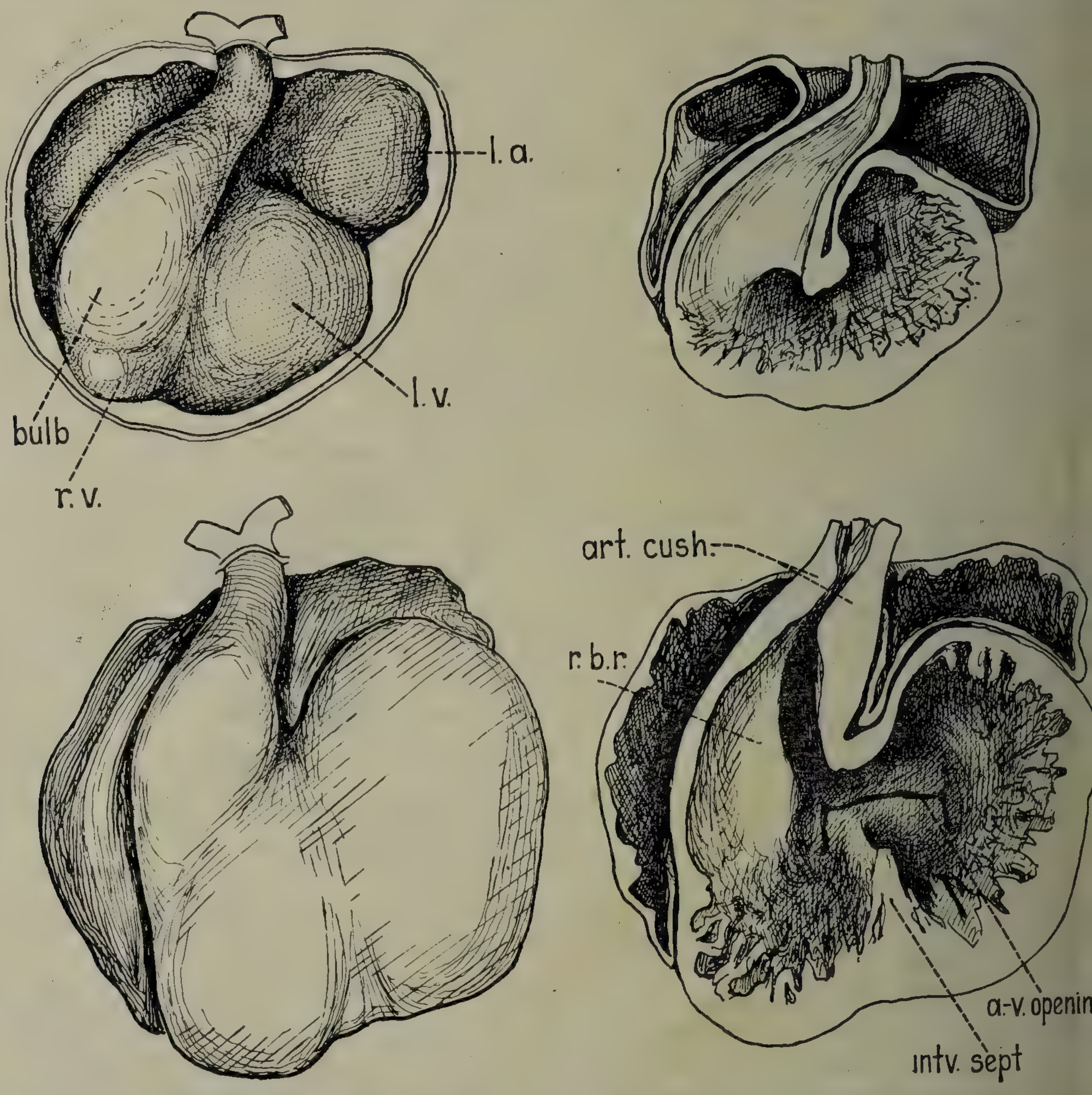


FIG. 642.—VIEWS FROM THE FRONT OF HEARTS OF EMBRYOS OF THE FO AND FIFTH WEEKS (4·5 MM. AND 10 MM.) (FROM RECONSTRUCTIONS)

On the right are shown the interiors of these hearts, the front walls of the tricles and bulbs, and to some extent of the atria, having been rem *l.a.*, *l.v.*, left auricle and ventricle; *r.v.*, right ventricle; *r.b.r.*, right b ridge; *art. cush.*, endocardial cushions at beginning of arterial trunk; *sept.*, interventricular septum.

A.V. cushion. This septum is really little more than the original floor o cavity persisting at its original level, the two subdivisions of the cavity larging downwards on each side of it. Thus the right ventricle starts existence as a bulging of the common ventricle; this bulging can be seen o surface view of the heart.

Turning now to the 10 mm. embryo (Fig. 642), it is to be noticed tha bulbo-ventricular spur has decreased much in prominence; this is due to *a atrophy and disappearance*, so that the bulbar opening is now above the

e right-hand end of the A.V. aperture. The ventricles have become deeper the septum proportionately higher, but that the septum has not grown ırd is evident from the fact that it retains its old level of attachment to the A.V. cushion.

t the 15 mm. stage (not shown) the process of reduction of the bulbo-icular angle has gone even farther, the whole left and back wall of the having practically disappeared, so that the arterial cushions are, in this very near to the A.V. cushions. At the same time the greater part of the opening is, as a result, now brought directly under the passage into the ining bulbus.

urning back to the 10 mm. specimen (Fig. 642), certain changes within ulb itself are to be seen. These consist in the development of two **bulbar s.** The *right* ridge is seen almost entire; it begins above just below the ial cushions (with the right one of which it is continuous), and passes down back on the right bulbar wall, to end in a blunt extremity just to the right

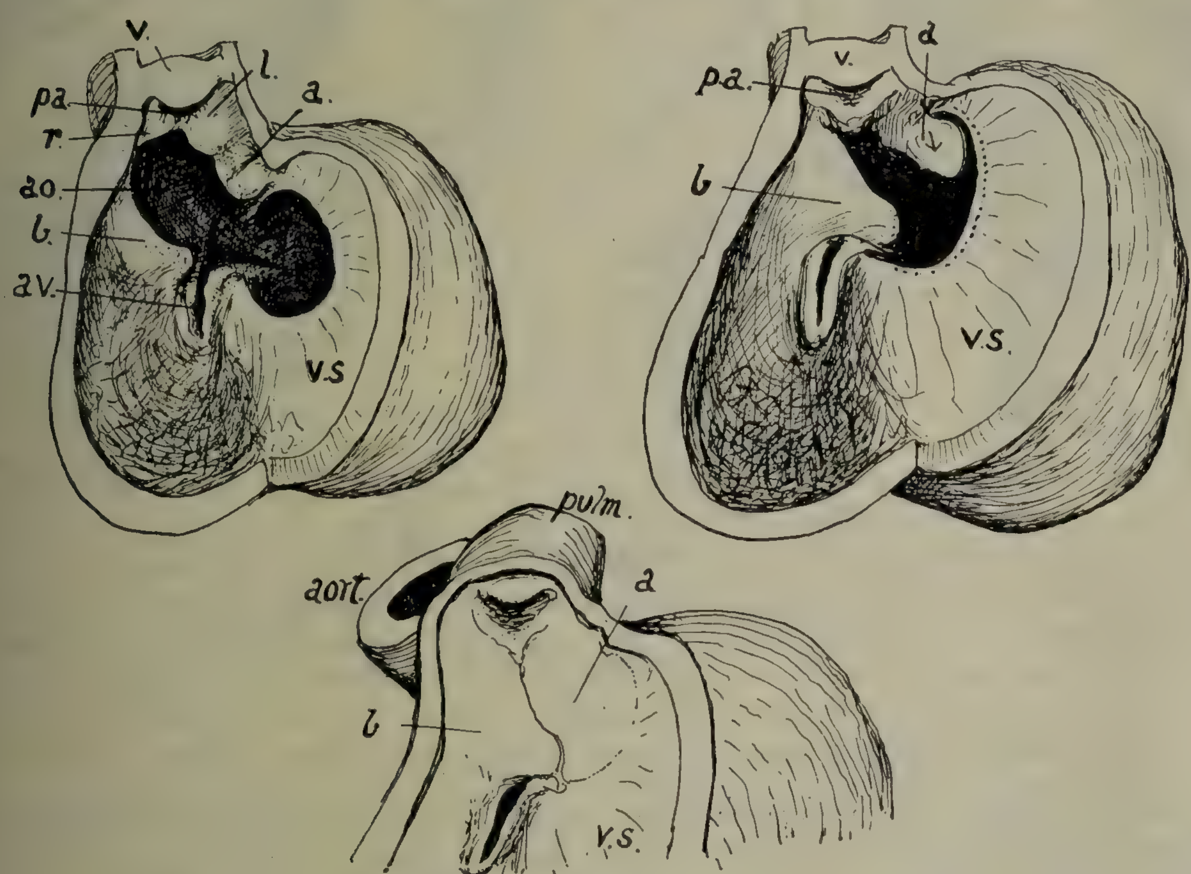


FIG. 643.—TO SHOW METHOD OF DIVISION OF BULBAR REGION AND FORMATION OF AORTIC VESTIBULE.

(Explanation in text.)

ıe A.V. opening. The *left* ridge starts below the left lateral aortic cushion, extends downwards and forwards on to the left front wall of the bulbus; his part has been cut away in the figure, the ridge is only partly seen cut ss. These two bulbar ridges thus overhang a deep channel, which can be in the figure, traceable downwards and to the left towards the left ventricle, each which its groove would be continued in front of the A.V. cushions and ve the edge of the ventricular septum. This channel becomes the **aortic nnel,** or *aortic vestibule* of the complete heart, closed in, as will be described, the fusion of the ridges with each other, and with the edge of the septum.

In the 15 mm. stage, when the spur and the associated bulbo-ventricular on the surface have disappeared, the atrophy affects mainly the wall of the *behind and below* the left ridge, but this is nevertheless shorter than the t ridge, thus exhibiting the general tendency to shortening of this region. complete division of the bulbar region and separation of the two ventricles n follow; the way in which this happens is schematically shown in Fig. 643.

In these schemes the front wall of the right ventricle only is supposed to be been removed with that of the bulb, so that the interventricular septum (w in the previous figures has only been seen in part) is now seen as a whol not only reaches the lower A.V. cushion, but runs into the upper cushion corresponding situation, making a free falciform edge between these two po The free edge forms the boundary of the **interventricular foramen,** the do wall of which is made by the cushions. The dorsal and ventral cushions leaving now two lateral *atrio-ventricular openings,* one on each side of the p of the septum and interventricular foramen. In the first diagram the bulbar ridge is seen at *a* and the right at *b*; these are continuous above the left (*l*) and right (*r*) arterial cushions respectively; these cushions are fu so that a *pulmonary* orifice (*pa*) is between them and the ventral cushion

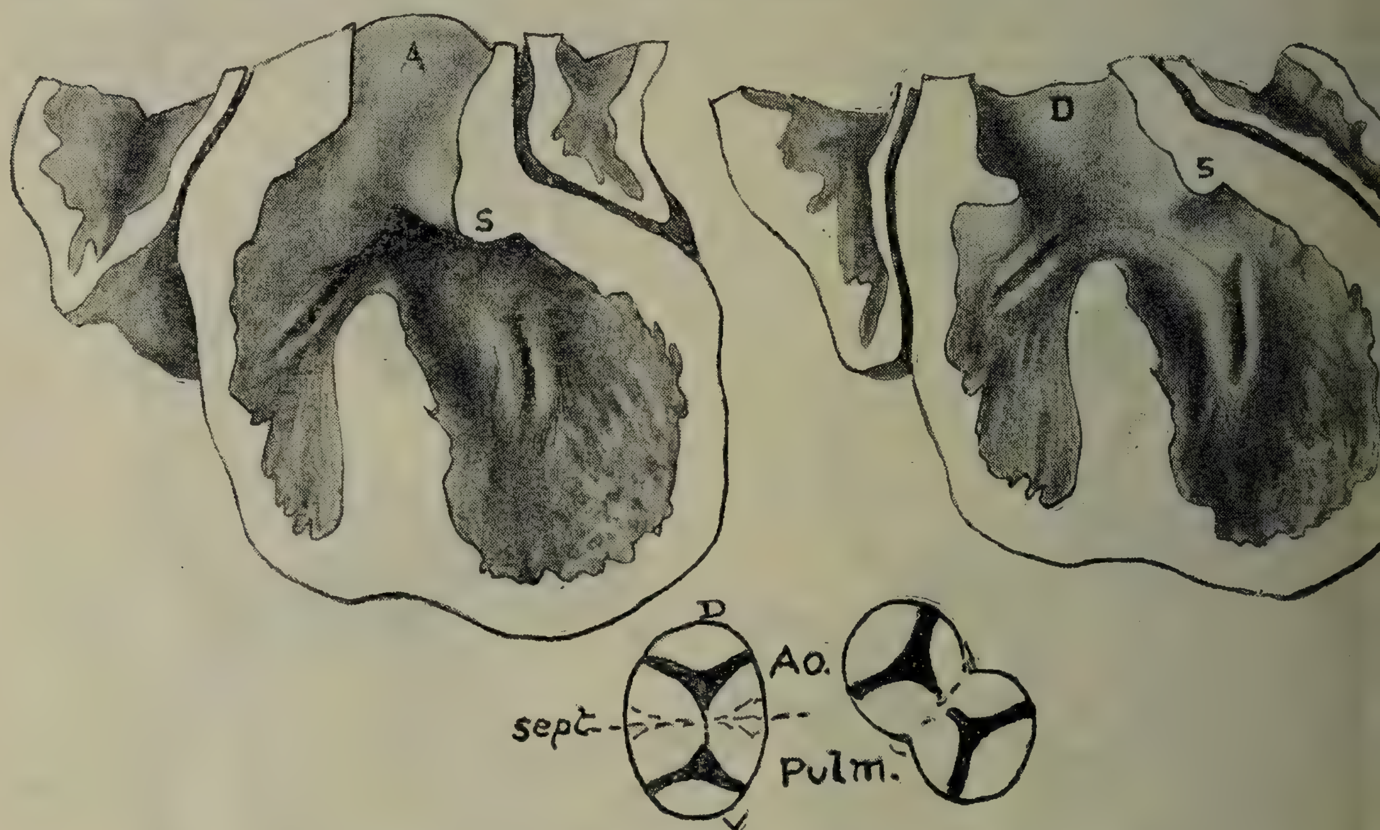


FIG. 644.—BULBO-VENTRICULAR REGION (15 MM.).

The first figure shows the bulbar ridges in position, the second shows the ao channel, the ridges and parts of the walls being cut away. S, upper of interventricular septum; A, the fused (lateral) arterial cushions; D, dorsal arterial cushion.

The two small figures show how the septum between aorta and pulmon artery meets the fused lateral arterial cushions, leaving three semilu rudiments to each artery. D, V, dorsal and ventral cushions.

The second plan shows how the descriptive position of the definite cu results from a small amount of rotation from right to left.

and separated by these from the *aortic* orifice, which lies between them and dorsal cushion. The aortic orifice leads into the aortic channel (*ao*), wh overhung by the bulbar ridges, passes downwards and to the left in front of A.V. cushions, and through the interventricular foramen into the left ventri When fusion occurs between the A.V. cushions it affects those parts that in the floor of the aortic channel—*i.e.*, the cushions bounding the transve slit and the upper part of the right lateral slit—leaving the lower part (*av*) the right lateral slit as the permanent right opening.

In the second diagram the mode of closure is illustrated. The right bul ridge grows towards the left across the right lateral A.V. orifice—between closed and unclosed parts—and just reaches the attachment of the ventricu septum to the lower cushion. The left ridge, in contact from its early st

the upper part of the septum, begins to *extend along the free margin of this* ; ĸtent of its growth along this margin is indicated by the dotted line. The idge in this way reaches the right ridge by growth along the edge of the entricular foramen, and *by fusion between the two ridges* the *aortic channel fed in* and separated from the (right) cavity continuous with the pulmonary e. In the third figure the actual conditions (a little simplified) are shown embryo of the sixth week, in which the various parts are in the process ıction and consolidation; it may be noted that a certain amount of extension sue from the fused arterial cushion takes place between the upper parts e two bulbar ridges.

or descriptive purposes the dorsal wall of the bulbar region has been given gth in the figure greater than it really possesses; owing to the disappearance e left dorsal wall with the bulbo-ventricular spur, the dorsal arterial cushion ctically next to the A.V. cushions, so that the ' floor ' of the aortic channel below the aortic orifice is made by the fused A.V. cushions; this is the *mem-us part of the ventricular septum,* separating the *aortic channel* (aortic oule) from the *right atrium.* The ventral wall of the aortic vestibule is made ne fused bulbar ridges, and it is evident that the **interventricular foramen,** ugh it no longer affords a passage between the left and right ventricles, *sts as the opening into the aortic vestibule* (from the general cavity of the entricle) to the right of the left A.V. orifice. The remnants of the A.V. ons, presenting as pouting lips in the ventricular cavities, and continuous with the endocardial covering of the muscular network of the ventricles, ne *atrio-ventricular valves,* modification in the network producing the *chordæ neæ* and *papillary muscles.* On the left the cushion lips are placed vertically e the vertical slit, and the two valves derived from them lie naturally een the opening and the aortic vestibule and the left marginal wall respec-y. On the right the vertical lips (Figs. 643 and 644) separate the orifice from eptum and the right marginal wall respectively, but in addition there is a sverse flap derived from (or in association with) the right bulbar ridge e this crosses the line of the orifice, and this flap separates the orifice from oulmonary channel, and hence becomes the *anterior* (*infundibular*) *cusp.*

umming up the description given of the formation of the parts, it may be that the *infundibulum* is a remnant of the bulbus cordis, but its *dorsal wall* oduced by fused bulbar ridges; the *cavity of the aortic vestibule* is also a part ıat of the bulbus, with an added ' ventricular ' part brought into existence he disappearance of the bulbo-ventricular spur; the *membranous part of entricular septum* marks the position of fused A.V. cushions; the inter-ricular foramen remains as the opening into the aortic vestibule from the ral cavity of the left ventricle; and the *A.V. valves* are derived from the cushions, the *anterior cusp* of the *right* valve being an additional structure iected with the growth of the right bulbar ridge.

he *arterial* (*semilunar*) *valves* are developed by hollowing out of their arterial ıces from the **arterial cushions** already mentioned. These are four in number ght and left lateral, dorsal, and ventral. The lateral cushions fuse, con-ing the single orifice into two—ventral or pulmonary, and dorsal or aortic. division of the bulbar region below these cushions has been described, and bulbar ridges which make the dividing wall have been seen to be continuous e with the fused lateral cushions; in a similar way the dividing wall between two arteries above them is continuous with the fused lateral cushions. The arteries become completely separated, the separation extending through valvular region, and incompletely involving the bulbar region. Thus the original cushions are divided (Fig. 645) into six, three for each orifice, these are hollowed into the arterial valves; the pulmonary orifice has the tral flap and two postero-lateral, the aortic opening has two antero-lateral the dorsal flap. Towards the end of intra-uterine life, however, the heart ergoes a rotation from right to left to such an extent as to place the root of pulmonary trunk in front and to the left of the root of the aorta. The a, as well as the pulmonary trunk, is involved in this rotation, and the seg-

ments of the pulmonary and aortic valves are now permanently alterec position. The relations of the various segments *in the adult* are as follc the cusps of the **pulmonary valve** are disposed as *two anterior,* right and and *one posterior;* whilst the cusps of the **aortic valve** are *one anterior* and *posterior,* right and left.

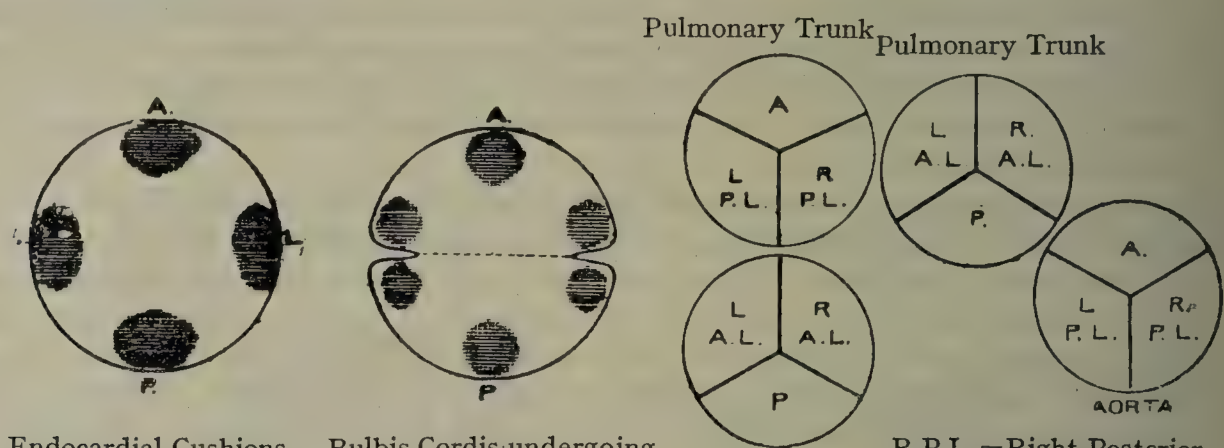


FIG. 645.—SCHEMES TO SHOW FORMATION OF ARTERIAL VALVES FRO ARTERIAL CUSHIONS.

A, P, ventral and dorsal cushions. The second scheme shows the divisior the four cushions into six. The third scheme shows the effect of rotat on the descriptive positions of the valves.

The rotation just referred to also explains why the left ventricle of the ac heart is chiefly postero-inferior in position, comparatively little of it appea on the sterno-costal surface of the adult heart.

Peculiarities of the Fœtal Circulation.—The structures peculiar the fœtus in connection with the circulation of the blood are follows:

1. Foramen ovale.
2. Valve of the inferior vena cava.
3. Ductus arteriosus.
4. Umbilical arteries.
5. Umbilical vein.
6. Ductus venosus.

The **foramen ovale** is an oval opening in the atrial septum. to the fourth month of intra-uterine life it is quite free, but af that period the *valve of the foramen ovale* gradually extends upwa on the left side of, and beyond, the annulus ovalis, and acts as a va during the latter months of fœtal life. The blood can then only fl from the right atrium into the left, its return being prevented this valve.

The **valve of the inferior vena cava** is of large size during fœ life, and is associated with the orifice of the inferior vena cava at postero-inferior angle of the right atrium. It is a crescentic fold of endocardium, which extends between the anterior margin of orifice of the inferior vena cava and the anterior horn of the annu ovalis. Its situation is such as to direct the blood entering the rig atrium by the inferior vena cava to the foramen ovale.

The **ductus arteriosus** connects the pulmonary trunk to the a of the aorta at a point immediately beyond the origin of the

clavian artery, and conveys most of the blood from the right tricle to the descending thoracic aorta.

The **umbilical arteries** (**hypogastric arteries**), right and left, are proged from the common iliac arteries to the umbilicus, through which y leave the body of the fœtus, and pass along the umbilical cord e distributed to the fœtal part of the placenta. They convey the ure blood of the fœtus to the placenta.

The **umbilical vein** extends from the fœtal part of the placenta ough the umbilicus to the inferior surface of the liver, where it joins left branch of the portal vein. After parting with its right and left nches the umbilical vein is prolonged, under the name of the **tus venosus,** to the inferior vena cava, which it joins at the fossa vena cava of the liver. The umbilical vein conveys pure blood n the placenta into the body of the fœtus.

Fœtal Circulation.—The right atrium receives blood from the erior and inferior venæ cavæ, and from the coronary sinus. The erior vena cava returns the venous blood from the head and neck, upper limbs, and the thoracic portion of the trunk; and the inferior a cava returns the blood from the lower limbs, the abdominal tion of the trunk, and the placenta. The placental blood is pure, l reaches the inferior vena cava in two ways: (1) a large quantity it is conveyed directly into the inferior vena cava by the ductus osus; and (2) some of it circulates through the liver in the branches the portal vein, and is then conveyed to the inferior vena cava by hepatic veins. The blood entering the right atrium by the inferior a cava is necessarily of a mixed nature, being partly placental and tly venous.

The impure blood which enters the right atrium by the superior a cava, having received a small quantity of the mixed blood which ers by the inferior vena cava, passes through the right atriotricular orifice into the right ventricle, and from thence is driven o the pulmonary trunk. A small quantity of it is conveyed to the gs by the right and left pulmonary arteries, which at this period of small size, and it is returned from the lungs to the left atrium the pulmonary veins. By far the greater part of the right ventricular od, however, enters the ductus arteriosus, and is conveyed by it the aorta immediately *beyond* the origin of the left subclavian artery. ne of this blood, therefore, enters the three great vessels which ring from the arch of the aorta. The whole of it descends in the scending thoracic and abdominal portions of the aorta, and has a ofold destination. Part of it is distributed to the abdominal and lvic viscera, and the lower limbs, whence it is returned by the rtal vein and inferior vena cava; but the greater part of it is conyed out of the body of the fœtus to the placenta by means of the nbilical arteries. Having been purified in the placenta, it is returned ence by the umbilical vein into the body of the fœtus. This placental ood, as stated, reaches the inferior vena cava in two ways: partly rectly by means of the ductus venosus, and partly indirectly by

means of the hepatic veins after having circulated through t
liver.

A small quantity of the mixed blood which enters the right atri
by the inferior vena cava mingles with the venous blood which ent
that cavity by the superior vena cava; but by far the greater part
it is directed by the valve of the inferior vena cava to the foram
ovale, through which it passes into the left ventricle. Here it recei
the blood which has been returned from the lungs by the pulmona

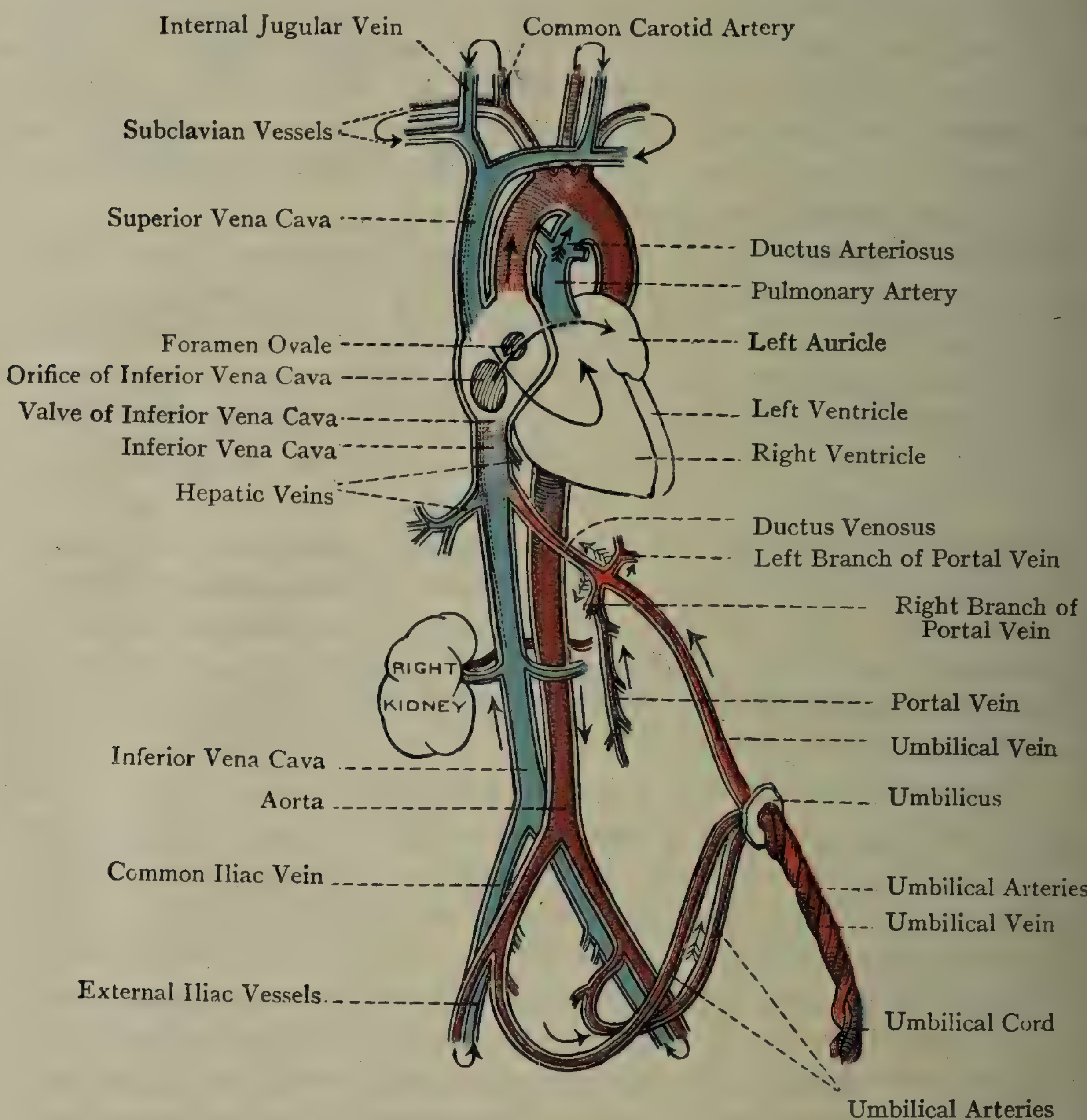


FIG. 646.—DIAGRAM OF THE ORGANS OF CIRCULATION IN THE FŒTUS

The arrows indicate the course of the circulation.

veins, and then it passes through the left atrio-ventricular orifice in
the left ventricle. From the left ventricle it is driven into the aor
and the greater part of it passes into the innominate, left comm
carotid, and left subclavian arteries, to be distributed to the bra
head and neck, and upper limbs, as well as to the substance of the hea
by the coronary arteries. A small quantity, however, of this mix
blood passes into the descending thoracic aorta, and mixes with t
venous blood entering by the ductus arteriosus. The blood is return
to the right atrium of the heart from the brain, head and neck, a

er limbs, by the superior vena cava, and from the substance of heart by the coronary sinus.

Changes at Birth.—At birth respiration is established, and the s perform their respiratory function; the right and left pulmonary ries undergo rapid enlargement; and the placental circulation is rely arrested. The **umbilical arteries** become obliterated and sformed into fibrous cords, except at their roots, where they ist as the *internal iliac arteries*. The **umbilical vein** becomes terated, and is now known as the *ligamentum teres of the liver*. **ductus venosus** becomes transformed into a fibrous cord, called *ligamentum venosum*, which occupies the fissure of that name in liver. The **foramen ovale** is closed by the *valve of the foramen le* becoming adherent to the margin of the *annulis ovalis* on its left . In some cases, however, this union is incomplete, and a minute ning persists, through which a small probe may be passed. In y rare cases a fairly large opening may remain, as in the condition wn as *morbus cæruleus*. As viewed from the interior of the left um, the upper crescentic border of the valve of the foramen ovale isible upon the atrial septum, and above this border there is a slight ression. The **ductus arteriosus** becomes obliterated, and persists a fibrous cord, called the *ligamentum arteriosum*, which passes n the root of the left pulmonary artery to the arch of the aorta nediately *beyond* the origin of the left subclavian artery.

The closure of all the peculiar structures associated with the al circulation is usually complete from the eighth to the tenth day er birth.

Trachea in the Thorax.—The thoracic portion of the trachea extends m the level of the upper border of the manubrium sterni to the el of the intervertebral disc between the bodies of the fourth and h thoracic vertebræ, where it divides into the two bronchi, right and . It occupies a median position in the superior mediastinum, and length is about $2\frac{1}{2}$ inches. As in the neck, it is cylindrical and n in front and at the sides, but posteriorly it is flattened and membnous, where it rests upon the œsophagus.

Relations—*Anterior.*—The manubrium sterni, and the origins of sterno-hyoid and sterno-thyroid muscles; the remains of the ymus; the origins of the innominate and left common carotid eries, and the left innominate vein; and the arch of the aorta, which s upon it immediately above its bifurcation into the two bronchi, th the intervention of the deep cardiac plexus of nerves. *Posior.*—The œsophagus, which in an upward direction inclines rtially to the left of the trachea. *Right.*—The right vagus nerve; e innominate artery after it has left the front of the trachea; and e right pleural sac. *Left.*—The arch of the aorta and the left mmon carotid artery after these have left the front of the trachea; e left subclavian artery; and the left recurrent laryngeal nerve.

Bronchi.—The bronchi, right and left, commence at the bifurcan of the trachea, and each passes to the hilum of the correspond-

ing lung, where its ramifications commence. As in the tracl each bronchus is cylindrical and firm in front and at the sides, posteriorly it is flattened and membranous. There being cert differences between the bronchi, a separate description is requi for each.

The **right bronchus** is about 1 inch in length up to the point wh it gives off its first, or eparterial, branch. It has about six ca laginous rings, and is larger than the left bronchus. It is more verti than the left bronchus, a therefore coincides with direction of the trachea t greater extent than its fello

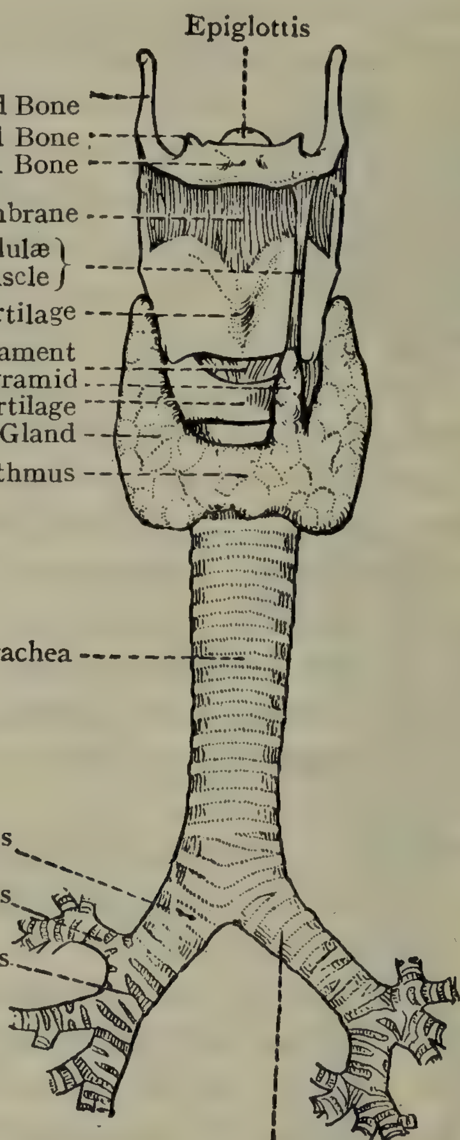


FIG. 647.—THE HYOID BONE, LARYNX, TRACHEA, BRONCHI, AND THYROID GLAND (ANTERIOR VIEW).

Relations—*Superior.*—T vena azygos arches over it open into the superior ve cava. *Posterior.*—The rig vagus nerve.

About 1 inch from commencement the rig bronchus gives off a bran from its outer side whi passes to the upper lobe the right lung. This bran is known as the *eparter bronchus,* because it ari above the right pulmona artery. The rest of the rig bronchus is spoken of as bei *hyparterial.*

The **left bronchus** is abo 2 inches in length. It h about twelve cartilagino rings, and is smaller than t right bronchus on account the smaller size of the l lung. Its course is more o lique than that of its fello and it is directed downwards and outwards beneath the arch of t aorta to the hilum of the left lung.

Relations—*Anterior.*—The left pulmonary artery, which subs quently lies *above* it. *Posterior.*—The œsophagus and the descendi thoracic aorta.

The left bronchus has no eparterial branch.

When the interior of the trachea is viewed from above, as in usi the laryngoscope, the openings of the two bronchi are seen to l separated by a ridge which is situated to the left of the median lin and more of the interior of the right bronchus than of the left is visibl Partly on this account, and partly by reason of the more vertic

tion of the right bronchus, as well as its larger size, a foreign getting into the trachea is more apt to descend into the *right* chus than into the left.

The structure of the trachea will be described in connection with description of the windpipe in the neck.

Esophagus in the Thorax.—The œsophagus or gullet extends from pharynx to the stomach. In the first part of its course it lies e neck, and this portion will be found described in connection with region. The **thoracic part** (see Fig. 651) extends from the level he upper border of the manubrium sterni to the level of the of the eleventh thoracic vertebra, where, ng previously passed through the œsophageal opening of the diaphragm, it terminates he cardiac orifice of the stomach. Its se is not quite vertical. At its commencement the thoracic portion lies partially to the of the middle line, but as it descends it es to occupy a median position about the l of the fifth thoracic vertebra, and inrly it again inclines partially to the left. ccupies the superior and posterior mediasl spaces, and lies in front of the vertecolumn, accurately following the thoracic ro-posterior curve.

FIG. 648.—TO SHOW RELATIONS BETWEEN AORTA, TRACHEA AND ŒSOPHAGUS (FROM THE FRONT).

Relations—*Anterior.*—The trachea as low he intervertebral disc between the bodies he fourth and fifth thoracic vertebræ; the t pulmonary artery; the root of the left nchus; the posterior wall of the pericardium osite the back of the left atrium of the rt; and the vertebral portion of the diaagm. *Posterior.*—The vertebral column; longus cervicis muscles, especially the left; thoracic duct and vena azygos; the right terior intercostal arteries; the upper and er transverse azygos veins; and inferiorly descending aorta. *Right.*—The right erior and posterior mediastinal pleuræ. *Left.*—The thoracic portion the left subclavian artery; the upper part of the thoracic duct; left superior mediastinal pleura above and the left posterior diastinal pleura just before it pierces the diaphragm; and the cending aorta, except inferiorly.

The right and left vagus nerves are intimately related to the œsoagus. They are at first disposed laterally, and their branches give to the *œsophageal plexus.* Subsequently the right vagus nerve cends on the posterior surface of the œsophagus, and the left on anterior surface, in which positions they accompany the gullet ough the œsophageal opening of the diaphragm.

Blood-supply—Arteries.—These are (1) the œsophageal bra of the descending aorta, (2) the œsophageal branches of the left ga artery, and (3) twigs from the left phrenic artery. In the neck œsophagus receives branches from the right and left inferior th arteries.

The **veins** accompany the corresponding arteries, and term in the vena azygos and the two venæ hemiazygos.

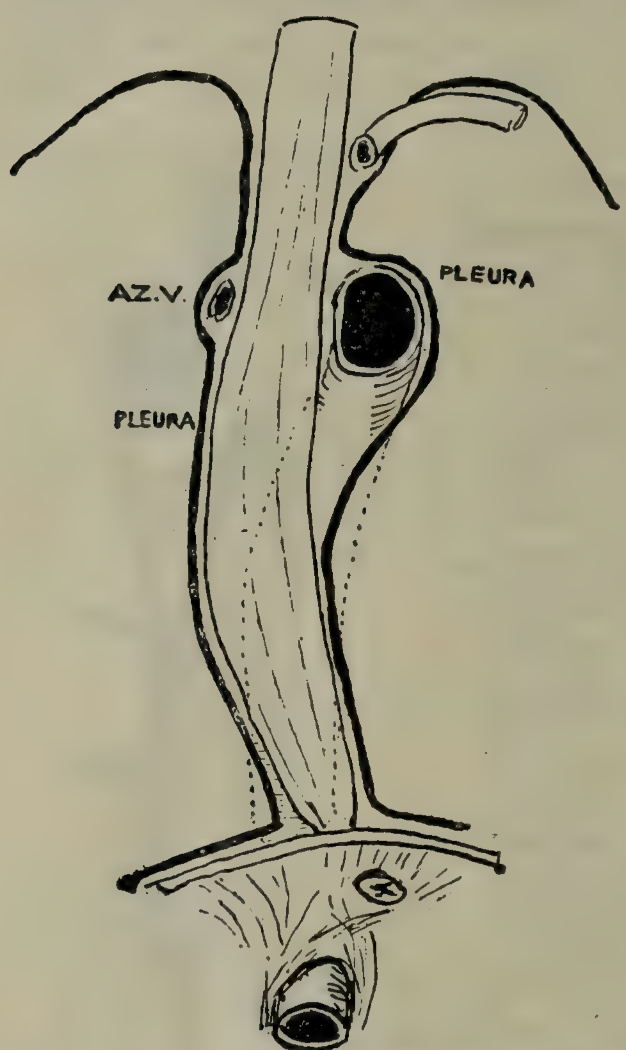


Fig. 649.—Diagram to show Pleural Relations (Thick Black Lines) of Œsophagus (Frontal Section).

Lymphatics.—These pass to posterior mediastinal glands whic mainly in front of the œsophagus.

Nerves.—These are derived from vagus and sympathetic nerves.

Structure.—The wall of the œsoph consists of three coats—namely, musc submucous, and mucous.

The **muscular coat** is thick, and is posed in two layers, an external longitu and an internal circular.

The *longitudinal muscular fibres* ar tached superiorly to the upper part o median ridge on the posterior surface o cricoid cartilage, and from this point descend as two flattened bands, one on e side of the tube. These expand and meet, giving rise to one continuous which completely surrounds the œsoph Inferiorly they are continuous with longitudinal muscular fibres of the stom Accessory fleshy slips are described as pa from this layer to the back of the trac the back of the root of the left bronc the pericardium, and the left pleura.

The *circular muscular fibres* are con ous superiorly with the lower fibres of inferior constrictor muscles of the phar and inferiorly with the circular, and with the oblique, muscular fibres of stomach.

The muscular tissue of the œsophagus is of the striated variety over abou *upper third* of the tube, but elsewhere it is of the plain or non-striated var

The **submucous coat** consists of loose areolar tissue, which contains larger bloodvessels and the mucous glands.

The **mucous membrane** is thick, and is thrown into longitudinal folds account of the loose disposition of the submucous coat. The portion of it the submucous coat consists of plain muscular fibres, which are arranged lo tudinally. This portion is known as the *muscularis mucosæ*, and it is marked in the lower part of the œsophagus. The inner surface of the mu coat is provided with numerous papillæ, and it is covered by stratified squa epithelium, which is thrown into elevations by the papillæ.

The *mucous glands* are racemose, and are situated in the submucous c Their ducts are large and long, and on their way to the free surface som them traverse small collections of lymphoid tissue.

Development.—The œsophagus is developed from that part of the fore which succeeds to the portion from which the pharynx is developed. At fir is very short, on account of the imperfect development of the neck. As, howe

neck becomes formed, and as the stomach descends, the œsophagus becomes gated.

Descending Aorta.—The descending aorta, which is the continua- of the aortic arch, commences on the left side of the body of fourth thoracic vertebra on a level with its lower border, and inates at the lower border of the body of the twelfth thoracic ebra. At the latter level it passes through the aortic opening he diaphragm, and enters upon the abdominal part of its course. vessel lies in the posterior mediastinum, and its course is down-

Fig. 650.—Transverse Section of the Wall of the Œsophagus.

ds and medially, so that, though at first on the left side of the verte- column, it subsequently takes up a position in front of it.

Relations—*Anterior.*—From above downwards, the root of the lung; the pericardium; the œsophagus; and the vertebral portion the diaphragm. *Posterior.*—The bodies and intervertebral discs horacic vertebræ below the fourth; and the upper and lower trans- e azygos veins. *Right.*—The œsophagus superiorly; the thoracic t; and the vena azygos. *Left.*—The left superior and posterior liastinal pleuræ; and the upper and lower left azygos veins. In- orly the œsophagus inclines slightly to the left. It is to be noted

that the œsophagus has a threefold relation to the descending ac
At first it lies upon the right side of the vessel; then directly in f
of it; and finally it inclines slightly to its left side.

Branches.—These are as follows: bronchial, pericardial, œsophag
mediastinal, posterior intercostal and subcostal.

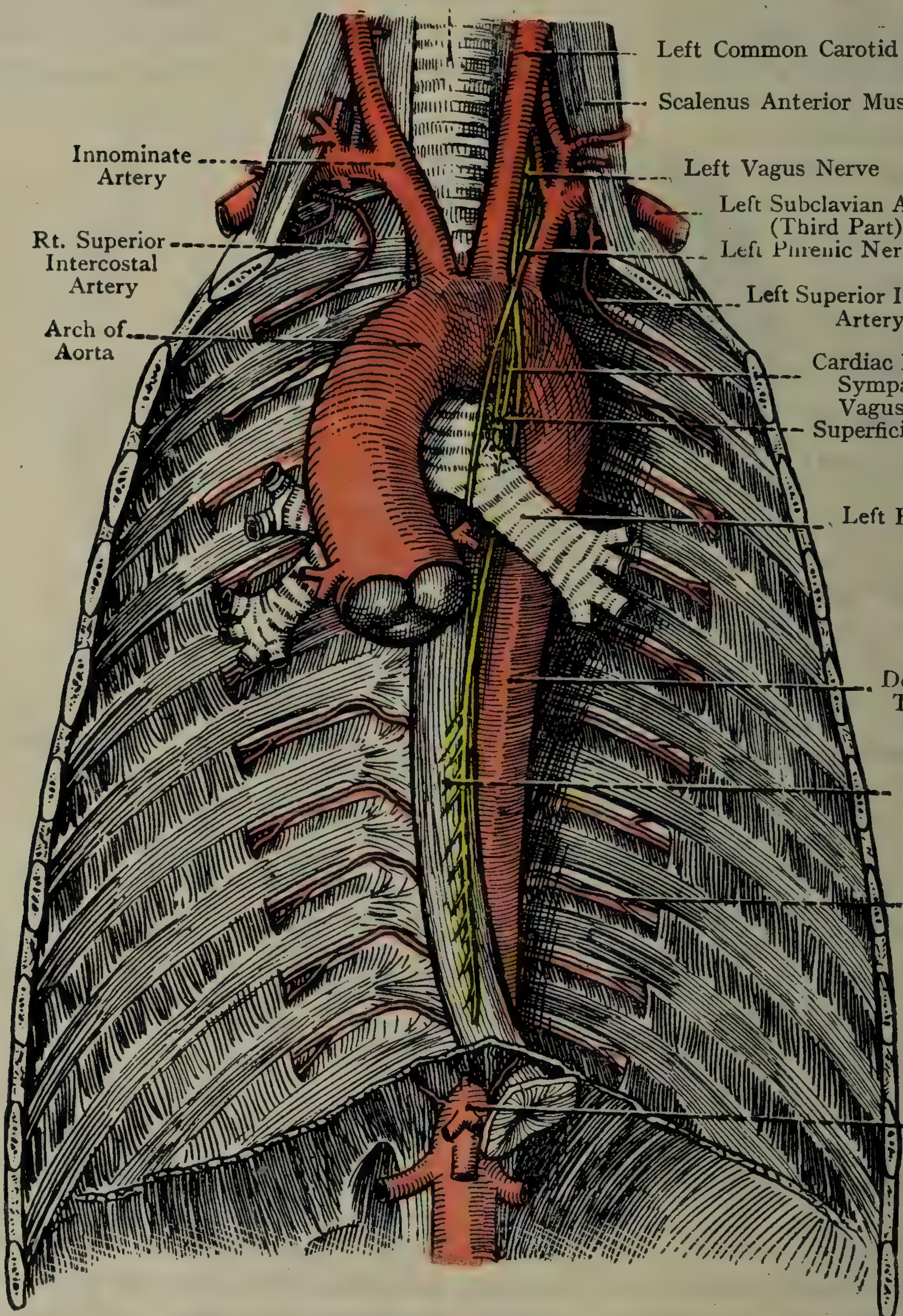


FIG. 651.—DISSECTION OF THE POSTERIOR WALL OF THE THORAX.

The *bronchial arteries* supply the lungs and the bronchial lymph
glands. They are usually three in number—one right and two l
The *right* bronchial artery arises from the aorta in common with
upper left bronchial artery, or sometimes from the first right poste
intercostal artery. The *two left* bronchial arteries, upper and low

: directly from the aorta near each other. The arteries enter the ective lungs behind the bronchi, and in their further course and ibution they follow the ramifications of he bronchial tubes.

The *bronchial veins* accompany the corre ponding arteries. The : vein opens into the vena azygos; and the left vein opens either the superior vena hemiazygos or into the left superior inter-al vein. The bronchial veins are con-rably smaller than the corresponding ries.

The *pericardial branches* supply the pos-or part of the pericardium.

The *œsophageal branches* are numerous, arise at irregular intervals. Superiorly spring from the right side of the aorta, inferiorly from its anterior wall. They stomose freely with one another along wall of the œsophagus: superiorly with œsophageal branches of the inferior oid arteries, and inferiorly with the phageal branches of the left gastric ry, the latter branches entering the ax through the œsophageal opening of diaphragm.

The *mediastinal branches* are very minute, supply the lymphatic glands and areolar ie in the posterior mediastinum.

The **posterior intercostal arteries** are ar-ged in pairs, and are nine in number on 1 side. They are destined for the lower e intercostal spaces, the first two spaces ng supplied by the superior intercostal ery, which is a branch of the second part he subclavian on the right side, and of first part on the left side. They arise in s from the posterior wall of the descend-aorta, and pass outwards upon the bodies he vertebræ to the posterior extremities he intercostal spaces. The arteries of right side pass behind the œsophagus, thoracic duct, and the vena azygos; l those of the left side pass behind the erior and inferior venæ hemiazygos ac-ding to their level. The arteries of both sides pass behind the ipathetic trunk. The upper right posterior intercostal arteries longer than those of the left side, on account of the position of the cending aorta on the left side of the vertebral column. All the eries lie behind the parietal pleura. Each artery, on entering an ercostal space, lies at first between the parietal pleura and the

FIG. 652.—TO SHOW THE RELATIONS TO EACH OTHER OF THE AORTA, THORACIC DUCT, AZYGOS VEIN, AND INTERCOSTAL ARTERIES (ANTERIOR VIEW).

posterior intercostal membrane. Its course is outwards and sligl upwards, and partly on this latter account, but chiefly on acco of the downward slope of the rib, it soon gains the lower borde the upper rib. At a point corresponding to the angle of the rib

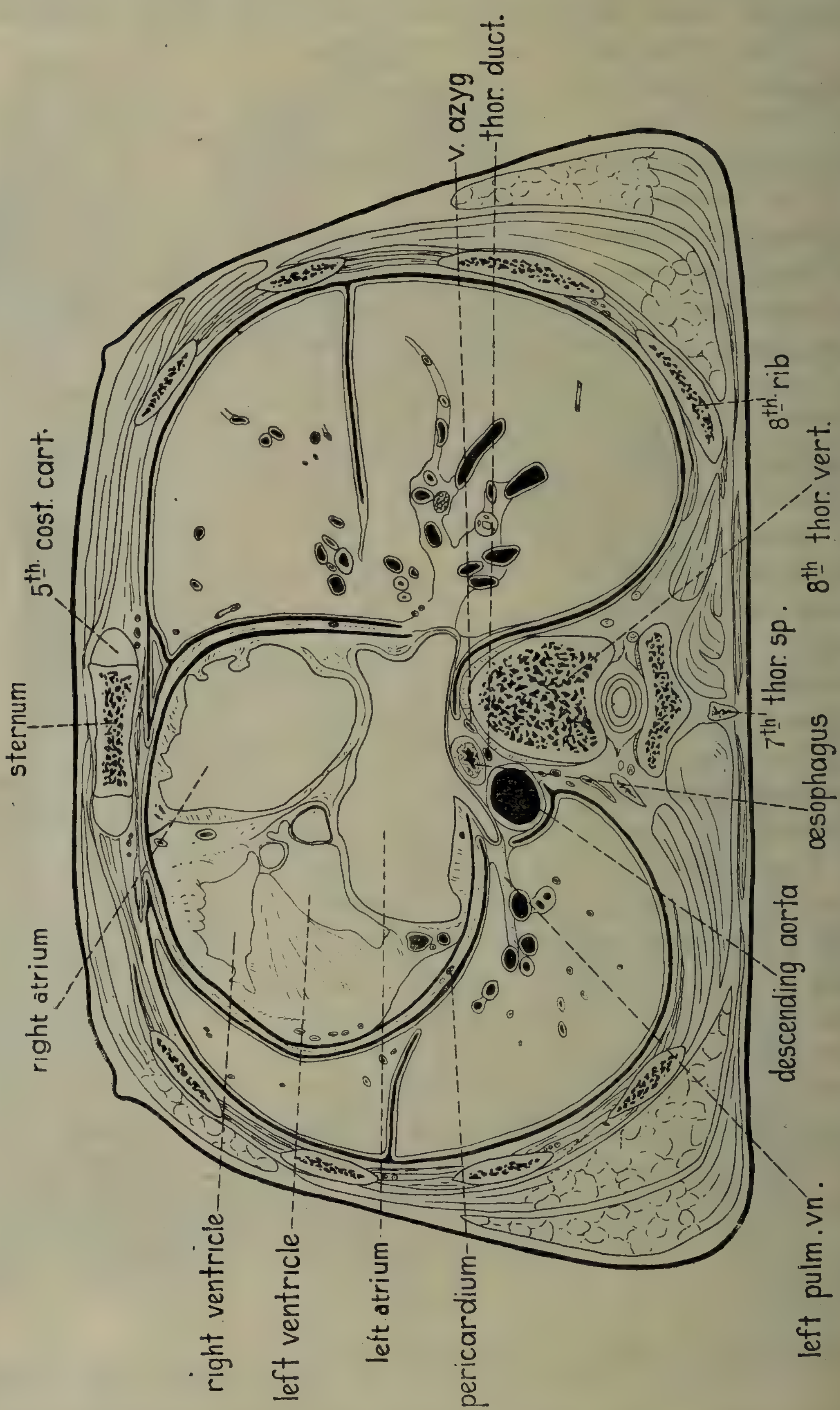


FIG. 653.—SECTION THROUGH THORAX AT LEVEL OF EIGHTH THORACIC VERTEBRA (AFTER SYMINGTON).

artery pierces the posterior intercostal membrane, and passing betw the external and internal intercostal muscles, it enters the costal groo of the upper rib. In this position it courses forwards, and ends anastomosing with the upper anterior intercostal branch of the inter

ımary artery, or of its musculo-phrenic branch, according to the .

'he companion intercostal vein lies above the artery, and the ɛsponding intercostal nerve lies below it. The order of struc-ɩ, therefore, in the costal groove, from above downwards, is as ws: intercostal vein, intercostal artery, and intercostal nerve. upper seven posterior intercostal arteries are confined to the costal spaces which they occupy; but the lower two—namely, ɛ in the tenth and eleventh intercostal spaces—ultimately leave ɛ spaces, and pass into the abdominal wall, where they have been ɪbed in connection with the abdomen.

ranches.—These are posterior, giving off a spinal branch; collateral costal; and lateral cutaneous.

'he *posterior branch* arises from the posterior intercostal artery as vessel enters the posterior extremity of an intercostal space. It ɛs backwards, in company with the posterior primary division of the ɛsponding spinal nerve, between the adjacent transverse processes, ɛ it lies internal to the superior costo-transverse ligament. Op-e the intervertebral foramen it gives off its *spinal branch*, which ɪs the vertebral canal through the foramen to be distributed to sseous and ligamentous walls, as well as to the spinal cord and its branes. The posterior branch, continuing its course backwards, les into a medial and lateral branch, which supply the muscles ntegument of the back.

he *collateral intercostal artery* arises from the main posterior inter-l opposite the angle of the rib. It passes obliquely downwards outwards to the upper border of the lower rib, along which it ses, lying between the external and internal intercostal muscles. riorly it ends by anastomosing with the lower anterior intercostal ch of the internal mammary artery, or of its musculo-phrenic ch, according to the level.

he *lateral cutaneous branches* accompany the lateral cutaneous ches of the corresponding intercostal nerves to the integument.

he *first* posterior intercostal artery—namely, that which lies in *hird* intercostal space—furnishes a branch, of variable size, which ıds over the neck of the third rib to the second intercostal space. branch anastomoses with the second posterior intercostal artery, h is a branch of the superior intercostal, and may even replace it.

he *subcostal arteries*, right and left, are the last branches of the ɴding thoracic aorta. They are serially continuous with the rior intercostal arteries above, and with the lumbar arteries below. vessel winds round the side of the body of the twelfth thoracic bra, and, passing beneath the lateral arcuate ligament of the ıragm, enters the wall of the abdomen, where it lies along the lower ɛr of the twelfth rib. These vessels will be found described in ɛction with the abdomen (see p. 848).

he first and second intercostal spaces receive their arteries from *uperior intercostal artery*, which is a branch of the second part

of the subclavian on the right side, and of the first part on the side. Having descended in front of the neck of the first rib to posterior extremity of the first intercostal space, the vessel furni the first posterior intercostal artery to that space, and it also g off the second posterior intercostal artery, which descends in f of the neck of the second rib to the second intercostal space. stated, the second posterior intercostal artery receives a branch f the third posterior intercostal artery, which ascends over the of the third rib.

Development of the Descending Aorta.—The upper portion of the descen aorta is developed from that part of the *left* primitive dorsal aorta whicl between the fourth left aortic arch and the place of junction of the two prim dorsal aortæ. The greater portion of it, however, results from the union o two primitive dorsal aortæ. The **posterior intercostal arteries** are devel from thoracic intersegmental arteries.

Posterior Intercostal Veins.—The intercostal veins are eleve number on either side, and each lies in the costal groove above corresponding posterior intercostal artery. In the region of the a of the rib each vein receives the *collateral intercostal vein*, which acc panies the artery of that name. At the posterior extremity o intercostal space each vein receives a large *posterior branch*, w returns blood from the muscles and integument of the back, external vertebral venous plexus, and the vertebral canal. With exception of the upper three or four veins, all the other interc veins pass inwards, behind the corresponding sympathetic cord to the bodies of the thoracic vertebræ, from which they receive s twigs. Their mode of termination differs on the two sides. On *right side* the veins, having passed behind the œsophagus, termi in the vena azygos. On the *left side* the lower four veins—namely eighth, ninth, tenth, and eleventh—open into the inferior vena h azygos; and the succeeding three (or four)—namely, the fifth, s and seventh (and, it may be, the fourth also)—open into the sup vena hemiazygos.

The **first posterior intercostal vein** of each side accompanies corresponding superior intercostal artery, and terminates in innominate vein, or, it may be, in the vertebral vein, of its own sid

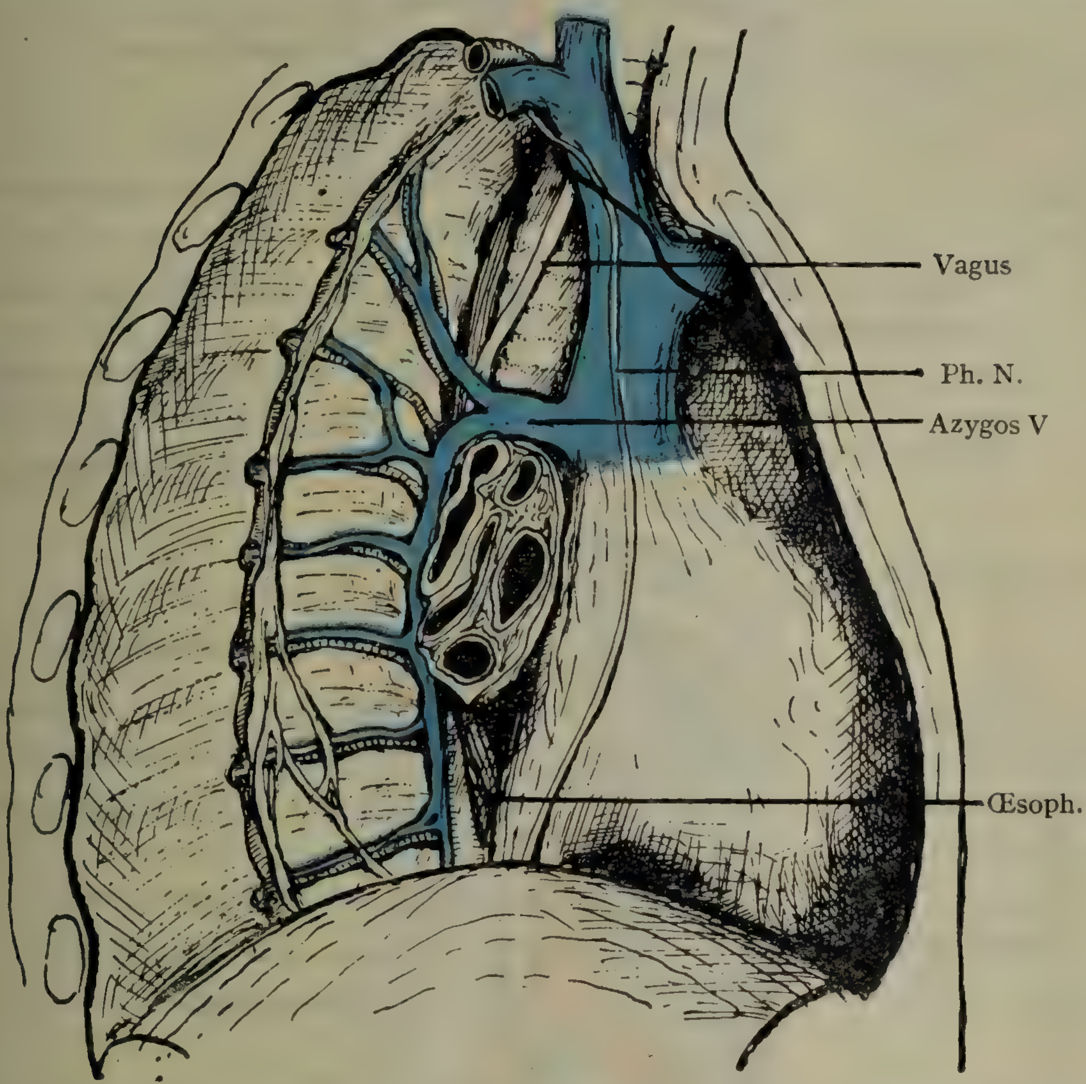
The **second** and **third posterior intercostal veins** (and, it may be fourth) of each side unite to form the superior intercostal vein. **right superior intercostal vein,** after a downward course, joins the u part of the vena azygos. The **left superior intercostal vein** forn loop which lies in front of the arch of the aorta, and opens into left innominate vein. It sometimes receives the left bronchial as a tributary.

Summary of the Posterior Intercostal Veins—Right Posterior Inter Veins.—The first opens into the right innominate vein, or sometimes into the vertebral vein. The second and third (and, it may be, the fourth also) to form the right superior intercostal vein, which opens into the vena az The lower eight (sometimes the lower seven) are direct tributaries of the azygos.

Left Posterior Intercostal Veins.—The first opens into the left innominate n, or sometimes into the left vertebral vein. The second and third (and, it y be, the fourth also) unite to form the left superior intercostal vein, which ens into the left innominate vein. The fifth, sixth, and seventh (and, it may the fourth also) terminate in the superior vena hemiazygos. The eighth, th, tenth, and eleventh are tributaries of the inferior vena hemiazygos.

The left superior intercostal vein is developed from two sources. The *upper rt* is formed by the portion of the left anterior cardinal vein below, and jacent to, the commencement of the transverse jugular vein. The *lower part* ormed by the upper portion of the left cardinal vein.

Intercostal Glands.—These glands form a chain on either side of the vertebral umn, in line with the necks of the ribs. The main glands of each chain lie



G. 654.—Vena Azygos and Right Sympathetic Chain, showing Ganglia and the Greater and Lesser Splanchnic Nerves arising from it.
Ph. N, phrenic nerve.

the *posterior* parts of the intercostal spaces, and one or two glands accompany ch posterior intercostal artery for a very short distance.

The intercostal glands receive their *afferent* vessels from (1) the posterior half the costal pleura, (2) the posterior halves of the external and internal interstal muscles, (3) the deep muscles of the back, and (4) the vertebral canal. eir *efferent* vessels, on either side, pass to the *thoracic duct*; those from the ver four or five spaces usually unite to form a trunk which, running vertically wnwards, pierces the diaphragm, and opens into the thoracic duct near its mmencement, or it may be into the cisterna chyli itself.

The *efferents* of the upper right intercostal glands sometimes open into a ght broncho-mediastinal lymphatic trunk, which terminates in the right mphatic duct.

The **right superior intercostal vein** is developed from the anastomotic channels hich connect the upper three thoracic segmental veins of the right side.

The Venæ Azygos et Hemiazygos Veins.—The **vena azygos (ve azygos major)** commences in the abdomen as the *right ascendi lumbar vein,* and enters the thorax through the aortic opening of t diaphragm, lying on the right side of the aorta, the thoracic du intervening. It then ascends, under cover of the œsophagus, up

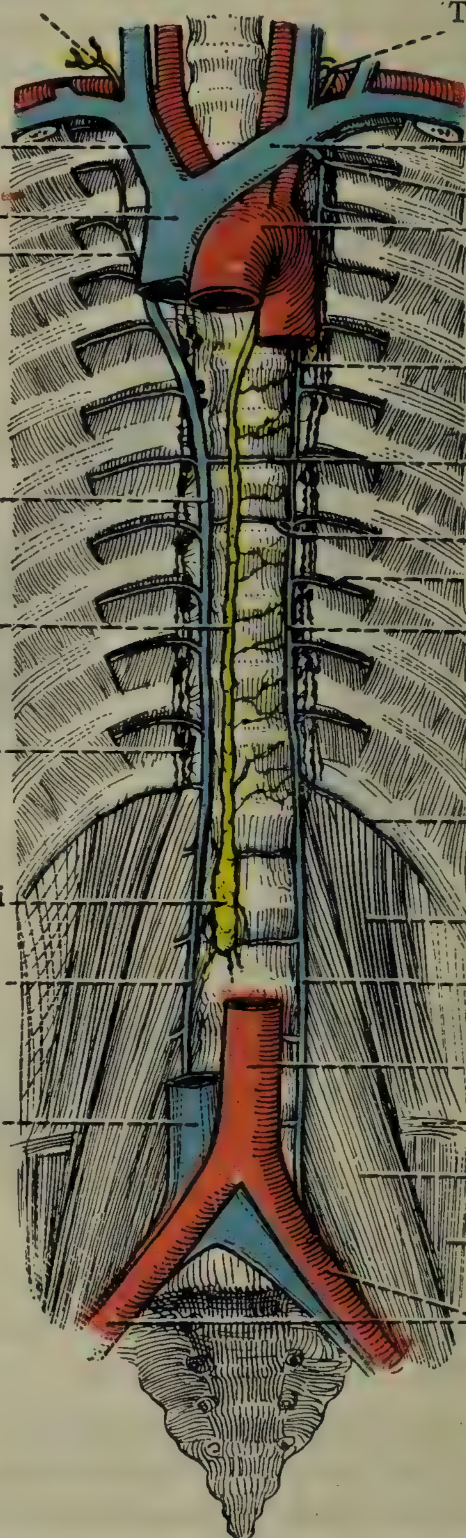


FIG. 655.—THE THORACIC DUCT, AZYGOS AND HEMIAZYGOS VEINS, AND POSTERIOR INTERCOSTAL GLANDS.

the bodies of the thoracic vertebræ, crossing in its course the rig posterior intercostal arteries. Having reached the level of the fif thoracic vertebra it leaves the vertebral column, and arching forwar over the right bronchus it opens into the superior vena cava ju before that vessel pierces the pericardium. In the thorax the ve

s continues to lie on the right side of the aorta, the thoracic duct
vening.

ributaries.—These are as follows:
The right subcostal vein.
The lower seven (sometimes the lower eight) right posterior
costal veins.
The right superior intercostal vein.
The right bronchial vein.
Some œsophageal veins.
Some pericardial veins.
The lower and upper transverse azygos veins.

he **inferior vena hemiazygos** (**vena azygos minor inferior**) commences
e abdomen as the *left ascending lumbar vein,* and enters the thorax
iercing the left crus of the diaphragm. It ascends upon the
bral column to the level of the eighth thoracic vertebra, lying in
of the lower posterior intercostal arteries, and it takes up the
four left posterior intercostal veins. It then crosses the vertebral
nn from left to right under the name of the *lower transverse azygos*
passing behind the descending aorta and thoracic duct, and
ng into the vena azygos.

ributaries.—These are as follows:

1. The left subcostal vein.
2. The lower four left posterior intercostal veins.
3. Some œsophageal veins.

he **superior vena hemiazygos** (**vena azygos minor inferior**) is formed
e union of the fifth, sixth, and seventh left posterior intercostal
(sometimes also the fourth). At the level of the seventh thoracic
bra it crosses the vertebral column from left to right under the
of the *upper transverse azygos vein,* passing behind the descending
and thoracic duct, and opening into the vena azygos. It com-
cates above with the left superior intercostal vein, and below
the inferior vena hemiazygos.

ributaries.—These are as follows:
. The fifth, sixth, and seventh left posterior intercostal veins
etimes also the fourth).
. The left bronchial vein, as a rule.
. Some œsophageal veins.

he superior and inferior venæ hemiazygos, which are subject to
variation, sometimes unite to form one transverse azygos vein.
he other hand, the hemiazygos veins are not infrequently multiple,
multiple openings into the vena azygos.

mmary of the Azygos and Hemiazygos Veins—Vena Azygos.—This vessel
es (1) the right subcostal vein; (2) the lower seven (sometimes the lower
) right posterior intercostal veins; (3) the right superior intercostal vein;
e right bronchial vein; (5) some œsophageal veins; (6) some pericardial
; and (7) the lower and upper transverse azygos veins.

ferior Vena Hemiazygos.—This vessel receives (1) the left subcostal vein;
e lower four left posterior intercostal veins; and (3) some œsophageal veins.

Superior Vena Hemiazygos.—This vessel receives (1) the fifth, sixth, seventh (sometimes also the fourth) left posterior intercostal veins; (2) th bronchial vein, as a rule; and (3) some œsophageal veins.

The vena azygos and the inferior vena hemiazygos, through connection with the ascending lumbar veins, establish communica with the inferior vena cava and with the common iliac veins or of their tributaries. They therefore form important channels by wh considerable quantity of blood is returned from the lower limbs abdominal wall in cases of obstruction of the inferior vena cava. venæ azygos et hemiazygos frequently communicate with the renal v

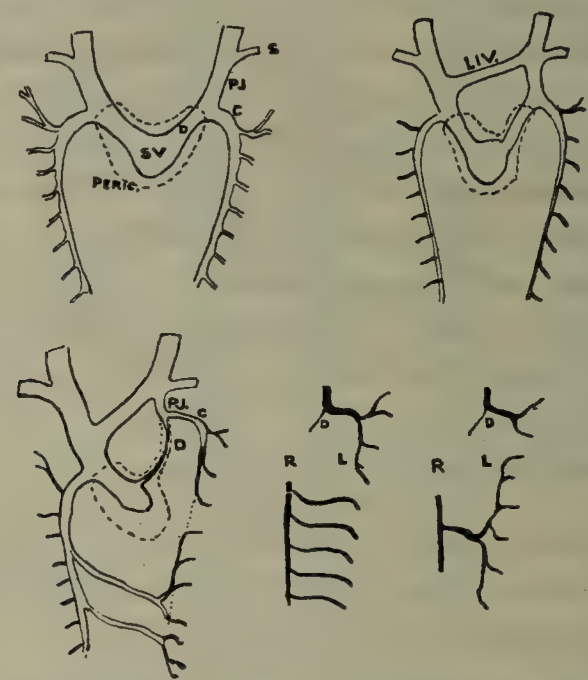


Fig. 656.—To show the Derivation of the Azygos Veins.

First figure shows original symmetry, the primitive jugular (PJ) on each joining the cardinal (C) to make the duct of Cuvier (D), which enter sinus venosus (SV); the duct of Cuvier is intrapericardial. In the se figure the left innominate vein (LIV) is formed, taking over the left ju and subclavian drainage, and leading to the appearance of a 'superior cava.' Further changes on left side affect the cardinal, which is rec in size and broken in various ways, such as in the next figure. The 'sup intercostal vein' here is seen to be formed from cardinal (C) and terr piece of jugular (PJ), and at the junction of these parts the duct of C (D) is present as an obliterated remnant; the lower left intercostals to the right vein by two cross-connections. The longitudinal left vein persist, with connections, or (as in figures) the lower left veins may separately, or may join to form one large transverse vessel, or some n fication of these variations may be found.

Development.—The **azygos vein** is developed at its upper end from terminal part of the right *cardinal* vein; below the mid-thoracic level it is by *supracardinal* (periganglionic) reaching the cardinal through an interme piece of *subcardinal*. The **hemiazygos veins** (lower) are derived from the *supracardinal*, developing transverse retro-aortic connections. The **hemiazygos** (left superior intercostal) is partly *cardinal* and (at its termina *primitive jugular* (see Fig. 656).

Subcostal Veins.—These are two in number, right and left, they are serially continuous with the intercostal veins. Each v enters the thorax from the abdomen by passing behind the lat

ıate ligament of the diaphragm. As stated, the right vein opens the vena azygos, and the left into the inferior vena hemiazygos.

Anterior Primary Rami of the Thoracic Spinal Nerves.—These are lve in number on each side. The first eleven enter intercostal

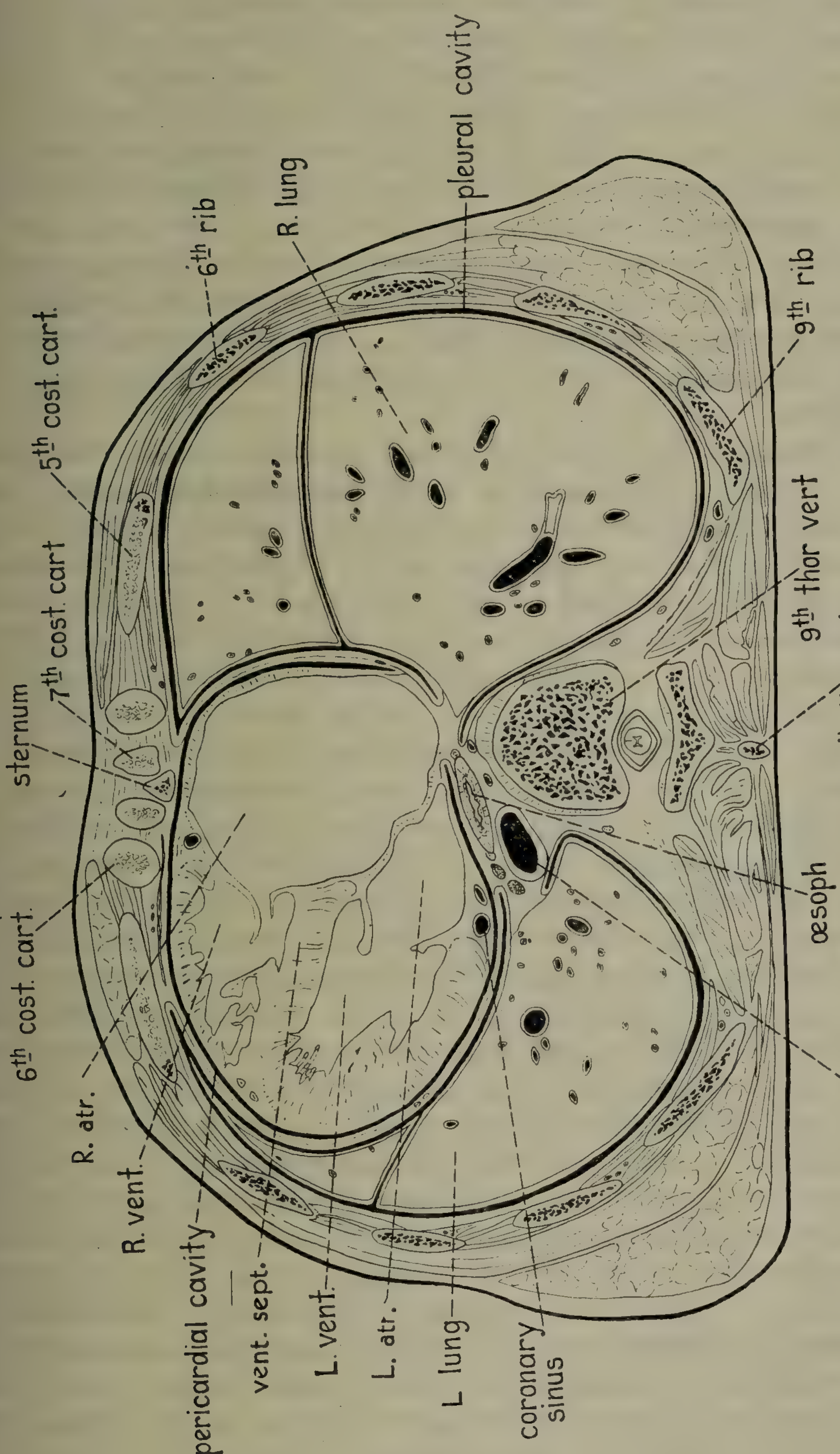


Fig. 657.—Transverse Section through Ninth Thoracic Vertebra (after Symington).

aces, and are called the **intercostal nerves.** The last, which belongs the abdomen, lies along the lower border of the twelfth rib, and is lled the **subcostal nerve** (' last dorsal nerve '). At the posterior tremities of the intercostal spaces the intercostal nerves are near

the sympathetic trunk, and each nerve is connected with the adjace sympathetic ganglion by two *rami communicantes*, which are nec sarily very short. One of these rami, being composed of spinal fibr is *white*, and the other, which consists of sympathetic fibres, is *gr* Each intercostal nerve lies below the corresponding artery, and, li it, lies between the parietal pleura and the posterior intercos membrane as far as the angle of the rib. Its subsequent course cor sponds to that of the artery. The first intercostal nerve is of sm size, because the greater part of the anterior primary ramus of t first thoracic nerve takes part in the formation of the brachial plex The second intercostal nerve sometimes gives off a small bran which ascends to join the portion of the anterior primary ramus the first thoracic nerve which takes part in the brachial plexus. T further course and distribution of the intercostal nerves belong to t thoracic and abdominal walls, in connection with which they will found described.

Thoracic Duct.—The thoracic duct commences in the abdom in a dilatation, called the **cisterna chyli (receptaculum chyli)**, which situated in front of the bodies of the first and second lumbar vertebr and terminates by opening into the angle of junction of the intern jugular and subclavian veins of the left side. It is about 18 inch in length, and enters the thorax from the abdomen by passing throu the aortic opening of the diaphragm, where it lies between the ao on the left and the vena azygos. In this position it ascends in t thorax, resting upon the vertebral column, the right posterior int costal arteries, and the lower and upper transverse azygos vei being under cover of the œsophagus. Up to the level of the four or fifth thoracic vertebra it occupies the middle line. At this level passes behind the arch of the aorta, inclining to the left of the mid line. It then ascends in close contact with the left side of the œsophag and behind the thoracic portion of the left subclavian artery. In t position it enters the root of the neck on the left side, where it ascen upon the left side of the œsophagus between the left common caro and left subclavian arteries. At about the level of the seven cervical vertebra it describes a curve, and passes outwards, forwar and downwards in contact with the dome of the left pleura. It ne inclines inwards, and terminates by opening into the angle of juncti between the internal jugular and subclavian veins of the left sid In the lower part of the thorax the thoracic duct is of smaller calib than in the upper part. Its course is somewhat undulating, a when distended it presents a beaded appearance, especially in t upper part, due to the number of valves with which it is provide Sometimes the duct divides into two branches in the lower part the thorax, which reunite at a higher level. The duct is freely provid with valves, especially in its upper part, and at its termination there an important valve, consisting of two segments, which are so direct as to prevent effectually the reflux of chyle, or the flow of blood in the duct.

he thoracic duct receives lymphatic vessels from the following es: (1) the lower limbs; (2) the abdomen and its viscera, except of the lymphatics from part of the upper surface of the liver; ie left half of the thoracic wall; (4) the left lung and the left half e heart; (5) the lower right intercostal spaces; (6) the left upper ; and (7) the left side of the head and neck. Most of the lymphatics e right half of the thorax and those of the right lung and right of the heart pass to the right lymphatic duct, for the description iich see the section dealing with the neck.

horacic Lymphatic Glands.—These are arranged in several groups ollows: internal mammary; intercostal; innominate; anterior astinal; posterior mediastinal; tracheo-bronchial, and caval.

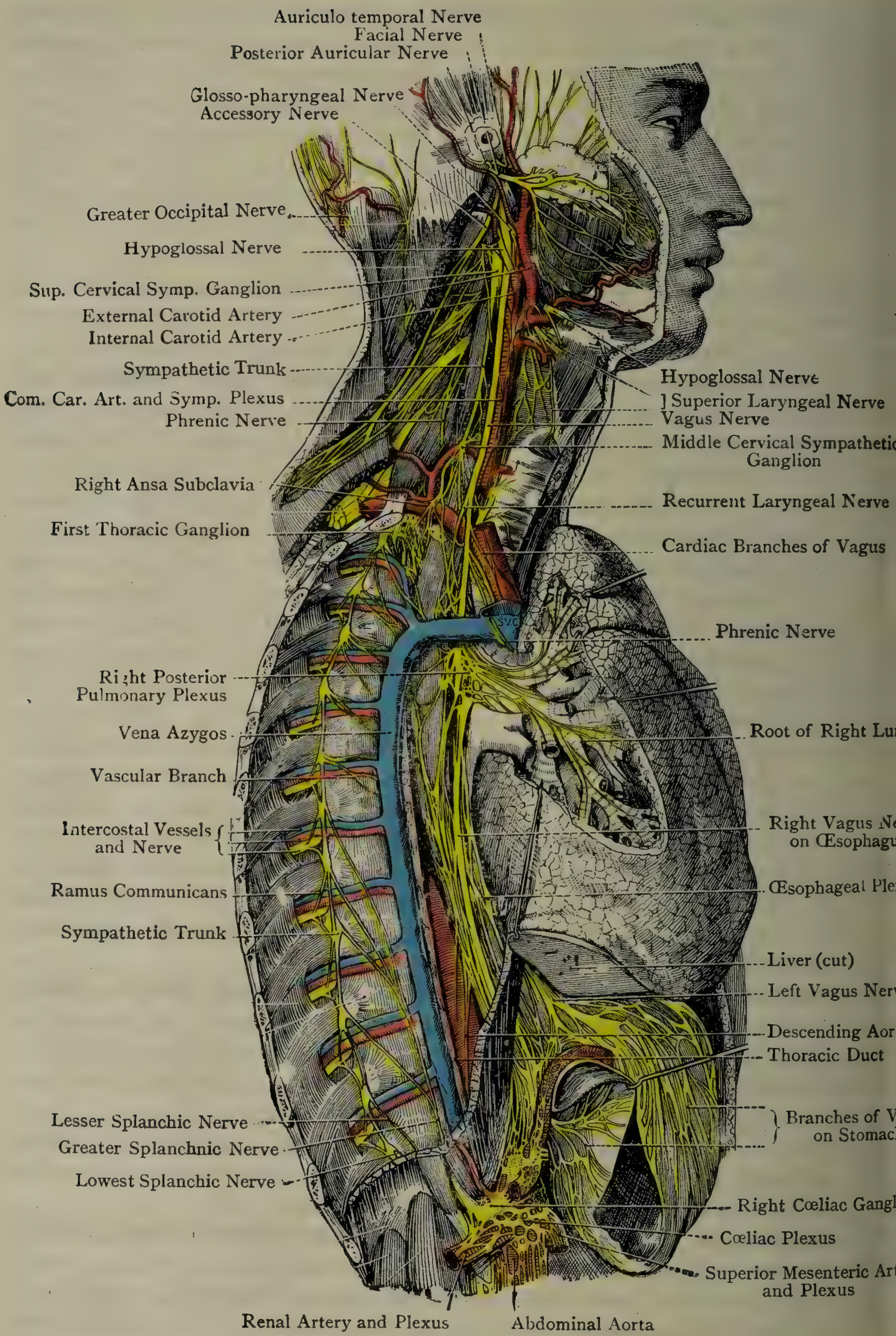
'he **internal mammary lymph glands** (**sternal lymph glands**) will und described on p. 996. They receive their afferent vessels from he anterior parts of the upper six intercostal spaces; (2) the inner on of the mammary gland; (3) the lymphatics accompanying the rior epigastric artery from the upper part of the anterior abdominal ; (4) the lymphatics accompanying the musculo-phrenic artery the anterior parts of the seventh, eighth, and ninth intercostal es, and from a portion of the diaphragm; and (5) the lymphatics the anterior set of diaphragmatic glands. The efferent vessels ie right glands terminate in the right lymphatic duct, and those ie left glands in the thoracic duct.

'he **intercostal lymph glands** are situated on either side of the ebral column, where they lie in the intercostal spaces, there being one to three in each space. They receive their afferent vessels (1) the posterior parts of the intercostal spaces; (2) the parietal ra; (3) the vertebral canal; and (4) the deep muscles of the back. efferent vessels of the left intercostal glands open into the thoracic :. On the right side the efferent vessels from the lower glands to the thoracic duct, but those from the upper glands open into right lymphatic duct.

[he **innominate lymph glands** (**superior mediastinal lymph glands**) n the superior mediastinum in relation to the arch of the aorta the innominate veins; they are continuous with the posterior iastinal and tracheo-bronchial glands below and with the chain ymph glands along the recurrent laryngeal nerves above. They ive their afferent vessels from the pericardium, the heart, trachea, phagus, and the thymus in early life, and their efferent vessels to the thoracic duct and right lymphatic duct.

[he **innominate lymph glands** (**anterior mediastinal lymph glands**) n the lower part of the anterior mediastinum in front of the peri-ium. They receive their afferent vessels from (1) the median portions ie right and left lobes of the liver in the vicinity of the falciform nent; (2) the adjacent portion of the diaphragm; (3) the anterior of the pericardium. Their efferent vessels pass to the internal imary lymph glands.

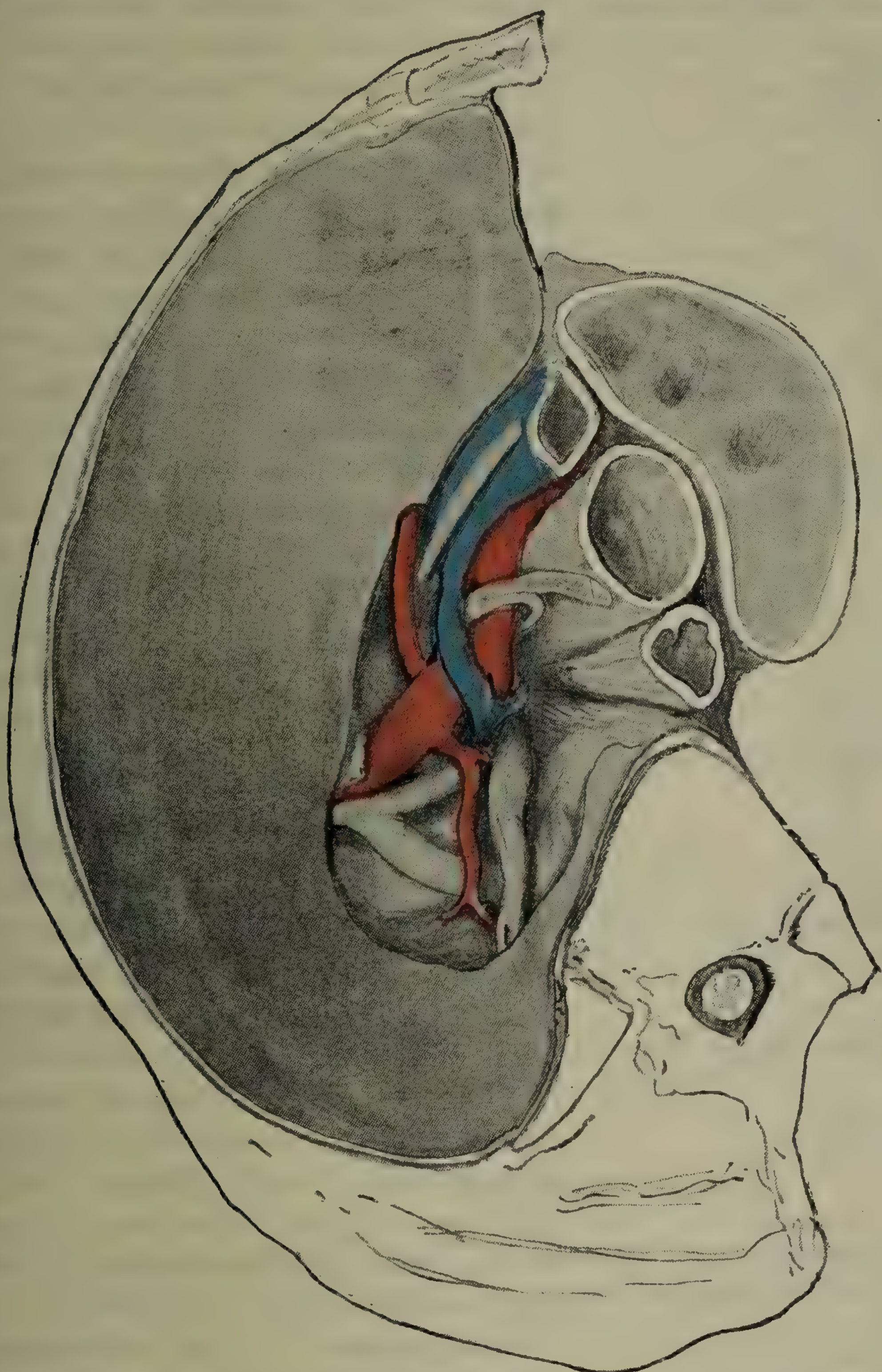
[he **posterior mediastinal lymph glands** are situated in the posterior



S.V.C. Superior Vena Cava

FIG. 658.—NERVES OF THE RIGHT SIDE OF THE FACE, NECK, AND THORA (HIRSCHFELD AND LEVEILLÉ).

iastinum, along the course of the descending aorta and œsophagus. y receive their afferent vessels from the œsophagus, the posterior of the pericardium, and the vertebral portion of the diaphragm. r efferent vessels pass, for the most part, to the thoracic duct.



. 659.—A Dissection of the Right Apical Region to show the Stellate Ganglion (viewed from below after removal of the Pleura).

ıddition to the subclavian vessels, the lower two brachial nerves are seen, with the ganglion and the superior intercostal artery.

The **tracheo-bronchial lymph glands** are very numerous, and are ıated partly in the angle between the trachea and bronchi, partly ween the two bronchi, and partly at the root of each lung. They very dark in colour, and receive their afferent vessels from the lungs l the visceral pleuræ. Their efferent vessels pass to the thoracic ct and right lymphatic duct.

The **caval glands** are situated in contact with the limited tho portion of the inferior vena cava. They receive their afferent ve from the bare area of the posterior surface of the liver, and also t deep lymphatics of that organ which accompany the hepatic veir the fossa for inferior vena cava. Their efferent vessels pass to thoracic duct. One of these glands often be found lying upon the inf vena cava within the fibrous pericardi

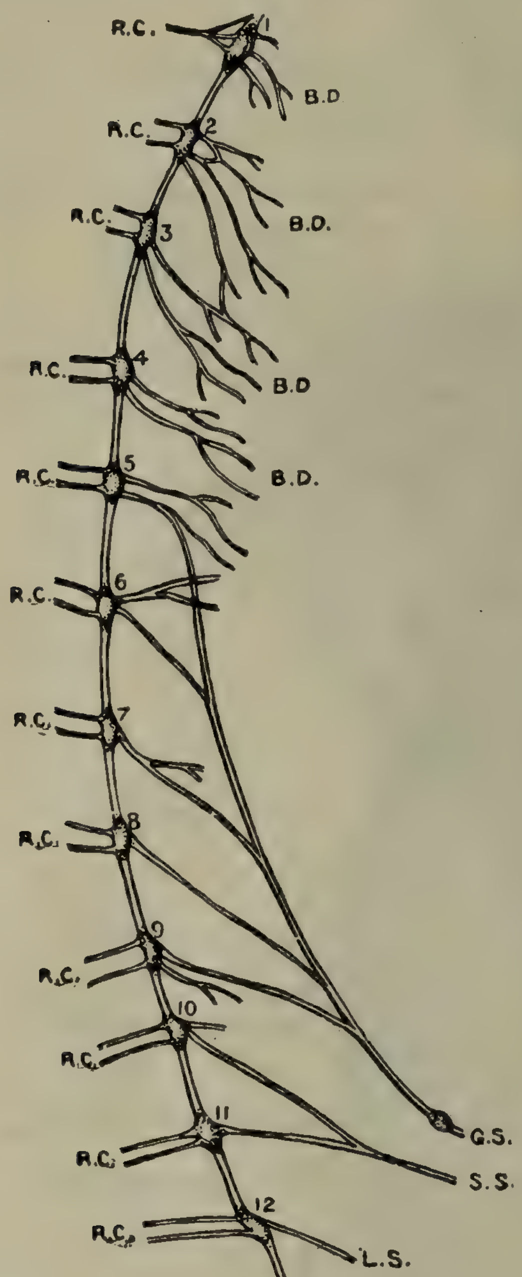


FIG. 660.—SCHEME OF THE THORACIC PART OF THE SYMPATHETIC SYSTEM (AFTER FLOWER).

1 to 12. Thoracic Ganglia
R.C. Rami Communicantes
B.D. Branches of Distribution from Upper Ganglia
G.S. Greater Splanchic Nerve and Ganglion
S.S. Lesser Splanchnic Nerve
L.S. Lowest Splanchnic Nerve

The Thoracic Part of the Sympatl System.—The sympathetic system in thorax consists of (1) two gangli trunks, right and left; and (2) a vertebral plexus—namely, the car plexus. The latter plexus has already described. The gangliated tr lies on each side of the vertebral col behind the parietal pleura, and superf to the posterior intercostal vessels. presents, as a rule, eleven ganglia. first or stellate ganglion is situated at inner end of the first intercostal sp and probably is formed by the fusio two originally distinct ganglia; the sec ganglion lies on the head of the third and the other ganglia follow in more less regular sequence, lying on the he of the ribs until the last two ganglia reached; these lie upon the sides of bodies of the eleventh and twelfth thor vertebræ. The first thoracic ganglio the largest of the thoracic series, and previously known as *stellate ganglion.* sympathetic trunk leaves the thorax passing behind the inner part of medial arcuate ligament of the diaphra and so enters the abdomen.

Branches—1. **Of Communication** These are called the *rami communican* Two of these, one *white* and the ot *grey*, pass between each ganglion and adjacent intercostal nerve. The wl fibres are of spinal and the grey of sy pathetic origin. From the proximity of the ganglia to the interco nerves the rami communicantes are necessarily short.

2. **Of Distribution.**—From the upper five ganglia small *vasc branches* are given off, which are distributed to the coats of the thor aorta. From the second, third, and fourth ganglia *pulmon branches* are given off to the posterior pulmonary plexus. From

ganglion downwards the three splanchnic ('visceral') nerves—
er, lesser, and lowest—are given off.

ie **greater splanchnic nerve** arises by five separate roots from the sixth, seventh, eighth, and ninth ganglia, the fibres of the upper being traceable in the sympathetic trunk as high as the second ion. The roots arch obliquely forwards and downwards upon des of the bodies of the adjacent vertebræ, and by their union form a large nerve, which pierces the crus of the diaphragm and nates in the cœliac ganglion. The greater splanchnic nerve ins a large number of spinal fibres, which impart to it a white r and firm consistence. The right nerve presents a small ganglion before it leaves the thorax, called the *splanchnic ganglion*, there may be one on the left nerve. The greater splanchnic gives vascular branches to the lower part of the thoracic .

he **lesser splanchnic nerve** arises by two roots from the ninth and ganglia. It pierces the crus of the diaphragm, and terminates e aortico-renal ganglion of the cœliac plexus.

he **lowest splanchnic nerve,** which is sometimes absent, arises ne root from the eleventh ganglion. It either passes behind the al arcuate ligament of the diaphragm or through the crus, and it inates in the renal plexus. When the lowest splanchnic nerve sent, its place may be taken by a branch from the lesser splanchnic e.

araganglia.—Situated in close relationship to the sympathetic lia are small bodies to which the name of paraganglia has been ı. They consist of chromaphil tissue like that which forms the ılla of the suprarenal glands, and probably secrete a substance h is excitory to non-striped muscle.

he diaphragm will be found described in connection with the men.

The Joints of the Vertebral Column.

. **Joints of the Bodies of the Vertebræ.**—These joints belong to class of **secondary cartilaginous joints.** The ligaments are as ws: the anterior longitudinal ligament, the posterior longitudinal nent, and the intervertebral discs.

he **anterior longitudinal ligament** (**anterior common ligament**) is a e band of white glistening fibres, which extends over the anterior ıces of the bodies of the vertebræ and intervertebral discs. It nds from the axis to the first segment of the sacrum, and its fibres disposed longitudinally. The most superficial fibres extend from a n vertebra to the fifth below it; the intermediate fibres pass from ven vertebra to the third below it; and the deepest fibres pass a given vertebra to the one immediately below it. The fibres are ly attached to the intervertebral discs and margins of the vertebral ies, but very loosely to the centres of the bodies, on account of the

presence of bloodvessels. The anterior longitudinal ligamen broadest in the lumbar region, and thickest in the thoracic region. is thicker opposite the centres of the bodies than elsewhere, an these situations it fills up the concavities, and so renders the fron the column less undulating than it otherwise would be. Over lateral surfaces of the bodies a few scattered fibres are present, w pass from one vertebra to that below. In the sacral region the ante longitudinal ligament is lost in the periosteum of the bone, bu reappears lower down as the anterior sacro-coccygeal ligament. anterior longitudinal ligament is serially continuous superiorly with anterior atlanto-occipital membrane.

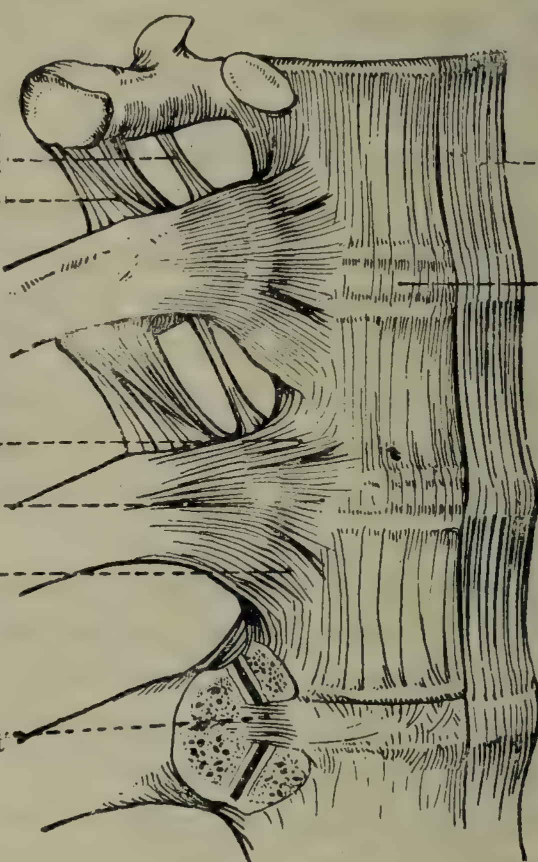
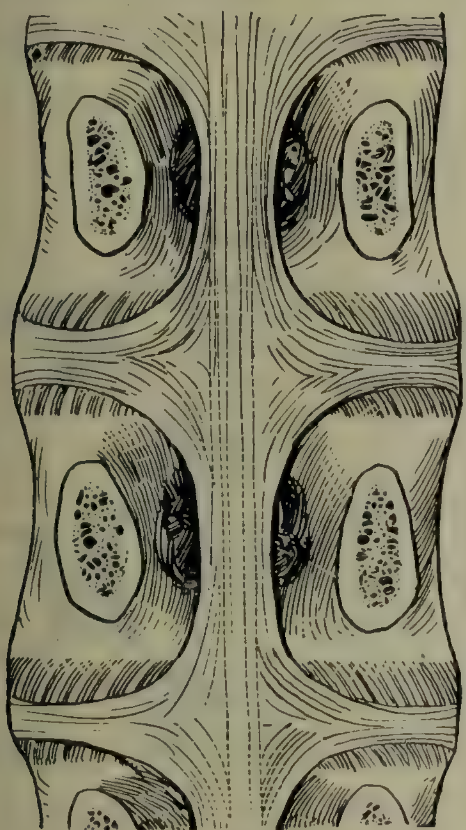


FIG. 661.—LIGAMENTS OF THE BODIES OF THE VERTEBRÆ AND JOINTS OF HEADS OF THE RIBS ON THE RIGHT SIDE.

The **posterior longitudinal ligament** (**posterior common ligamen** situated within the spinal canal, and extends over the poste surfaces of the bodies of the vertebræ and intervertebral discs. I broader above than below, and consists of glistening fibres, wh extend from the axis to the first coccygeal vertebra, its sacral p however, being very narrow and delicate. Its fibres are firmly attac to the intervertebral discs and margins of the vertebral bodies, but t are separated from the centres of the bodies by the transverse ven communications between the basivertebral veins. In the cerv region the ligament is of almost uniform breadth, being expanded c the vertebral bodies, as well as over the intervertebral discs. In thoracic and lumbar regions, however, it is narrow opposite vertebral bodies, and broad opposite the intervertebral discs. margins, therefore, present dentations, which give it a denticula

rance. The arrangement of its fibres is similar to the arrange- of those of the anterior longitudinal ligament. The posterior udinal ligament is serially continuous superiorly with the brana tectoria.

he **intervertebral discs** are situated between the adjacent surfaces e bodies of the vertebræ, and they constitute the chief bond of between them. Their outline corresponds to that of the bodies een which they are placed, and they are elastic and compressible. pt in early life, the first or highest disc is situated between the bodies e axis and the third cervical vertebra, and in the adult the last west disc is situated between the bodies of the fifth lumbar and sacral vertebræ.



G. 662.—Posterior Longitudinal Ligament of the Bodies of the Vertebræ.

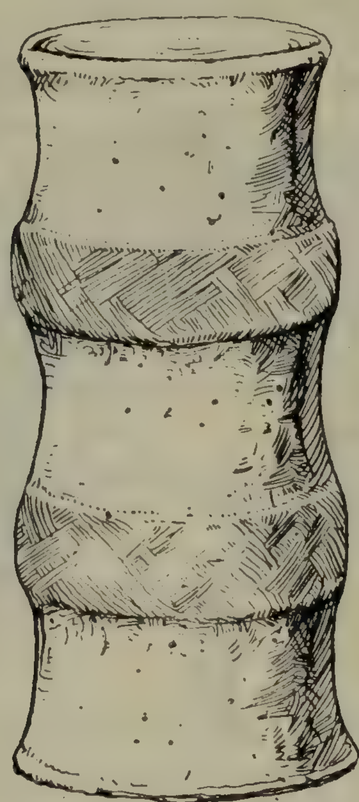


Fig. 663.—Intervertebral Discs (Anterior View).

Each disc is composed of a circumferential fibrous part, disposed e form of superimposed laminæ, and a central portion, the *nucleus osus*, which is soft and pulpy. The *annulus fibrosus* forms more half of the disc, and is composed of fibrous tissue and fibro- ilage. As seen in transverse section the laminæ are arranged entrically around the *nucleus pulposus*, which they closely embrace compress. The fibres of which they are composed are arranged parallel bundles, which extend obliquely between the adjacent aces of the vertebral bodies, being attached to the layer of hyaline ilage which covers them. The fibres of successive laminæ pass quely in opposite directions, and are disposed thus **X**. The outer næ consist of fibrous tissue, but the majority are composed of white -cartilage. As seen in vertical section the outermost laminæ are

bent outwards, and those around the nucleus pulposus are bent inw towards it, this arrangement contributing to the elasticity of the ve bral column. The *nucleus pulposus* consists of a soft, elastic, p substance, having a lobate arrangement. Being surrounded compressed on all sides by the annulus fibrosus, when a section disc is made the nucleus pulposus, being relieved from press projects beyond the level of the cut surface. It is composed cellular reticulum, supported by a delicate fibrous stroma.

The nucleus pulposus is a persistent portion of the notochord.

The intervertebral discs form about one-fourth of the lengt the vertebral column, and are thickest in the lumbar region. the cervical and lumbar regions they are deeper in front than beh and they give rise to the curve forwards in the cervical region, w they increase the forward curve in the lumbar region. In the thor

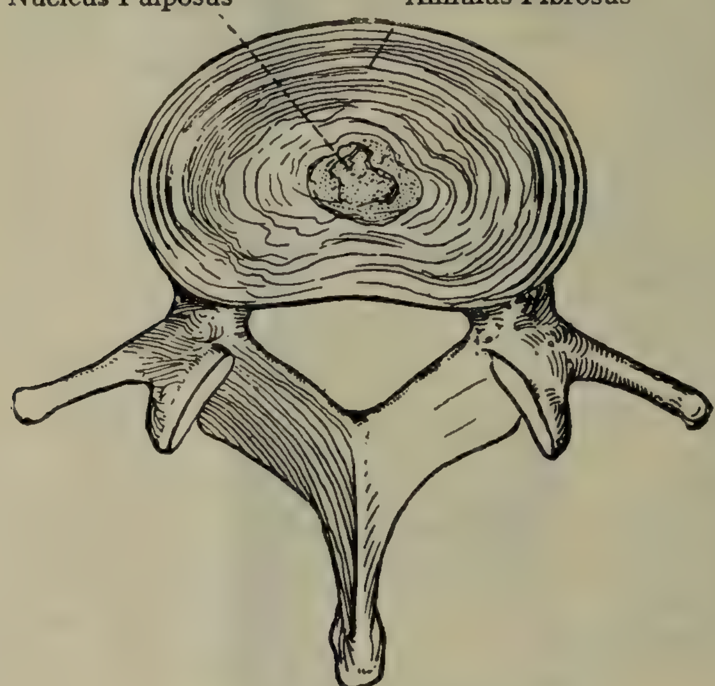


Fig. 664.—Intervertebral Disc (Transverse Section).

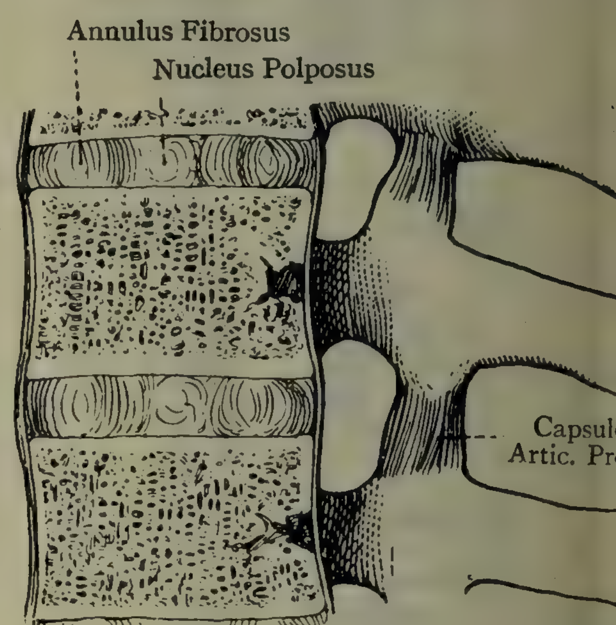
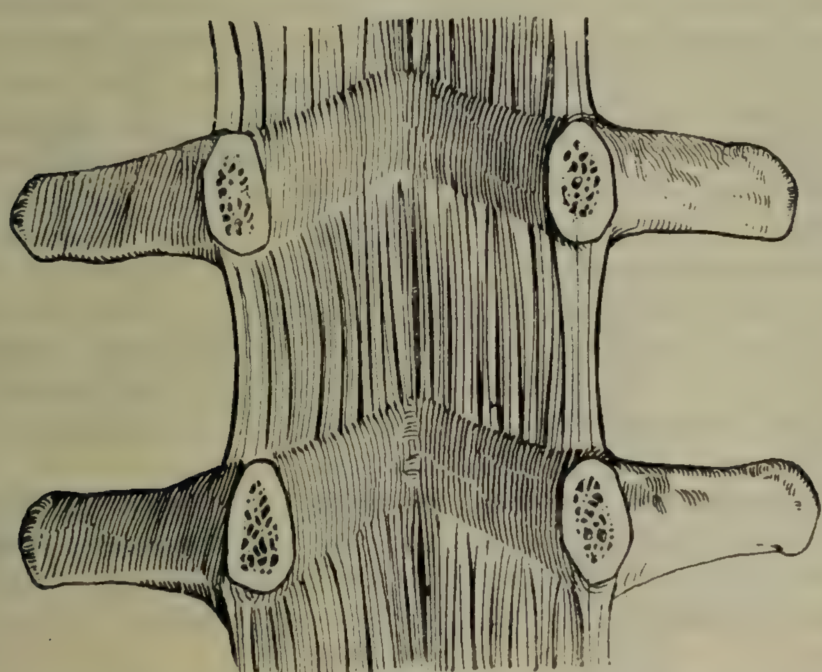


Fig. 665.—Vertical Sagittal Sec of Two Intervertebral Disc

region they are of uniform depth. Throughout the column t are intimately connected with the anterior and posterior longitud ligaments, and, in the thoracic region, with the radiate ligaments the intra-articular ligaments of the heads of most of the ribs. the cervical region the discs are not present at either lateral as of the opposed surfaces of the bodies. In these regions there synovial space on either side, between the projecting lateral lip of upper surface of the lower body and the bevelled lateral margin of lower surface of the upper body. The opposed surfaces are cove by cartilage, and there is an indistinct capsular ligament.

2. **Ligaments of the Laminæ.**—These are called the **ligam flava (ligamenta subflava)**. They are strong, thick plates of ye elastic tissue, which connect the laminæ together, and they ext from the axis to the first sacral segment. They are best seen from interior of the vertebral canal, and as they extend between the verte

es they close in the canal in these situations. Each ligamentum m extends from the root of the articular process to the place e the lamina joins its fellow to form the spinous process. At point it comes into relation with the ligament of the opposite a small interval being left between the two for the passage of s. Superiorly the ligament is attached to the anterior surface ie upper lamina a little above its lower border, and inferiorly it tached to the upper border, and adjacent part of the posterior ice, of the lower lamina. The ligamenta flava are wider in the ical and lumbar regions than in the thoracic region, and over the ter part of the latter region, as viewed from the exterior, they are ealed from view by the imbricated laminæ. Their importance ists in their great elasticity, which enables them to maintain the



G. 666.—Ligamenta Flava in the Lumbar Region (Anterior View).
The pedicles have been sawn through, and the vertebral bodies removed.

ebral column erect, and to restore it to the erect position after it been bent forwards.

3. **Ligaments of the Articular Processes.**—The joints between the cular processes belong to the class of **synovial joints** of the ie variety. The articular surfaces are covered by cartilage, and joint is surrounded by a **capsular ligament,** lined with a synovial nbrane. These ligaments are disposed more loosely in the cervical ion than elsewhere.

4. **Ligaments of the Spines.**—These are supraspinous and inter-ious.

The **supraspinous ligament** consists of longitudinal fibres which nect the extremities of the spines. It extends from the spine the seventh cervical vertebra to the spine of the fourth sacral ment, and its fibres are arranged in a manner similar to those of anterior longitudinal ligament. In the cervical region the supra-ious ligament is replaced by the ligamentum nuchæ. The **inter-**

spinous ligaments, which are thin and membranous, are situ
between adjacent spines, to the margins of which they are attac
from root to tip. They are strongest in the lumbar region, and in
neck they are replaced by deep processes of the ligamentum nucl

5. **The intertransverse ligaments.**—These consist of scattered fil
which pass between the extremities of the transverse processes in
thoracic and lumbar regions. In the neck they are replaced by
intertransverse muscles.

Movements.—The movements allowed in the vertebral column are fle
extension, lateral movement, rotation, and circumduction.

Flexion and **extension** are freely allowed in the cervical and lumbar reg
In the thoracic region these movements are very limited on account of (1)
small amount of intervertebral substance, and (2) the imbrication of the lam
Lateral flexion is allowed in the cervical, thoracic, and lumbar regions, bu
the neck it is associated with rotation. During these combined movemen
lateral flexion and rotation in the neck one inferior articular process g
upwards and forwards on that which is opposed to it, whilst the other inf
articular process glides downwards and backwards on the one opposed t
Pure **rotation** is allowed in the thoracic region round an axis corresponding
the centre of a circle of which the surfaces of the articular processes form
ments. This centre is necessarily anterior to the articular processes,
corresponds pretty nearly with the centres of the bodies of the vertebræ.
the lumbar region rotation is impossible, for the following two reasons: (1)
centre of the circle of which the articular processes form segments is poste
to these processes; and (2) the articular processes are so disposed as to be loc
In the lumbar region **circumduction** is allowed, which consists in a combina
of flexion, extension, and lateral movements.

Summary of Movements—Cervical Region.—(1) Flexion and extension;
(2) a combination of lateral flexion and rotation. **Thoracic Region.**—(1) Fle
and extension, but only to a limited extent; (2) lateral flexion; and (3)
rotation. **Lumbar Region.**—(1) Flexion and extension; (2) lateral flexion;
(3) circumduction.

The joints of the atlas, axis, and occipital bone will be fo
described in the section dealing with the head and neck.

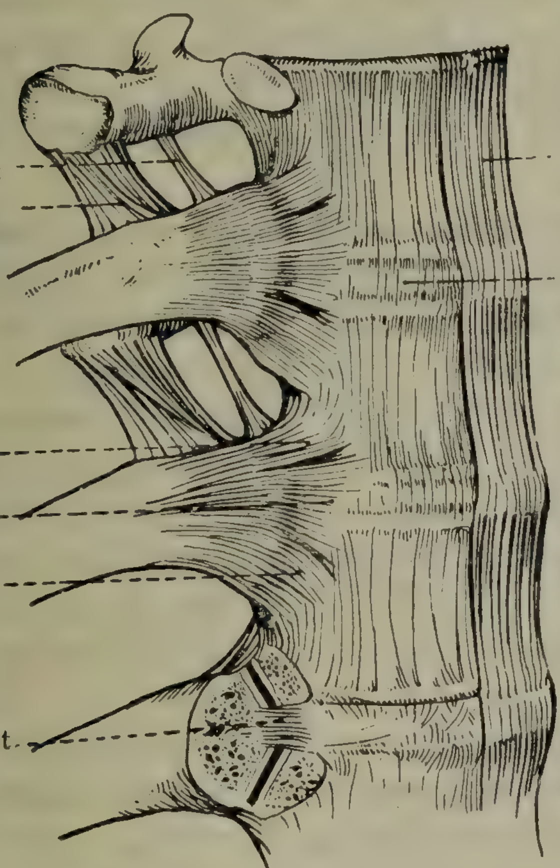
The Joints of the Ribs, Costal Cartilages, and Sternum.

1. **Ribs—Costo-vertebral Joints.**—These are divided into joints
the heads of the ribs and costo-transverse joints.

The Joints of the Heads of the Ribs.—These unite the heads of
ribs to the bodies of the thoracic vertebræ, and they are someti
spoken of as the *capitular joints*. They belong to the class of **syno
joints** of the **plane** variety. The articular surfaces are the facets
the heads of the ribs and the costal facets on the sides of the boc
of the thoracic vertebræ—that is to say, the lower facet of the verte
above and the upper facet of the vertebra below, the intervertel
disc intervening between the two. In the case of the first, the ten
the eleventh, and the twelfth vertebræ there is only one facet, and
corresponding intervertebral discs do not enter into the joints, unl
in the case of the first joint, into which the disc between the seve
cervical and first thoracic vertebræ may enter.

:aments.—These are as follows: radiate, capsular, and intra-lar.

.e **radiate ligament** (**anterior costo-central ligament**) or **stellate** **nt** consists of strong white fibres which are attached to the or margin of the head of the rib. From this point the fibres e inwards in three bands, one of which passes upwards to be ıed to the body of the vertebra above, a second horizontally ds to be attached to the intervertebral disc, and a third vards to be attached to the body of the vertebra below. e case of the first, tenth, eleventh, and twelfth joints, into of which only one vertebra enters, the ligament is composed of ands, instead of three. In the first joint the lower band passes body of the first thoracic vertebra, and the upper band to the



567.—Ligaments of the Bodies of the Vertebræ and Joints of the Heads of the Ribs on the Right Side.

of the seventh cervical. In each of the tenth, eleventh, and th joints the lower band passes to the body with which the head e rib articulates, and the upper band to the body of the vertebra e.

he **capsular ligament** is incomplete, and consists of thin loose s, which cover the posterior, superior, and inferior aspects of oint.

he **intra-articular ligament** consists of short stout fibres, which ıd from the ridge on the head of the rib, separating the two facets, ıe intervertebral disc. It divides the joint into two complete vial cavities, and it is wanting in the first, tenth, eleventh, and fth joints.

There are two distinct **synovial membranes** in those joints which

are provided with an intra-articular ligament—namely, from second to the ninth inclusive—one being above the ligament and other below it. In those joints in which the intra-articular ligan is absent—namely, the first, tenth, eleventh, and twelfth—ther only one synovial membrane.

Arterial Supply.—Branches from the *posterior* intercostal arterie

Nerve-supply.—Branches from the intercostal nerves.

Costo-transverse Joints.—These belong to the class of **syno joints** of the **plane** variety. The articular surfaces are the facet the tubercle of the rib and the facet on the anterior aspect of extremity of the transverse process of the thoracic vertebra.

Ligaments.—These are as follows: posterior costo-transve inferior costo-transverse, superior costo-transverse, and capsular.

The **lateral costo-transverse ligament** (**posterior costo-transv ligament**) is a strong flat band, situated on the posterior aspect of joint, and extending from the extremity of the transverse proces the non-articular part of the tubercle of the rib. The direction its fibres is outwards.

The **inferior costo-transverse ligament** (**middle costo-transv ligament**) consists of short strong fibres which pass between the poste surface of the neck of the rib and the anterior surface of the adjac transverse process—namely, that with which the tubercle of the articulates. Its fibres, which are disposed horizontally, extend fi the joint of the head of the rib to the costo-transverse joint. T ligament is rudimentary in the eleventh and twelfth ribs.

The **superior costo-transverse ligament** is a broad flat band, lat in position, the fibres of which pass from the crest on the upper bor of the neck of the rib to the lower border of the transverse proc immediately above, in the vicinity of its tip. Its fibres are direc upwards and outwards, and its outer border is continuous with posterior intercostal membrane. A feeble band of fibres, medial the preceding, extends from the back of the neck of the rib, below crest, to the lower aspect of the transverse process immediately abo close to its base, being termed the *posterior costo-transverse ligamen*

The superior costo-transverse ligament is wanting in the case the first rib.

The **capsular ligament** is formed in part by the lateral cos transverse ligament, and elsewhere by a thin loose membrane, fibres of which are attached lateral to the articular processes. is absent in the case of the eleventh and twelfth ribs.

The **synovial membrane** is single and small.

Arterial and Nerve Supply.—Offsets from the posterior branc of the intercostal arteries and nerves.

The costo-transverse joints are wanting in the case of the eleve and twelfth ribs, and sometimes in the case of the tenth.

Costo-chondral Joints.—These belong to the class of **fibrous joi** The outer extremity of the costal cartilage is implanted in the o pit on the anterior extremity of the rib, and the union is effected

continuity which takes place between the periosteum of the rib the perichondrium of the cartilage.

2. **Costal Cartilages—Sterno-Costal Joints.**—These belong to the s of **synovial joints,** except in the case of the first joint, which ngs to the class of **primary cartilaginous joints.** The cartilages ch take part in these joints are the first seven on either side, e being received into the costal pits or facets on the side of the num.

The ligaments are capsular, sterno-costal, and in the case of the nd joint at least intra-articular.

The Capsular Ligament.—The anterior part is a triangular band, the er fibres of which ascend upon the sternum, and the lower descend, lst the intervening fibres pass horizontally forwards. They de-

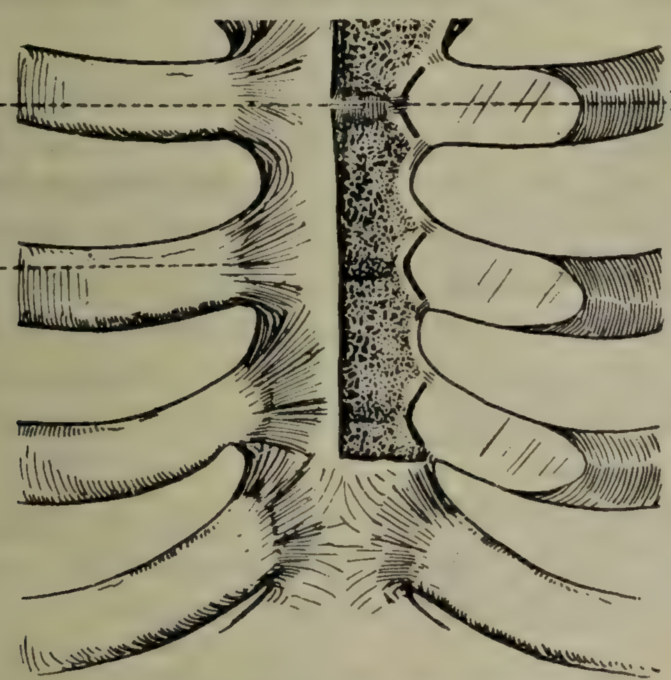


FIG. 668.—THE STERNO-COSTAL JOINTS (ANTERIOR VIEW).

The second, third, and fourth joints of the left side are seen in section.

sate with those of the opposite side, and blend with the tendinous es of origin of the pectoralis major muscle.

The posterior part of the capsular ligament is disposed in a manner ilar to the anterior ligament.

The **sterno-costal ligaments** pass from the upper and lower borders the costal cartilage to the side of the sternum.

The **intra-articular ligament** is present in the second joint, and may present in some of those succeeding to it. Its fibres extend hori-tally between the centre of the sternal end of the second costal tilage and the plate of fibro-cartilage between the manubrium and ly of the sternum. It divides this joint into two complete synovial ities.

The first joint has no synovial membrane, the first costal cartilage ng directly united to the manubrium sterni. The second joint, as ted, has two synovial membranes, one above and the other below intra-articular ligament. The succeeding joints have each usually

one synovial membrane, but sometimes one or more of them ma have two.

Arterial Supply.—The perforating branches of the internal mammai artery.

Nerve-supply.—The intercostal nerves as they are becoming tl anterior cutaneous nerves.

Interchondral Joints.—These belong to the class of **synovial join** of the **plane** variety. The cartilages involved are usually the sixt seventh, and eighth, but sometimes also the ninth, and it may be th fifth, and even the tenth. The lower border of each cartilage projec downwards, and comes into contact with the upper border of th cartilage below. Each joint is surrounded by fibres disposed in th form of a capsule, and it is provided with a synovial membrane.

Arterial Supply.—The musculo-phrenic branch of the intern mammary artery.

Nerve-supply.—The adjacent intercostal nerves.

3. **Sternal Joints.**—The joint between the manubrium and bod of the sternum belongs to the class of **secondary cartilaginous joint** The opposed surfaces are covered by hyaline cartilage, and a plat or disc of fibro-cartilage is interposed between them, which is connecte at either side with the intra-articular ligaments of the second stern costal joint. This disc may contain a small cavity. In front c and behind the joint there are ligamentous fibres which are dispose longitudinally.

The entire sternum is strengthened by its dense periosteum, b the radiating fibres of the sterno-costal ligaments, and by the tendinou fibres of origin of the pectoralis major muscles.

Movements of the Ribs.—The movement allowed at the **joints of the hea of the ribs** and **costo-transverse joints** is of a *gliding* nature, and takes place an upward and downward direction. During this movement the rib *rotat* round the **costo-vertebral axis,** which corresponds to a line passing oblique through the joint of the neck of the rib, the neck of the rib, and the costo-tran verse joint. Owing to the curve and downward inclination of the rib, th result of this rotation is that the anterior and lateral parts of the rib are elevate Simultaneously, on account of the obliquity of the axis of rotation, the anteri part of the rib is carried forwards, and along with it the sternum, thus increasin the *antero-posterior diameter* of the thorax. The lateral part of the rib, and to certain extent the anterior part also, are carried outwards, thus giving rise t *eversion* of the lower border of the rib, and at the same time the angle betwee the rib and its costal cartilage is opened out. In this manner an increase in th *transverse diameter* of the thorax is produced. During the elevation of th anterior and lateral parts of the rib and the eversion of its lower border th movement takes place round the **costo-sternal axis,** which corresponds to a lin drawn from the costo-central joint of one side to the corresponding stern costal joint. It is usual to liken this movement to the movement of the hand of a bucket.

In the case of the first rib elevation and depression are the chief movemen allowed, the amount of eversion being trivial, inasmuch as the axis of rotatic is almost transverse. In the case of the second, third, fourth, fifth, and sixt ribs elevation and depression, along with eversion, are allowed, the axis of rotatio in each case becoming successively more oblique. The seventh, eighth, nintl and tenth ribs, in which the costo-transverse articular surfaces are almost fla

ides rotating round the costo-vertebral axis, also rotate round the costo-nal axis. In the case of these ribs elevation is accompanied by a backward vement, and depression by a forward movement. These backward and vard movements take place more freely in the case of the eleventh and lfth ribs, which have no costo-transverse joints. At the sterno-costal joints movement is limited, and consists elevation and depression, together h forward and backward movement. At the interchondral joints slight ing movement is allowed.

Muscles concerned in Respiration.—**ordinary quiet inspiration** the muscles cerned are as follows: (1) the dia-agm; (2) the external and internal rcostal muscles, assuming Haller's v to be correct; (3) the levatores tarum; (4) the serratus posterior su-ior; (5) the serratus posterior inferior; (6) the quadratus lumborum as being iliary to the diaphragm, the serratus terior inferior being also auxiliary. **inary quiet expiration** is due to (1) the tic recoil of the lungs, (2) the elastic oil of the thoracic wall (costal carti-es and sternum), (3) the sterno-costalis scle, and (4) the muscles of the antero-ral wall of the abdomen, which press dly upon the abdominal viscera, and reby push the diaphragm upwards ards the thorax.

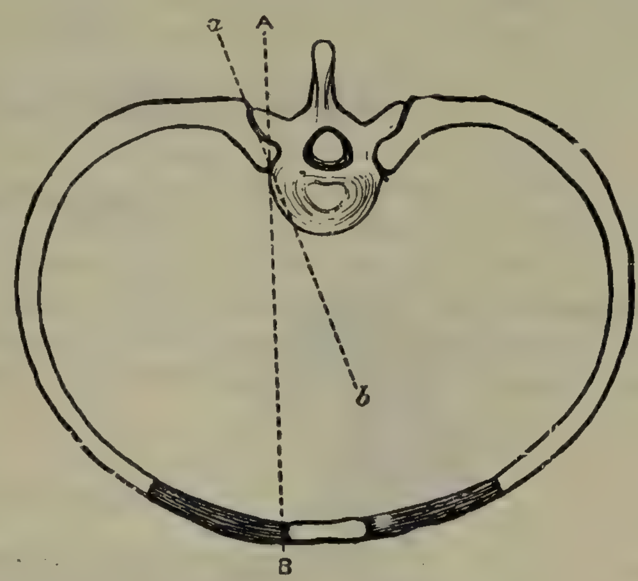


Fig. 669.—Diagram showing the Axes of Rotation of the Ribs (from Halliburton's 'Handbook of Physiology').

A, B, axis passing from the joint of head of rib to chondro-sternal joint; *a*, *b*, axis passing through costo-transverse and joints of heads of ribs. (The movement round the axis A, B resembles the raising of the handle of a bucket.)

In forced inspiration the following scles come into play: (1) the scaleni; the sterno-mastoid; (3) the serratus erior; (4) the pectoralis major and toralis minor; and (5) the latissimus si. As auxiliary muscles there are the trapezius, levator scapulæ, and rhom-l muscles, which, by their action upon the scapula, fix the shoulder.

In **forced expiration** the muscles of the antero-lateral wall of the abdomen with considerable strength, and now depress those ribs with which they connected, and necessarily also the sternum. By some authorities the atus posticus inferior is regarded as being concerned.

In inspiration the thoracic cavity is enlarged in its vertical, antero-posterior, transverse diameters. The increase in the **vertical diameter** is due to the traction and descent of the diaphragm; the increase in the **antero-posterior neter** is caused by the anterior parts of the ribs, and along with them the num, being carried forwards; and the increase in the **transverse diameter** rought about by the eversion of the lower borders of the ribs, and the opening of the angles between the ribs and their costal cartilages.

CHAPTER XIII

DEVELOPMENT OF VASCULAR SYSTEMS

Principal Arteries and Veins.

It was shown at the beginning of this book (pp. 51, 91) that the **vasc** **system,** in its earliest stages, came into existence as the result of the establishm of connections between networks of channels formed on the yolk-sac, in body-stalk, and in the embryonic body; an extension from the body-stall

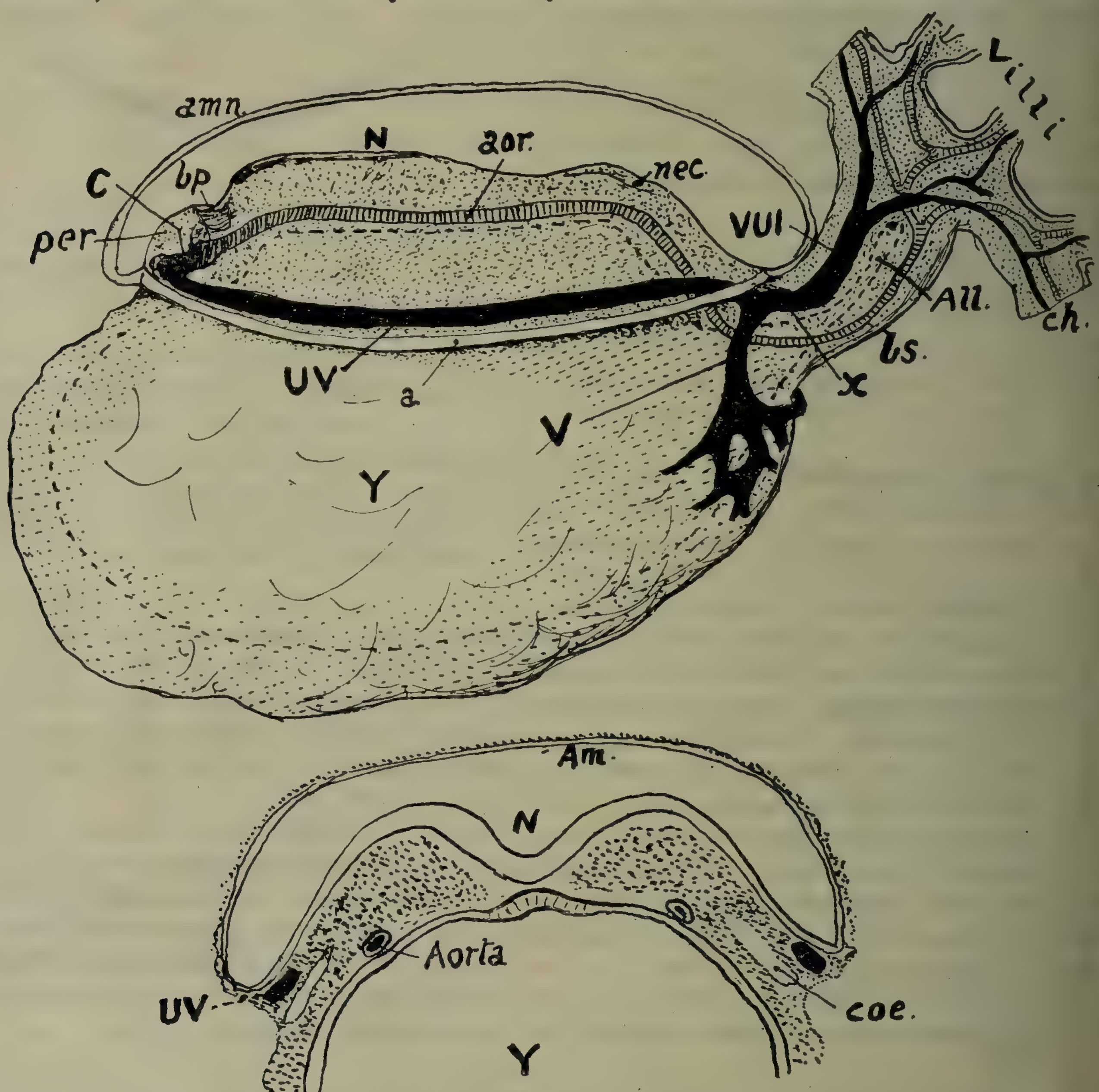


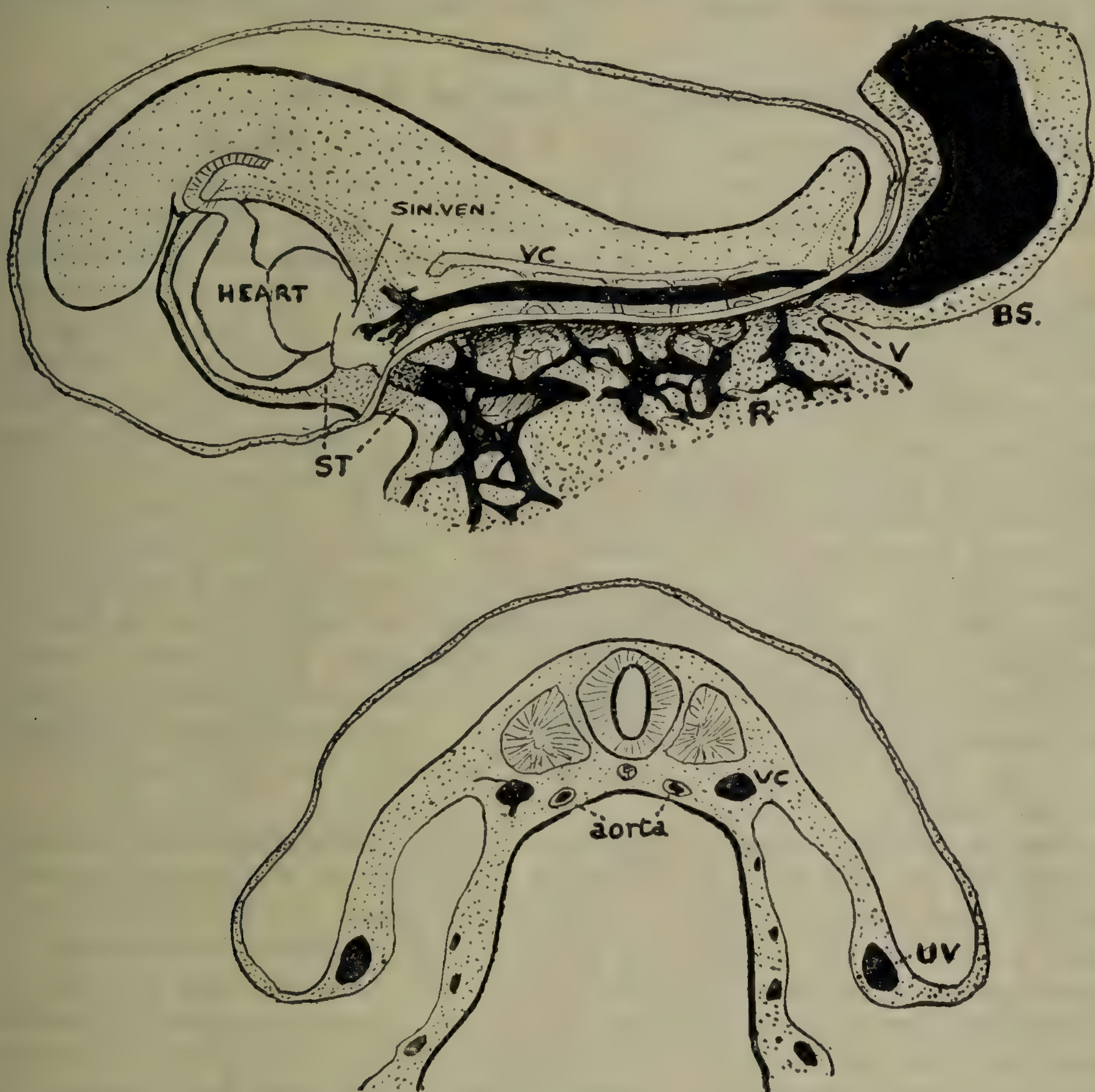
FIG. 670.—SCHEME OF EARLIEST CIRCULATORY SYSTEM. (FOUNDED ON ETERNO The lower figure is a diagrammatic section to show position of aortæ and umbil veins (UV). Am, amnion; N, neural groove; coe, intra-embryonic cœlom

the chorion (where similar channels are possibly formed also) puts th anastomosing systems into relation with the growing villi.

The primitive circulation would seem to be possible through channels est lished in this way at an early stage in embryonic formation; such might represented schematically as in Fig. 670. In this figure it can be seen t

ns (vitelline) pass up the wall of the yolk-sac to reach the posterior part of : embryonic rim, where they join a vein coming from the body-stalk and nning forward to enter the primitive heart-tube. This (C) is a very short oe, doubled in origin, which runs back towards the bucco-pharyngeal area (bp), ing off here two *primitive aortæ*, which pass back on each side of the area the future membrane, and continue their course caudally to reach the body-lk. As they pass back in the embryo they give off vitelline branches down-rds on to the wall of the yolk-sac; later, as the somites form, they will be found give intersegmental branches running dorsally between the somites. When y reach the chorion they are distributed throughout it and to its villi.

The *veins* which return the blood in this early circulation must come into stence, of course, with the 'arteries,' and can be said in general terms to



. 671.—SCHEMES FOUNDED ON CONDITIONS IN AN EMBRYO OF ABOUT TWELVE SOMITES, IN WHICH THE INTRA- AND EXTRA-EMBRYONIC CŒLOMIC CAVITIES ARE CONTINUOUS.

se from the common vascular network as enlargements of its 'peripheral' t, the 'central' vessels becoming arterial. Thus veins are found extending the heart along the embryonic rim, which receive the blood returning through body-stalk; these veins (uv), are the *umbilical veins*, which, passing forward ng the margins of the embryonic plate, reach the anterior end of the heart-e in this margin. The vein is shown in black in the figure, where only the sels of the left side are seen; actually there are two primitive aortæ and two bilical veins.

The conditions illustrated in the last figure are those present in the embryo, which there are as yet no somites and no body cavity continuous with the ernal cœlom. The result of somite formation, with the reversal of the erior end of the embryonic plate, is shown in the next figure (Fig. 671),

where the heart is now reversed, and the arterial end points forward, while paired aortæ run upwards beside the bucco-pharyngeal membrane and then t back; intersegmental branches are appearing now. It can be seen now, moreo that well-defined **vitelline** veins are reaching the venous end of the heart (n posterior) by passing up the *front* of the yolk-sac; the earlier posterior ve have disappeared. The splitting of the embryonic rim by the cœlomic extens leaves the vitelline arteries on the splanchnic wall, but puts the umbilical ve in the somatic wall, close to the continuity of this wall with the amnion; thi shown in the section in Fig. 671.

The paired aortæ lie on the roof of the primitive pharynx, and receive in t situation ' aortic arches ' from the ventrally placed arterial trunk and vess but behind the pharynx they fuse into a single vessel, which divides again i two as it approaches the hinder end; these two *umbilical arteries* pass into body-stalk.

Development of Principal Arteries.

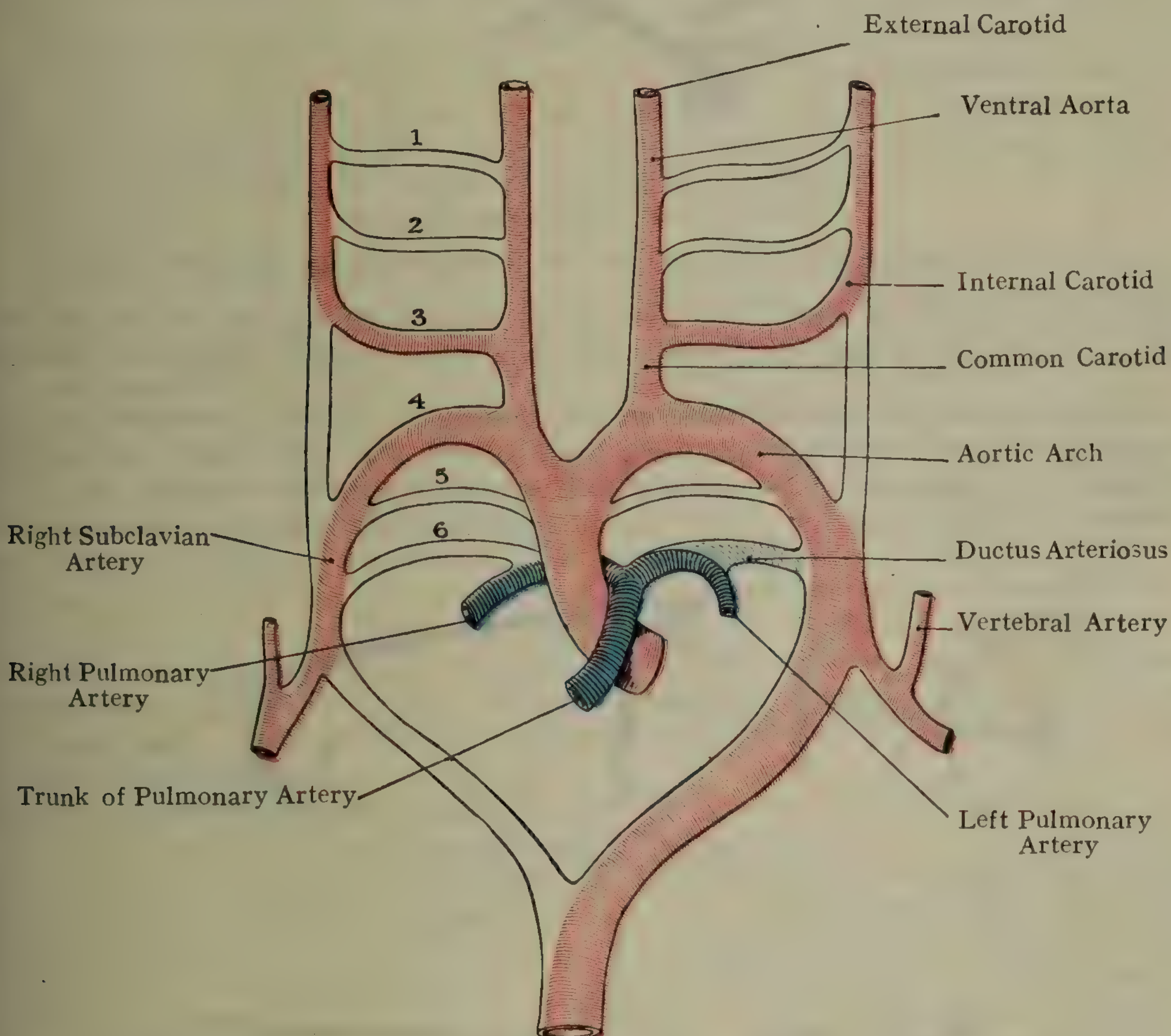
The arterial end of the heart opens into a dilated **arterial sinus,** from wh right and left arteries run into the pharyngeal arches, passing through th to join the right and left **dorsal aortæ** which are lying on the roof of the primit pharynx. All told, there are six of these **aortic arches** (or pharyngeal arte arches) on each side, but they are never present at any one moment in th totality. They appear from before backward, like the mesodermal arches which they lie. The *first* is possibly the direct descendant of the primitive ao of its side, passing dorsally round the bucco-pharyngeal membrane; in any c it is found very early, before reversal is nearly completed. The *second* aor arch comes a little later. The *third,* when it appears, seems to take on the dir supply of blood to the dorsal aorta at its anterior end, where this vessel is givi branches to the growing neural (brain) tube, and the first and second arcl break up rapidly and disappear, except for their upper and lower ends for so little time. The *fourth* arch appears at about the same time as the third, *fifth* is very small and short-lived, like the rudimentary mesodermal arch in wh it lies, and the *sixth* appears behind this. All these arterial arches, then, app as vessels running ventro-dorsally within their corresponding pharyngeal arch and conveying blood from the ventrally-placed arterial sinus to the dor aortæ for distribution.

The presence of the arterial sinus makes the details of further developme slightly different in the human embryo from those in lower forms, but differences are only slight, and the main evolution of the adult pattern fr that of the aortic arches is in line with the generalized vertebrate evoluti Such a generalized conception of the system of aortic arches is that (Fig. 6 given by Rathke many years ago, on which the special variations found amo vertebrates can be worked out. The plan shows the arterial arrangeme flattened out, so that, from the arterial stem, right and left *ventral aortæ* r forward (below the pharynx) and give off at intervals the six aortic arches reach the *dorsal aortæ* (above the pharynx). Small branches pass from sixth arches into the lungs, evidently the future pulmonary arteries, while anterior end of each dorsal aorta is carried (beyond the scheme) into the cran cavity as a cerebral artery. It may be added here that eight intersegmen branches arise from each dorsal aorta, the lowest coming off about oppos or just below the fourth arch on each side; seven of these arteries are cervic but the first is cranial, accompanying the hypoglossal.

Disregarding the gill-bearing vertebrates, we may come at once to Amniota, where the differences in the various phyla are classifiable easily on t scheme. In the first place it is a general rule that the third aortic arch is devot to supplying the brain, while the fourth becomes the main stem for the sup of the body. Thus the third arch *plus* the dorsal aorta in front of it becon the **internal carotid,** and the fourth arch becomes the **' arch ' of the systen aorta,** from which facts it can be assumed that the dorsal aorta between third and fourth arches loses its function, is stretched out, and disappea

e matter of the two **fourth** arches, these persist in the *reptiles*; the right one s the systemic arch in *birds*, and the left one in *mammals*.

he human conditions are thus shown (Fig. 672) on the scheme as mammalian. first two arches disappear, leaving the ventral aorta opposite them as nal carotid; the third, with the dorsal aorta in front of it, forms the nal carotid; the dorsal aorta behind it, between it and the fourth arch, pears; the ventral aorta between third and fourth becomes the **common id.** The original symmetry is disturbed behind this. The *fourth left arch* s part of the **systemic arch,** but not the whole of it; the dorsal part of this is formed by dorsal aorta, and the *ventral end is the beginning of the ventral* ; this is represented on the *right* side by the **innominate artery.** The *right h arch* becomes part of the **right subclavian;** the whole of the left subclavian he terminal piece of the right subclavian are of intersegmental value. Behind



IG. 672.—SCHEME OF THE AORTIC ARCHES AND THEIR DESTINATION.

e the fifth arches disappear; the *left sixth* remains as the **ductus arteriosus;** *right sixth* disappears except for its ventral end, from which the *right ionary artery* arises. The common arterial trunk is divided by a septum a dorsal part continuous with the sixth arches, and a ventral part for the ral aortæ, and this septum extends towards the heart in a spiral manner, nce the changing relations of **pulmonary artery** and **ascending aorta;** this vessel represents the common trunk and its systemic subdivision. Finally, right dorsal aorta disappears behind the right fourth arch, so that the rest ie **thoracic aorta** comes from the fused vessels.

n the **human** embryo there is no ventral aorta giving origin, as in the scheme, ll the arterial arches, but if we look at the arterial sinus as having the value hortened ventral aortæ conjoined, this difficulty disappears. In any case difference is not of much importance. Fig. 673 gives, in the upper row, s showing the changes in the human embryo as seen from the left. The

external carotid showing here may be a new formation, but might be some dr out persisting remnant of the ventral supply to the early anterior arches, the *common carotid* is either part of the third arch or a drawn-out portion o sinus; it is a very difficult question to decide. The lower figure shows

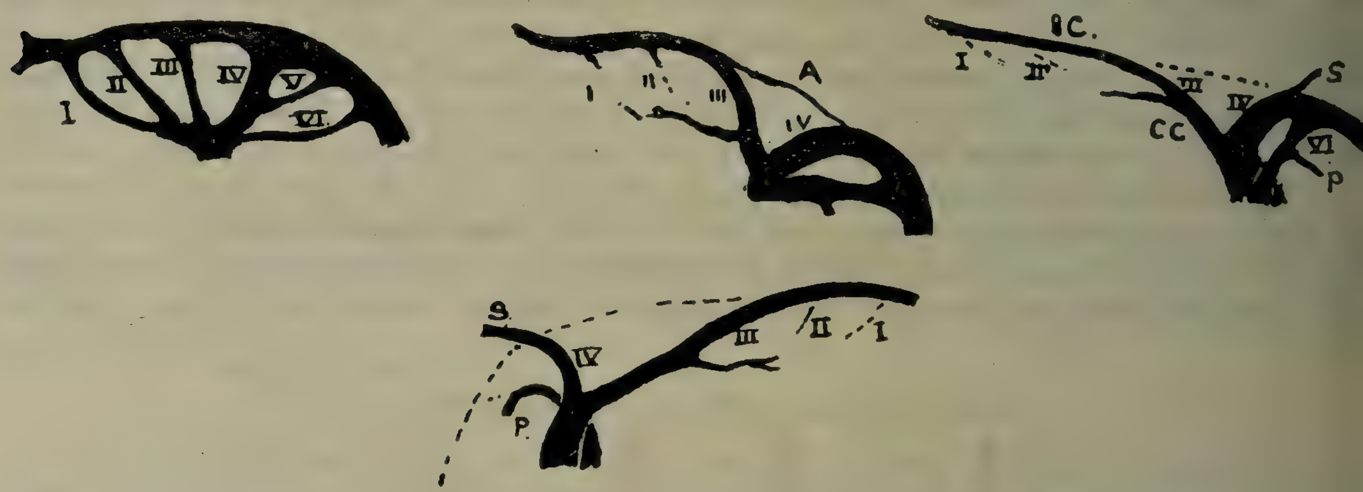


FIG. 673.—PLANS TO SHOW CHANGES IN HUMAN EMBRYO: UPPER ROW F LEFT, LOWER FROM RIGHT.

Aortic arches and their remnants numbered in Roman figures.

conditions on the right side; the *carotid developments are as on the left*, but fourth arch is part of the *subclavian*, and the *dorsal aorta disappears behind*

In estimating and following the changes which occur in the art arches in the neck it must be remembered that the head grows forw leaving structures behind it which were originally ventral to it; th what is really meant when the heart, for example, is said to 'desce

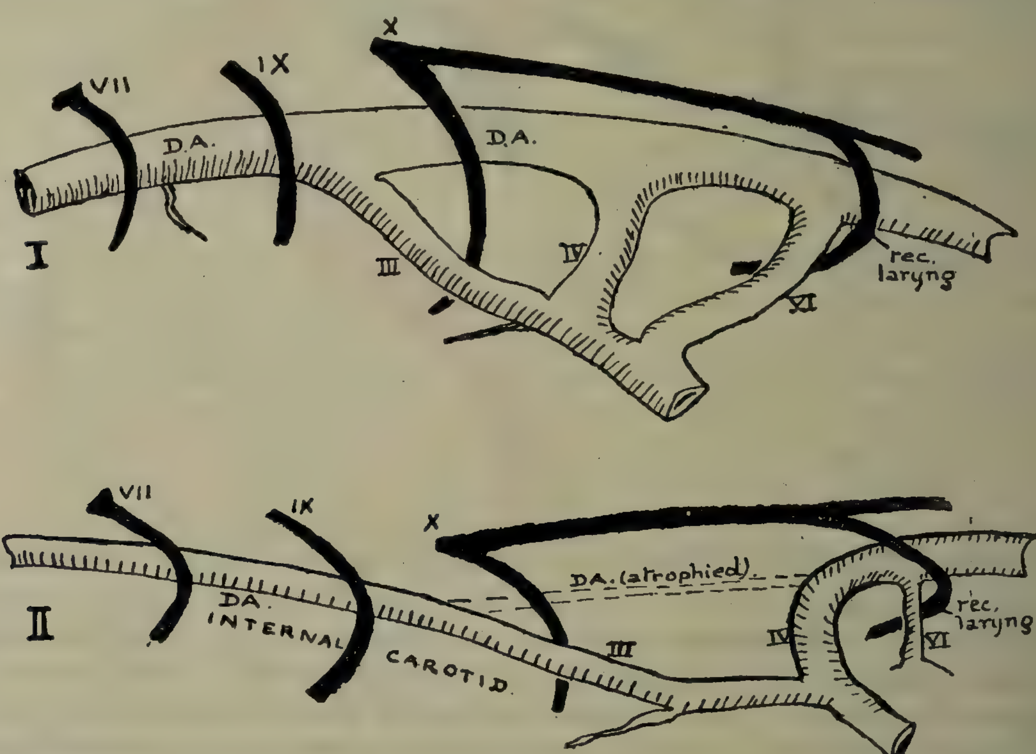


FIG. 674.—PLANS TO SHOW HOW THE EMBRYONIC RELATIONS BETWEEN NER AND ARTERIES ARE EXHIBITED IN THE ADULT CONDITION.

The growth of the head and elongation of the neck straighten out carotids, while the connection of the fourth arch with the trunk keeps it r the heart.

The relationship between the arterial stems (in the pharyngeal arc and the nerves of the arches is of interest from the point of view of the nor relations in the adult, and also in cases where the adult conditions are unusu

The **nerves of the first four arches** lie near the grooves in front of them, and thus in front of the arteries which lie more or less in the middle of the meso-mal masses. In **the sixth arch,** however, possibly because its artery runs k to it and is formed relatively late, *the artery lies in front of the nerve.* In cases the nerve, having crossed the dorsal aorta on its lateral side, then turns ards to gain the visceral surface; thus they all cross obliquely the lines of ir corresponding arteries, but whereas the first four cross in front of their sels, the last crosses behind it. It follows that, when the neck is elongated the vessels drawn out, they are drawn over the nerves of the arches behind m. Thus the internal carotid (third arch) has the superior laryngeal (fourth arch ve) deep to it, while its own nerve, the glosso-pharyngeal, is superficial to it rsal aorta). The fourth aortic arch (arch of aorta and right subclavian) has the ırrent laryngeal deep to it, but this nerve on the left turns first round the mentum arteriosum because it crosses *behind* that artery in the sixth arch.

The fifth arch, with its artery and nerve, is a tiny and transient formation, only brought into description to complete the various systems. Its artery may be as in Fig. 673, or may arise from the arterial sinus and end in one of the neighbouring arches, or even in the dorsal vessel, or may even arise from the proximal part of the sixth artery.

It disappears early and completely.

The **right subclavian artery,** as shown in the scheme, has its first part formed n the fourth right aortic arch, and its terminal piece from the seventh cervical ersegmental artery. Between these two there is a portion of the right dorsal ta; there is considerable doubt about the limits of these various parts.

There are two well-known **varieties** of the right subclavian artery of develop-ntal interest. In one the artery arises from the descending thoracic aorta, the other it arises from the left end of the arch of the aorta; in both cases it ses behind the œsophagus to gain the right side. The first of these varieties ms to be an example of *persistence of the right dorsal aorta*; the same explanation sometimes given for the second variety, but with much less probability, and vould seem to be more probably an example of *anastomosis between the two sal aortæ.* In both cases the fourth aortic arch has evidently disappeared the **right** side, and as a result the right recurrent nerve turns round the next h in front—*i.e.*, it runs *directly downwards to the lower border of the larynx, sing deep to the internal carotid.*

Intersegmental Branches : Vertebral Artery.—The first intersegmental artery en by each dorsal aorta accompanies the hypoglossal nerve. After this come en cervical intersegmental vessels. These pass back between the somites, ich they supply, and give branches also to the neural formations lying ernal to these. Since the cranial end of the dorsal aorta is about to be stretched in the internal carotid, and the next part of it is about to disappear, it is dent that, if these intersegmental arteries are to continue to supply the uctures mentioned, they must be provided with another artery of origin. e provision is made very early in their history in the form of a *longitudinal ıstomosis* connecting them together some little distance from their origins.

An anastomosis of such a sort is a normal occurrence among the inter-segmental vessels in the trunk. Usually it remains very small or disappears, but is seen occasionally in the adult, especially in the thoracic region. In the ordinary way, however, it is only in the cervical region that it enlarges and becomes functionally important.

This longitudinal anastomosis ends caudally in the seventh cervical inter-mental artery. Thus, when the origins from the dorsal aorta fail, the series vessels obtains its blood from this seventh artery. The longitudinally running tebral artery is thus made up of these bits of interarterial anastomosis, the ginal intersegmental vessels persisting as its branches. The portion above the as, however, which has a different relation to the issuing nerve, is of another ue, being the enlarged intersegmental spinal or neural branch.

The origin of a vertebral artery precedes that of the corresponding subcla artery, so that *the subclavian artery is originally a lateral branch of the verte artery.* As the development proceeds, however, the subclavian artery incre in size, and greatly exceeds the vertebral artery, the latter vessel being regarded as a branch of the subclavian.

Origin of Left Vertebral Artery from Aortic Arch.—This, the commo additional branch arising from the arch, is probably an example of the sistence (see Fig. 675) of the sixth intersegmental origin from the dorsal ac with the portion of this aorta remaining as far as the level of the fourth ac arch.

The thoracic and abdominal intersegmental arteries have been refe to already in connection with the aorta.

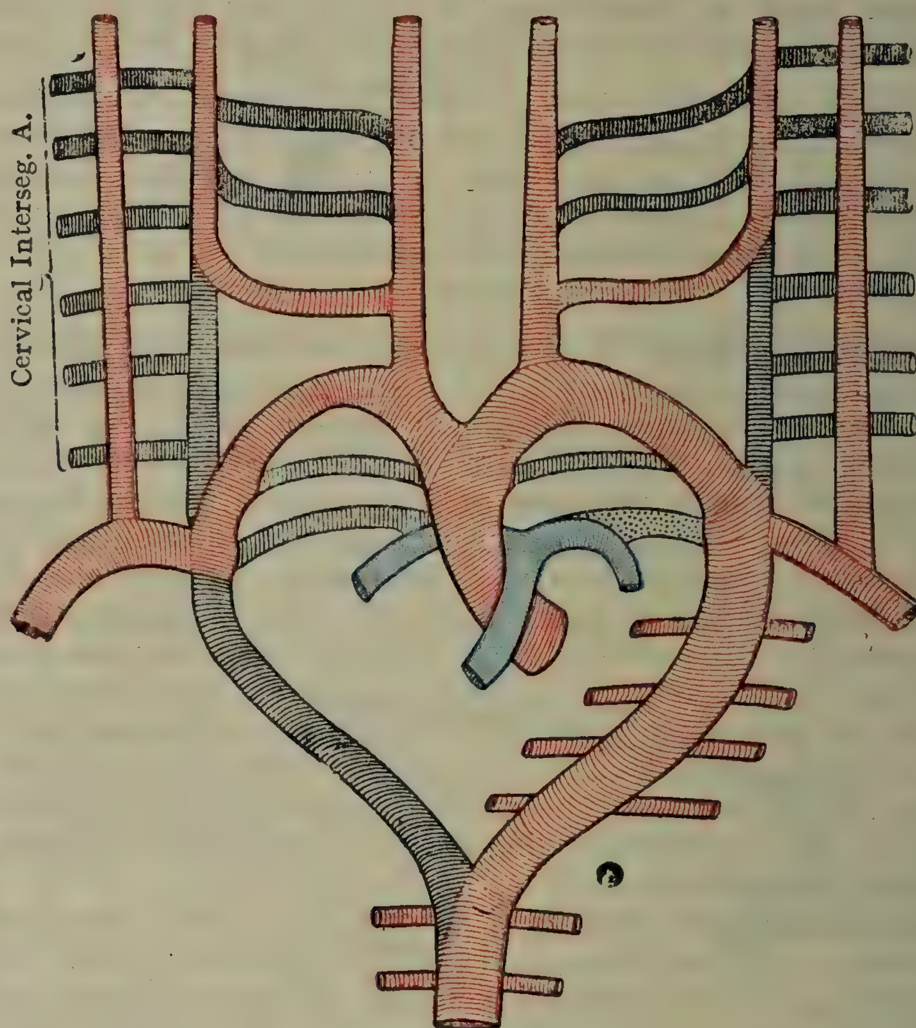


FIG. 675.—DEVELOPMENT OF CERVICAL, INTERSEGMENTAL, AND VERTEBRA ARTERIES, ACCORDING TO SCHEME.

The **intracranial prolongation of the dorsal aorta** on each side is an exan of the enlargement of a neural branch arising from the beginning of this ar and running dorsally into the paraxial tissue round the brain; the dorsal a itself lies on the upper in-turned ends of the visceral mesoderm of the arc below the layer of paraxial mesoderm. This terminal neural branch en the paraxial layer beside Rathke's pouch, and, in the adult, pierces the d mater here. Before reaching this, the **internal carotid** lies on the roof of tubo-tympanic recess, covered by the otic capsule; much later, this cap extends its ossification partly round it, enclosing it in the *carotid canal,* bu portion of the artery, still unenclosed, lies in front of this and crosses (as it in the foramen lacerum) the anterior margin of the recess, the auditory tube.

The ramifications of the cerebral arteries are formed in accorda with the growth of the parts of the brain, which is surrounded by a vasc network from a relatively early stage. These vessels are dealt wit part in the section on the central nervous system.

teries of Limbs.—The arteries of the **upper limb** have been already considered. the lower limb, the accepted views on their development are in large part iptions based on comparative anatomical observations, direct observation human embryo being an undertaking of great difficulty.

wer Limb.—At the beginning of the second month the main artery accom-s the sciatic nerve, passes *deep to* the rudiment of the popliteus, and runs en the primordia of the leg bones to the foot. This ' axial ' vessel is cted with a small plexus on the extensor aspect of the limb, from which at r stage the **femoral** artery will form. As the femoral channel enlarges, axis ' vessel sends a secondary branch down superficial to the popliteus, hen degenerates above the level of its connection with the femoral; this dary branch divides to form the **tibial** arteries, anastomosing with the al interosseous trunk, which has already given off the anterior tibial, and becomes a small branch of this. The inferior gluteal artery, the popliteal, art of its middle genicular branch, are remains of the original ' axis ' supply,

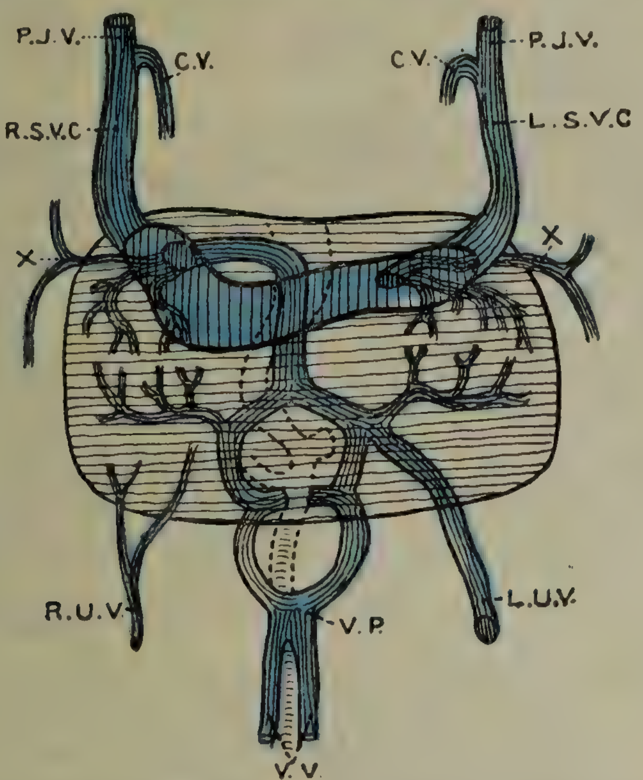


FIG. 676.—THE VENOUS TRUNKS OF THE SEPTUM TRANSVERSUM OF THE HUMAN EMBRYO (HIS).

J.V. Primitive Jugular Vein
C.V. Cardinal Vein
V.C. Right Duct of Cuvier
V.C. Left Duct of Cuvier
X.X. Upper separated portions of Umbilical Veins
R.U.V. Right Umbilical Vein
L.U.V. Left Umbilical Vein
V.P. Venous Loops round Gut
V.V. Vitelline Veins

the peroneal and perhaps part of the arterial structures in the sole are ed from its interosseous prolongation; the two femoral arteries and the enous branch of the descending genicular artery, when present, are remains e femoral extensor plexus.

Development of the Principal Veins (p. 51).

he primitive veins form two groups. One group returns the blood from the sac and the placenta; and the other group returns the blood from the head neck, anterior limbs, body-wall, mesonephric bodies, and posterior limbs. **first** group comprises: (1) the *vitelline* veins, in connection with which the l vein is developed; and (2) the *umbilical* veins. The **second** group consists) the *anterior cardinal* or primitive jugular veins; (2) the *posterior cardinal* ; and (3) the *subcardinal* veins; they drain into the veins (or ducts) of er on each side. The veins of each group are arranged in pairs, right and

Sinus Venosus.—This is the venous space made by the confluence of veins of the body; it discharges directly into the common atrium the bloo receives from the veins. It is placed in the septum transversum (pp. 46 and and consists of two 'horns,' each of which is made by the junction of the umbili vitelline, and Cuvierian veins of its own side. As described in the developm of the heart, the **right horn** is taken up into the *right atrium*, the **left horn** becon the *coronary sinus*. The vitelline veins reach the sinus venosus by runi in the visceral wall to the septum transversum, the others get to the septum the body-wall.

1. **Vitelline Veins and Portal Veins.**—These veins are developed early, they return the blood from the yolk-sac. They enter the body of the emb along the vitelline duct, and finally open into the sinus venosus after traver the septum transversum. Within the body they ascend parallel with each ot at first in front of, and subsequently on either side of, the duodenal portio the primitive intestinal tube. In the latter region on the caudal side of

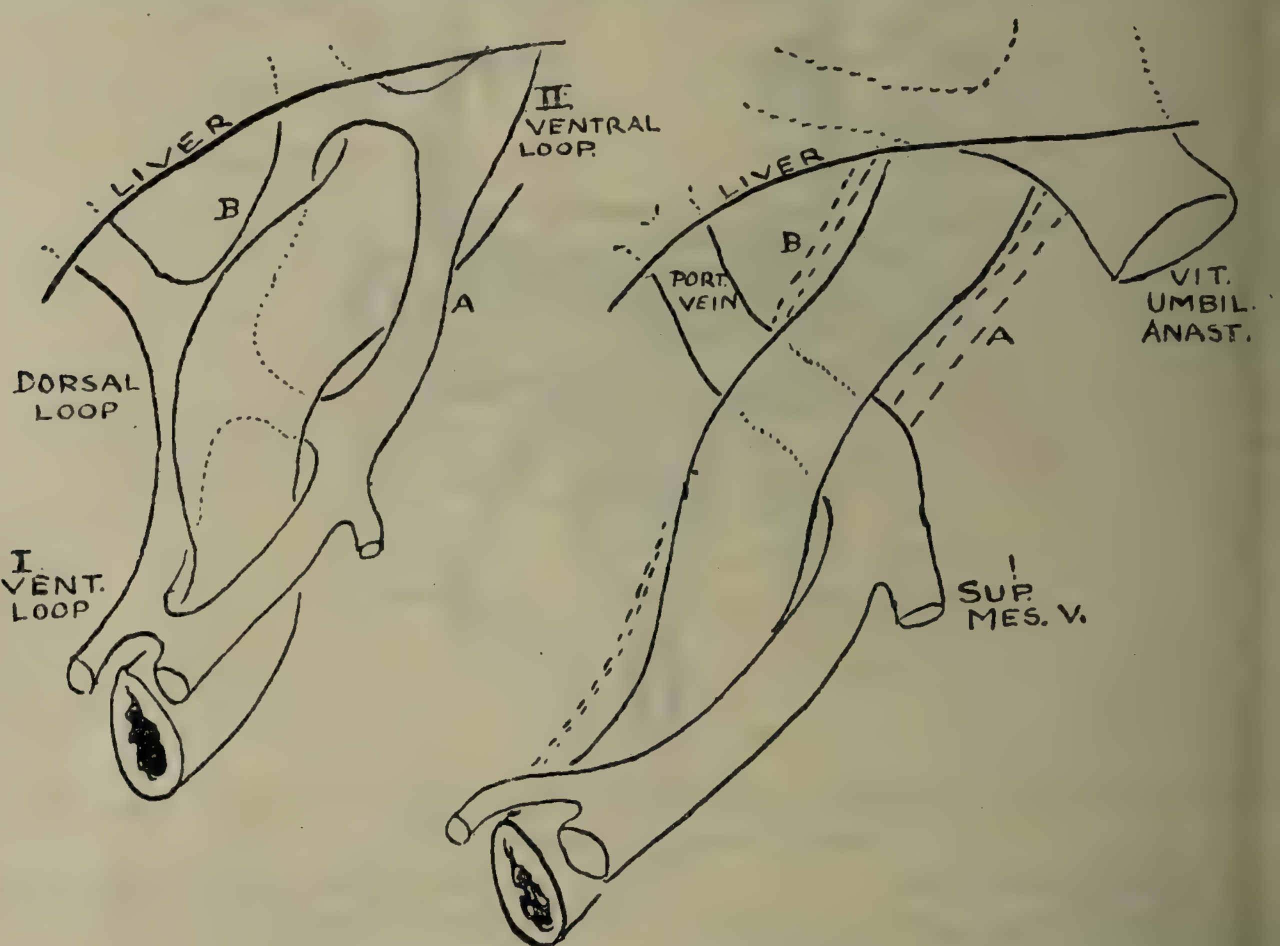


FIG. 677.—SCHEMES TO SHOW FORMATION OF PORTAL VEIN FROM DO CONNECTING LOOP BETWEEN THE RIGHT AND LEFT VITELLINE VEINS.

hepatic bud they become connected by three transverse anastomotic ves two of which lie across the *ventral aspect* of the gut, and one being placed o *dorsal aspect*. The first or lowest anastomotic vessel lies on the ventral as of the gut; the second or middle vessel is dorsal to the gut; and the thir highest, like the first or lowest, is ventral to the gut. This is shown in the scheme in Fig. 677.

By means of these three anastomotic vessels two venous rings—lowe caudal, and upper or cephalic—are formed around the duodenal portion of primitive intestinal tube, these rings constituting the *sinus annularis*. Du their formation the two divisions of the liver-bud are breaking up into hep cylinders, and these are giving off secondary cylinders. Owing to these hep developments the vitelline veins cease to communicate directly with the s venosus. The portions of the vitelline veins above the upper duodenal ve ring (shown in Fig. 676 to proceed from its sides) become surrounded by hepatic cylinders, and invaded by the secondary cylinders. In this ma

portions of the vitelline veins are freely subdivided into blood-channels, ı are known as *sinusoids* (Minot). These sinusoids form a network which ɔies the meshes of the network formed by the branches of the hepatic cylinders. veins which convey blood from the upper duodenal ring to the hepatic oids are now known as the *venæ advehentes*, and they become the *right* and *livisions* of the **portal vein.** The veins which carry the blood from the tic sinusoids to the sinus venosus are known as the *venæ revehentes*, and they ne the **hepatic veins.**

'runk of the Portal Vein.—The portions of the two vitelline veins which ıd *in front of* the primitive duodenum lie close together and parallel with other. These portions fuse for a short distance, and form a single venous , which opens into the first, or lowest, ventral anastomotic vessel, or, in words, into the lower part of the lower duodenal venous ring. This short receives the veins of the primitive intestinal tube, and it forms the *root* e **portal vein.** The primitive portal vein, therefore, receives its blood from ıe yolk-sac, and (2) the primitive intestinal tube within the abdomen. The r ventral anastomosis and the right vein immediately above it quickly ɔpear (Fig. 677).

ıs the yolk-sac atrophies the portions of the vitelline veins between it and commencement of the portal vein also atrophy, and the tributaries of the ıl vein gradually assume their condition in adult life. The vitelline vein, ever, does not disappear for a considerable time, but remains as a free cord 4) passing out of the umbilicus up to the entrance of the umbilical loop into belly.

The following parts of the *sinus annularis*, or double duodenal ring, undergo phy (see Fig. 677):

1. Right half of lower ventral anastomotic vessel.
2. Right half of lower duodenal ring.
3. Left half of upper duodenal ring.

The following parts of the *sinus annularis* persist:

1. Left half of lower ventral anastomotic vessel.
2. Left half of lower duodenal ring.
3. Middle or dorsal anastomotic vessel.
4. Right upper half of duodenal ring.
5. Upper ventral anastomotic vessel.

These persistent portions, with the exception of the *upper ventral anastomotic el*, form the *greater part* of the **trunk of the portal vein.** The upper ventral stomotic vessel represents a part of the left division of the portal vein.

The portal vein has originally a *spiral relation* to the duodenal portion of primitive intestinal tube—that is to say, it winds round the left side and sal aspect of the duodenum, and then appears on its right side.

Divisions of the Portal Vein.—These are connected with the upper duodenal ous ring. As previously stated, the veins which convey the blood from this ; to the hepatic sinusoids are known as the *venæ advehentes*, right and left. **right division** of the portal vein is formed by the *right vena advehens*, which ings from the right half of the upper duodenal venous ring. The **left division** ormed by (1) the upper ventral anastomotic vessel, and (2) the *left vena ehens.*

Umbilical Veins.—The two umbilical veins return the blood from the placenta the sinus venosus. They are of small size during the period of the vitelline ulation, but become enlarged as the placenta gradually forms. The two ns unite and form a single trunk within the umbilical cord. At the umbilicus ; trunk enters the body of the embryo, and immediately divides into two bilical veins, right and left, which traverse the septum transversum and open ɔ the sinus venosus. As they traverse the septum transversum they are se to the developing liver.

The **left umbilical vein** enlarges fairly rapidly, that on the right s
atrophying more slowly. Just before the 5 mm. stage the left vein effect
capillary junction with the *left vitelline vein* on the caudal aspect of the sept
transversum—*i.e., on the caudal or visceral surface of the small liver.* T
connection between the umbilical and vitelline veins of the left side enlar
very rapidly, thus making the vessel on the visceral aspect of the liver wh
is usually referred to as the ' left umbilical vein '; actually, of course, it is a **vite
umbilical anastomosis,** and the real umbilical vein passes up still beside the li
but dwindles rapidly, and cannot be certainly traced after a fairly short inter
When the anastomotic vessel collapses, after birth, it makes the **ligament
teres** of the liver.

In this region part of this fibrous cord lies in the abdominal wall a
part below the liver; the first of these parts is the true *umbilical vein,* w
the second is the *vitello-umbilical anastomosis.*

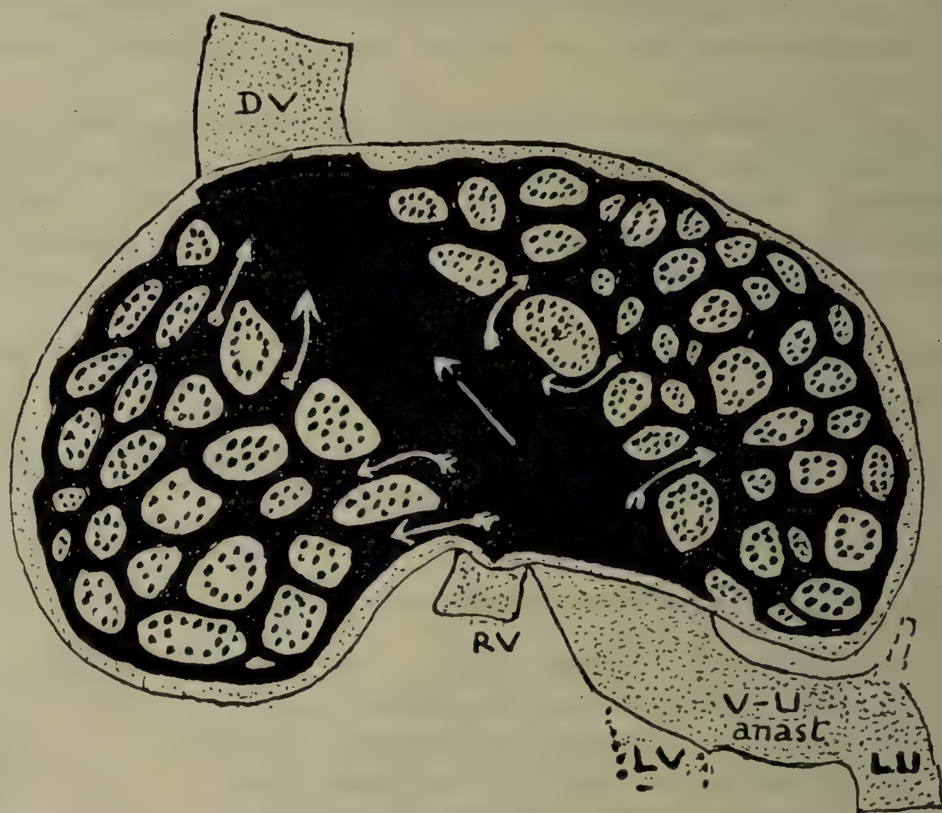


FIG. 678.—SCHEME TO SHOW EARLY CIRCULATION IN LIVER, AND DIRECT
OF DUCTUS VENOSUS.

The **right umbilical** vein also seems to develop some similar anastom
with the vitelline system, but owing to the atrophy of the vein the anastom
does not become evident.

The anastomosis of the left umbilical vein with the left vitelline vein oc
at the level (in this last vessel) *of the upper junctional loop with its fellow,* as sh
in Fig. 677. As already stated, this upper loop becomes embedded in the li
and forms a part of the *left portal vein,* whence the fact that the ligamen
teres, buried between two lobes of the liver, runs to join the left division of
portal vein.

There is possibly some connection between the entrance of the umbi
blood at this level and the disappearance of the original vitelline
(A in Fig. 677) between this and the next anastomotic loop, the vol
of blood from the larger vein prohibiting entrance of vitelline blood f
below.

Ductus Venosus.—Blood from the left umbilical vein enters the live
increasing amount as the placenta grows, and before long there becomes evi
a dilatation into a large vessel of the vascular spaces in the liver lying betw
the point of entrance of the blood and that of its discharge into the inf

, cava. This vessel is termed the **ductus venosus** (or ductus Arantii). It nds from the *left portal vein*, which has been formed from the uppermost line loop and receives (Fig. 678) the vitello-umbilical anastomotic vessel; sses upwards and to the right, reaching the terminal part of the *right hepatic nage* into the inferior vena cava, which becomes dilated to form its terminal e.

After birth, when the placental circulation has ceased, the *ductus venosus* becomes a fibrous cord, the **ligamentum venosum.**

\ minute portion of the lumen he left umbilical vein remains ious within the ligamentum s of the liver. This pervious ion communicates at the liver 1 the left division of the portal , and at the umbilicus it is nected with the epigastric veins the abdominal wall. It thus ns a channel of communication veen the left division of the al vein and the systemic veins he anterior abdominal wall. In pervious portion the blood can *towards* the umbilicus. This stomosis between the portal and emic circulations accounts for enlargement of the veins of the erior abdominal wall in cases of tal obstruction within the liver.

2. The **cardinal** system of veins nprises several vessels on each e, which ultimately *drain their od into the sinus venosus through right and left* **veins** (*or* **ducts**) *of* **vier.** A general idea of their tribution can be gained from . 679A. A large vessel, the **primi- jugular** or **anterior cardinal** (or cardinal), drains the *cranial part the body*, beginning in associa- n with the *venous drainage of brain*, and passing back through cervical region, where it re- ves intersegmental veins, includ- the subclavian (S). The **posterior dinal** runs caudo-cranially, being med in association primarily *with mesonephros* (W) and receiving ersegmental veins. The posterior l anterior cardinal veins join to m the 'duct of Cuvier,' situated the septum transversum, cranial the liver (L), and thus running ectly into the sinus venosus.

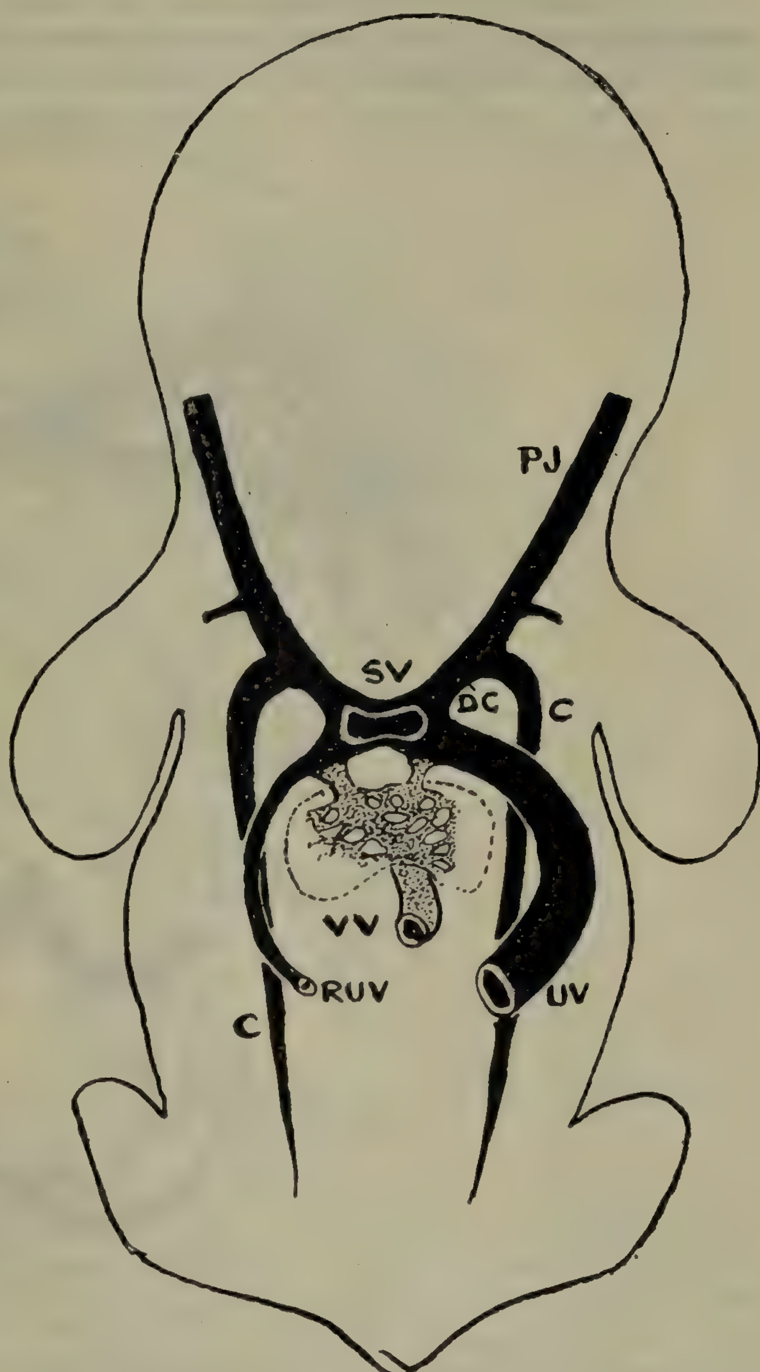


FIG. 679.—SCHEME OF MAIN VENOUS DRAINAGES OF EMBRYO.

SV, sinus venosus; DC, duct of Cuvier; PJ, anterior cardinal or primitive jugular; C, posterior cardinal; UV and VV, umbilical and vitelline veins.

The **anterior cardinal** or **primitive jugular veins** are two in number—right d left—and return the blood from the head, neck, and fore-limbs. Each vein nsists of two parts—intracranial and extracranial. The *intracranial part* gives e, directly and indirectly, to the intracranial sinuses, whilst the *extracranial rt* becomes the internal jugular vein. The *intracranial part* is known as the

principal or **primary head vein.** This vein at its anterior end is on the *inner* of the trigeminal ganglion; passing backwards from this point, it lies just a the outer part of the tubo-tympanic recess *lateral* to the facial ganglion and f nerve, and reaches behind this the outer side of the glosso-pharyngeal and va

Its different relations with the several cranial nerve-roots indicate it has been produced from two venous trunks, connected between the ro these trunks are represented *in lower vertebrates* by the **vena capitis late** and **vena capitis medialis.**

At its anterior end the principal head vein receives on each side the **ant** **cerebral veins,** a plexiform set of vessels draining the mid-brain, the back of fore-brain, and the optic outgrowth. The anterior cerebral veins anastor

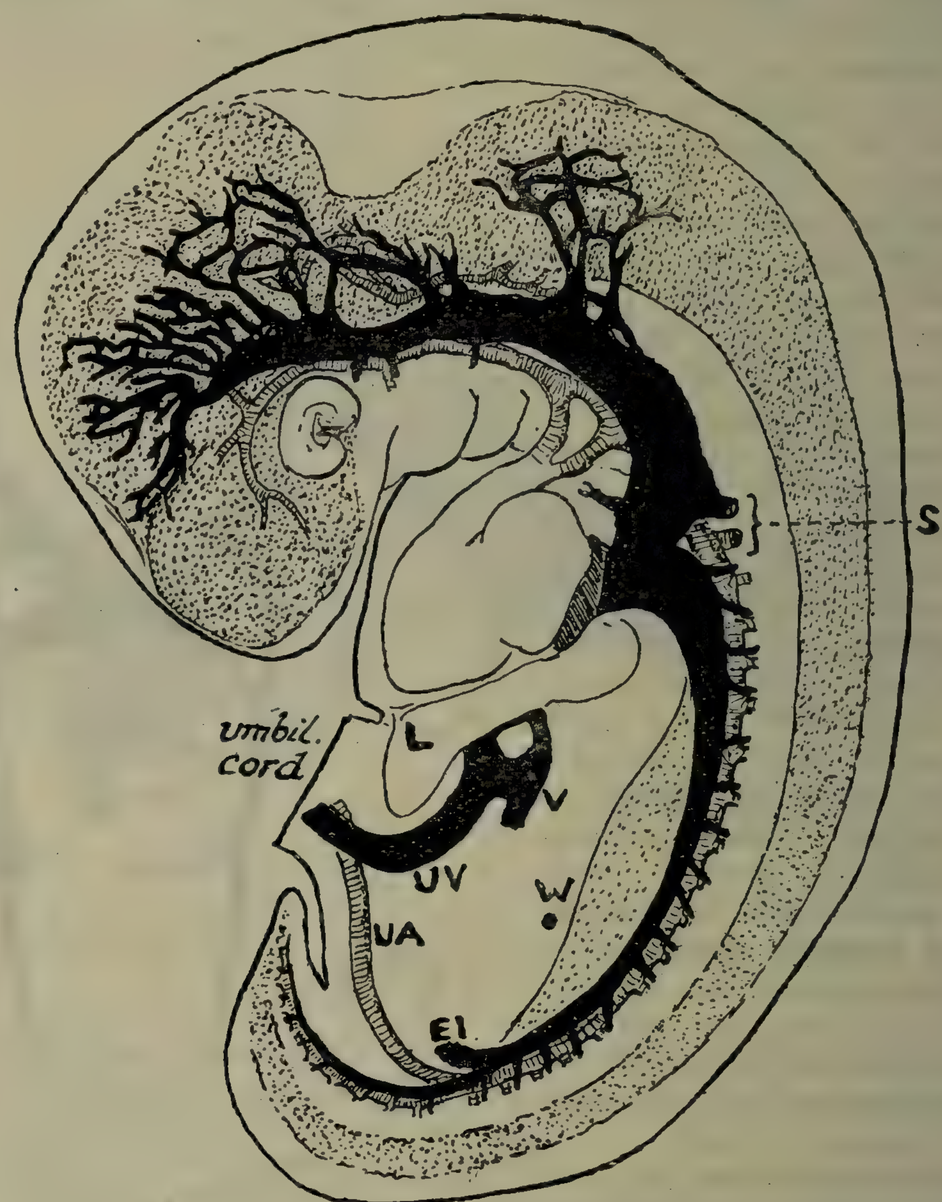


FIG. 679A.—TO SHOW MAIN TRUNK VEINS IN YOUNG EMBRYO.

with their opposite fellows dorsally between the two small cerebral vesic thus forming the rudiment of the *superior sagittal sinus,* which is elongated the vesicles grow backwards (Fig. 680).

Between the trigeminal and facial ganglia the principal vein receive **middle cerebral vein** or plexus, draining the front limb of the pontine flex and anastomosing with the anterior veins.

A plexiform **posterior cerebral vein** opens into the principal head vein betw the facial and glosso-pharyngeal ganglia; it drains the back of the pont flexure and the myelencephalon. These details are shown in Fig. 680, 1 scheme.

As the cerebral vesicles grow backwards, the *anterior plexus becomes m closely connected with the middle set,* and its blood is returned by this set

asing amount. Ultimately the *superficial* **middle cerebral** *vein*, the *spheno-tal sinus*, and the *ophthalmic veins*, are the only vessels left of the original isive **anterior** venous plexus. The *cavernous sinus* is the persisting anterior of the **principal head vein** (second figure).

he **middle cerebral vein,** however, has in the meantime *formed a secondary ecting channel* with the **posterior cerebral vein,** this channel lying above the capsule and beside the pontine flexure within the developing cranium. the blood which has already been seen to be derived from the anterior into the middle set is carried back through this new channel, and the nal principal vein in its intermediate part gets smaller and disappears, the l from its anterior end (cavernous sinus) now passing up the lower portion e original trunk of the **middle** cerebral vein to reach the new channel, through h it passes to the hinder part of the **posterior** vein, along which it runs down -enter the hinder part of its old vessel, and thus leaves the cranium with agus.

680.—Semi-schematic Figures to show Changes in Venous Drainage of Brain (founded on Streeter's Figures).

Continuing their growth backwards (third figure), the cerebral vesicles carry elongating *longitudinal sinus* with them, so that it ultimately comes to open th figure) into the **posterior** set of veins, from the lower part of which the *al sinus* is made. The **middle** cerebral plexus is covered over by the growing les, but is represented in the **great cerebral veins** and their tributaries, the *ar veins* being also remnants of their connections with the **anterior** venous The *straight sinus* is a new connection (arising on the dorsal side of the -brain flexure when this closes) between the **middle** and **posterior** sets of s. The *inferior petrosal sinus* represents the secondary re-establishment direct connection between the original and persisting anterior and posterior of the primary head vein, but the new channel is within the cranium, and is a reappearance of the old vein.

The *extracranial part* of the anterior cardinal vein, after the obliteration of vena capitis lateralis, commences at the jugular foramen, whence it extends ad, receiving in its course the *cervical intersegmental veins*. In the vicinity e sinus venosus it meets the posterior cardinal vein of its own side, with which nites. The venous trunk thus formed is called the **duct of Cuvier,** of which e are two—right and left. These two ducts pass transversely, one on either

side, to the sinus venosus, into which they open. At this stage the sinus veno also receives the vitelline and umbilical veins of each side. The ducts of Cu are in the septum transversum (see pp. 46 and 52).

As the heart descends from the region of the fore-gut, the ducts of Cu become vertical, and are in line with the anterior cardinal veins. When sinus venosus becomes merged into the right atrium, and the heart undergo slight rotation from right to left, the left duct of Cuvier is placed dorsal to left atrium before opening into the right atrium.

Each anterior cardinal vein is joined, near its caudal extremity, by corresponding **subclavian vein.**

Close to the junction the subclavian vein receives the **external jugular v** This vein is a secondary formation, and is probably derived from a poste auricular vein, being subsequently reinforced by a pre-auricular vein.

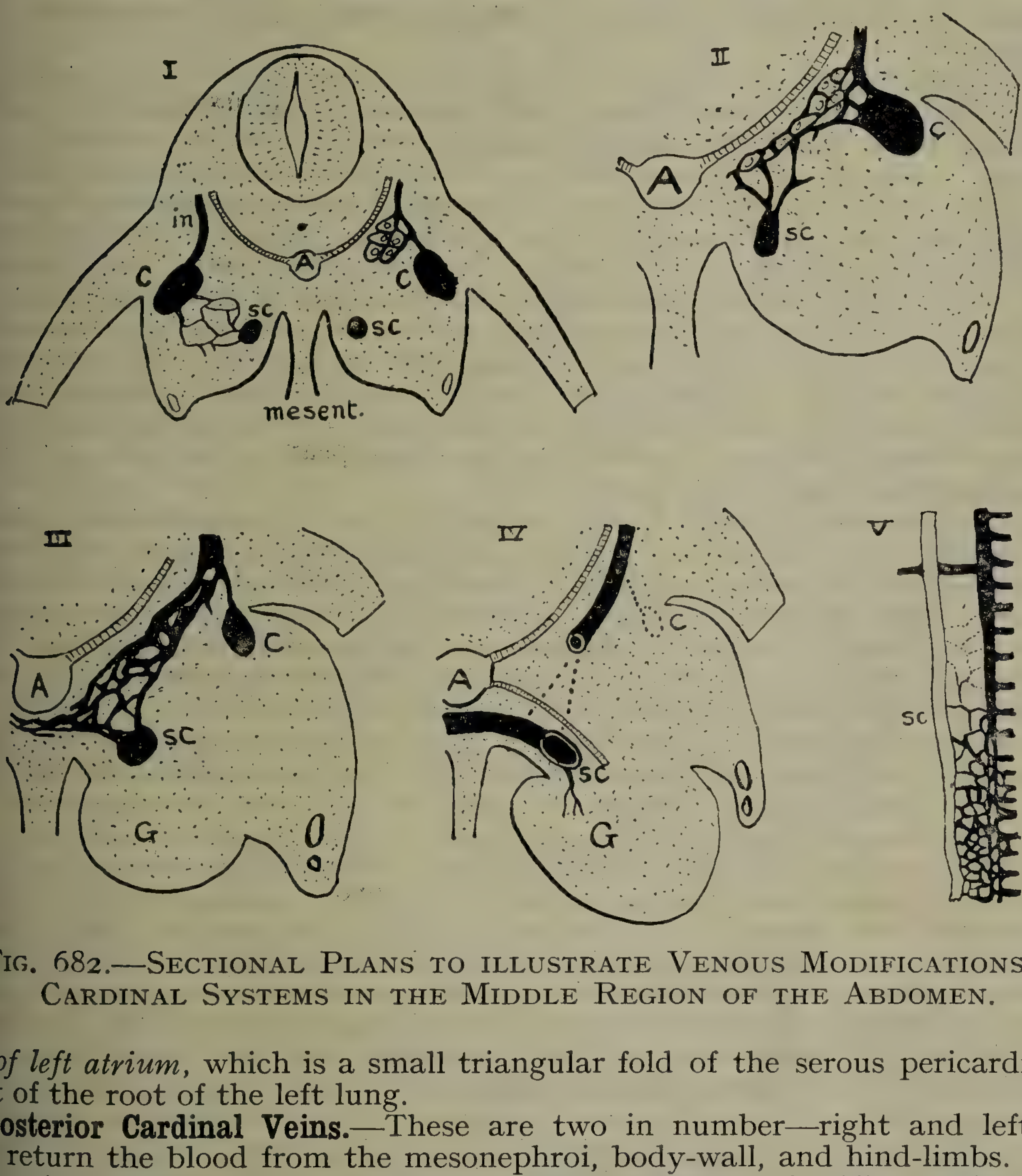
FIG. 681.—THE VENOUS PLEXUS LYING BETWEEN THE TWO PRIMITIVE JUGU JUST BEGINNING TO FORM THE LEFT INNOMINATE CONNECTION (19 MM.)

A transverse anastomotic vessel is now formed, called the **transverse jug vein.** It is developed (Fig. 681) in the ventral plexus connecting the primitive jugulars. It extends from the junction of the left anterior cardinal left subclavian veins to the right anterior cardinal vein at a point a little b the place where it receives the right subclavian vein. This transverse jug vein, which extends obliquely from left to right, with a downward inclina gives rise to the **left innominate vein.** The venous blood from (1) the left of the head and neck and (2) the left fore-limb now passes through the innominate vein into the permanent superior vena cava. The **right innomi vein** is formed by the short portion of the right anterior cardinal vein w intervenes between the place where it receives the right subclavian vein and place where the transverse jugular vein joins it. The portion of the *right* ante cardinal vein, which lies immediately *below* the place where the transverse jug vein joins it, forms the *upper* or *extra-pericardial part* of the **permanent supe vena cava**—that is to say, the part above the point where the vena azygos o into it. The *lower* or *intrapericardial part* of the superior vena cava is develo

. the *right* **duct of Cuvier.** The permanent superior vena cava therefore ɜsents (1) the lower part of the right anterior cardinal vein, and (2) the : duct of Cuvier.

'he portion of the *left* anterior cardinal vein immediately below the left ɜmity of the transverse jugular vein forms the *upper part* of the **left superior costal vein,** thus accounting for the ending of that vein in the left innominate which, as stated, is formed by the transverse jugular vein.

'he *left* **duct of Cuvier** undergoes partial obliteration. Its terminal part, ; with the left lateral cornu of the sinus venosus, gives rise to the **coronary ;.** The portion next the terminal part also persists in the form of a very ıte vein, called the *oblique vein of left atrium,* which lies over the posterior ct of the left auricle. The obliterated portion is represented by the *vestigial*



'IG. 682.—SECTIONAL PLANS TO ILLUSTRATE VENOUS MODIFICATIONS IN CARDINAL SYSTEMS IN THE MIDDLE REGION OF THE ABDOMEN.

of left atrium, which is a small triangular fold of the serous pericardium in t of the root of the left lung.

'osterior Cardinal Veins.—These are two in number—right and left—and ' return the blood from the mesonephroi, body-wall, and hind-limbs. They ɔn either side of the aorta dorsal to the mesonephroi. The caudal end of . vein receives the inferior gluteal vein, which is the primitive vein of the -limb. A little above this point it is joined at a later period by the external vein, which has now been developed.

'he cephalic end of each posterior cardinal vein joins the corresponding rior cardinal vein, and the trunk so formed is the duct of Cuvier.

ᐱmongst other tributaries, the posterior cardinal veins receive intersegmental s, such as the lumbar and intercostal veins, and veins from the intermediate mass.

The **posterior cardinal** veins lie on the dorsal side of the mesonephroi. **cardinal veins** run longitudinally on the inner and ventral sides of the mesonep within which the cardinals and subcardinals are connected by anastomo veins; they run into the cardinals at the two ends of the bodies. A third sy of veins develops on the dorsal side of the cardinal on each side, forming a pl round the groups of sympathetic ganglion cells as these grow down from posterior root ganglia. As this ' periganglionic ' system enlarges with the gr and extension of the nervous masses, it forms an extensive plexus, *joi laterally with the intersegmental veins, ventrally with the cardinal, and with subcardinal internal to this.* In many animal forms this venous system consti a definite **supracardinal vein** on each side, with retro-aortic anastomoses, but a development is not found in the human subject, and retro-aortic connec are few and far between; hence it seems convenient to use the term **ganglionic** as representing the *human* condition or *modification of the supracar formations.*

Progressing with the ganglionic and nervous growth, the perigangl plexus extends forwards and inwards on each side as a juxta-aortic plex veins, and from this a **pre-aortic plexus** is quickly formed. The pre-a extension is seen in the thorax, and is very marked in the abdomen belov level of the superior mesenteric artery; between these two parts the growt the suprarenal and its association with the sympathetic and the formatio the diaphragmatic crura seem to interfere with the formation of the pre-a plexus. The part of the **left renal vein** that lies in front of the aorta is made this plexus below the superior mesenteric artery, putting the two subcard in connection owing to the extensive anastomoses between these and the gro supracardinal vessels. Caudally, the aorta divides into two umbilical arte and the supracardinal plexus is carried down on each side dorsal to these arte extensions from this plexus here on the sacrum appear to be the origin of **left common iliac vein** in this part.

The sectional plans shown in Fig. 682 will be of use probably in enabling reader to follow the complicated changes going on in these different sets of ves In I are shown the two mesonephric formations in section, beside the me mesentery. On the left an intersegmental vein (in) is seen opening into posterior cardinal (C), which is situated on the dorsal and lateral side of mesonephros, and is joined by a plexus within that body with the subcar (SC) in the medial part of the body near the base of the mesentery. On the r side is shown a stage a very little later, in which a plexus of minute veins is surrounding the sympathetic neuroblasts which have descended from the ne crest; this ' periganglionic ' plexus is connected with the intersegmental and also (although this is not shown) actually with the posterior cardinal. plexus, following the extension of the neuroblasts, shows a rapid ventral exten as seen in II, towards the ventral aspect of the aorta, over which (III) it pa and joins with the plexus of the other side. It is to be noted that this exten is correlated with a marked anastomosis with the subcardinal, as seen in III, in the same figure is shown the evident tendency of the intersegmental ve transfer its drainage to the plexus—that is, in general terminology, to tra it to the supracardinal vessels. The connection with the subcardinals i marked that the transaortic plexus appears very soon to be intersubcard as is suggested in III, and becomes intersubcardinal in actuality before (IV), as the original anastomosis with the plexus begins to atrophy or break This break is favoured by the establishment of longitudinal anastomoses betv the successive ' plexus ' units, so that their blood is now carried cranially longitudinally running and definite supracardinal vessel, which only communic with the subcardinals here and there. In the meantime the intersegme veins have come to drain altogether via the ' plexus ' into this longitud vessel, and the posterior cardinal (in this abdominal region) disappears (c) the scene. These changes are shown in IV. The last figure (V) is a schem illustrate the age-changes described above. The intersegmental veins in younger stages (below) are joined by a plexus with the subcardinal (SC), bu

become older (higher) they establish a longitudinal drainage of their own lose their connections with the subcardinal, except, for example, where the renal vein is made.

he changes just described are of the nature of general changes; their modifica- and extensions, as shown in the development of the inferior vena cava azygos systems, remain for description.

umming up these matters from the viewpoint of the respective cardinal it may be said that the **posterior cardinal** is formed on each side in association the mesonephros, which it drains, and also receives intersegmental veins. he mesonephros degenerates the cardinal vein gets smaller, and disappears pletely in the abdomen. Its intersegmental tributaries have previously transferred to the supracardinal (periganglionic) system. Changes in the ax will be dealt with later.

he **subcardinal** is an accessory channel in the inner part of the mesonephros. xtent corresponds with this body, and it joins the main cardinal at its emities. It is connected with this vein by a venous plexus throughout its se, and also secondarily with the supracardinal system and its derivatives; of these last is the *left renal vein* in front of the aorta, which in this way mes practically an intersubcardinal connection.

The **supracardinal** system is not developed so completely in man as in most e other mammals; its early state constitutes a 'periganglionic' system, but term, it must be understood, is *only a descriptive word applicable to the human yo*, and indicates its **supracardinal** arrangements. The veins of this system lorsal to those described above, with which they are connected by free tomosis. They take over secondarily the intersegmental drainage, allowing posterior cardinals to disappear, and they develop a longitudinal drainage- el of their own, so that their contained blood is not (or is only in part) carried the subcardinal; at the upper end, however, this longitudinal vessel opens the subcardinal, as will be seen when treating of the thoracic vessels.

The compound systems of cardinal veins, as shortly described above, are metrically placed on the right and left sides, in the abdominal and (future) acic parts of the embryo. The development of the suprarenal glands, of liver, and of the diaphragmatic structures altogether breaks the continuity e systems, which can now be said to have thoracic and abdominal develop- ts only indirectly connected. The abdominal development is concerned he formation of the inferior vena cava and its associated vessels, while the gos and left superior intercostal systems are produced from the thoracic elopments; these vessels, therefore, can be considered at once.

Development of the Inferior Vena Cava.

The inferior vena cava, as regards its development, consists of two divisions wer or postrenal, and upper or prerenal.

These descriptive names are given to the two parts because it is at the level of the left renal vein, which has been seen to be practically inter- subcardinal, that the developmental values of the parts of the vein change; the 'renal' term, therefore, applies to the venous level, and not necessarily to the kidney itself.

Below the level of the left renal vein, the **inferior vena cava** is formed from the it longitudinal vessel of the **supracardinal** system, which receives the inter- mental (lower lumbar) veins of the right side; *a similar formation is found he left side.* The posterior cardinals disappear when the intersegmental veins r their terminations, and the subcardinals also atrophy, as the mesonephros ins to move down, only retaining the drainage of the gonad at this level; s the supracardinal alone is left to carry on the drainage of the body-wall, Further changes usually occur *on the left side*, where the longitudinal vessel upplanted by a *deeper longitudinal channel* connecting the intersegmental

veins on the transverse processes, deep to the psoas. Thus the more superfi
vessel disappears; but it occasionally persists as a **left inferior vena cava,** extend
up to the left renal vein (see Fig. 684).

Sometimes the *retro-aortic* anastomosis, which is a feature of the sup
cardinal system in other forms, may make a partial appearance in the hun
individual, when one or more lower left lumbar veins will pass behind
aorta to empty into the inferior vena cava.

Above the level of the left renal vein the subcardinals on each side lie in fr
of the suprarenal glands, round the outer sides of which the posterior cardi
course cranially. Before long the **right subcardinal** establishes a communicat

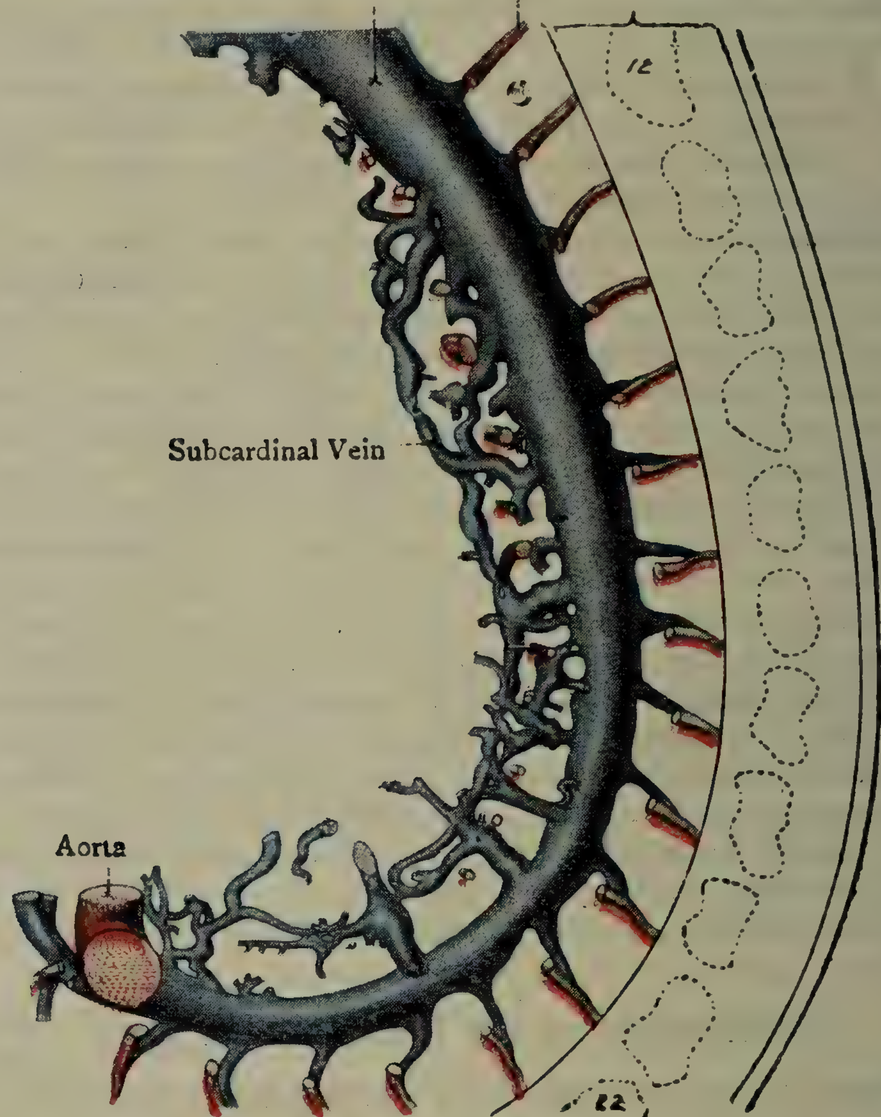


FIG. 683.—CARDINAL AND SUBCARDINAL VEINS, ETC.
(Frederick T. Lewis, in the *American Journal of Anatomy.*)

with the veins (hepatic) emerging from the dorsal aspect of the liver; this co
munication is situated in the right-hand part of the common dorsal mesente
This junction, enlarging steadily, provides a new and direct channel by which
blood in the right subcardinal can reach the heart, and the left renal, already
position, affords a means by which that from the left subcardinal can t
advantage also of the new channel. Thus the prerenal portion of the infe
vena cava is of **subcardinal** origin *from the entrance of the left renal vein to
relation with the suprarenal gland,* where it receives the suprarenal vein. Ab
this it is formed by the **hepatic** anastomosis and the **common hepatic vein,** wh
reaches the sinus venosus.

The **supracardinal system**—which empties itself fundamentally (w
possible) into the subcardinal—forms the *lower part of the main vein,* but as s

ssible—*i.e.*, where the subcardinal persists—opens into it. Thus the con-
y of the great vein is effected.

ie kidneys, growing cranially, lie among the veins of the **supracardinal** n, and drain into them. Thus the **right renal vein** is *altogether supra-ial in value,* and joins the longitudinal supracardinal vessel as this reaches bcardinal ending, thus a very little below the level of the left vein. The enal vein, *at its renal end,* is *of the same value as the whole of the right vein,* :s *transaortic portion* is not represented on the right side; it passes through

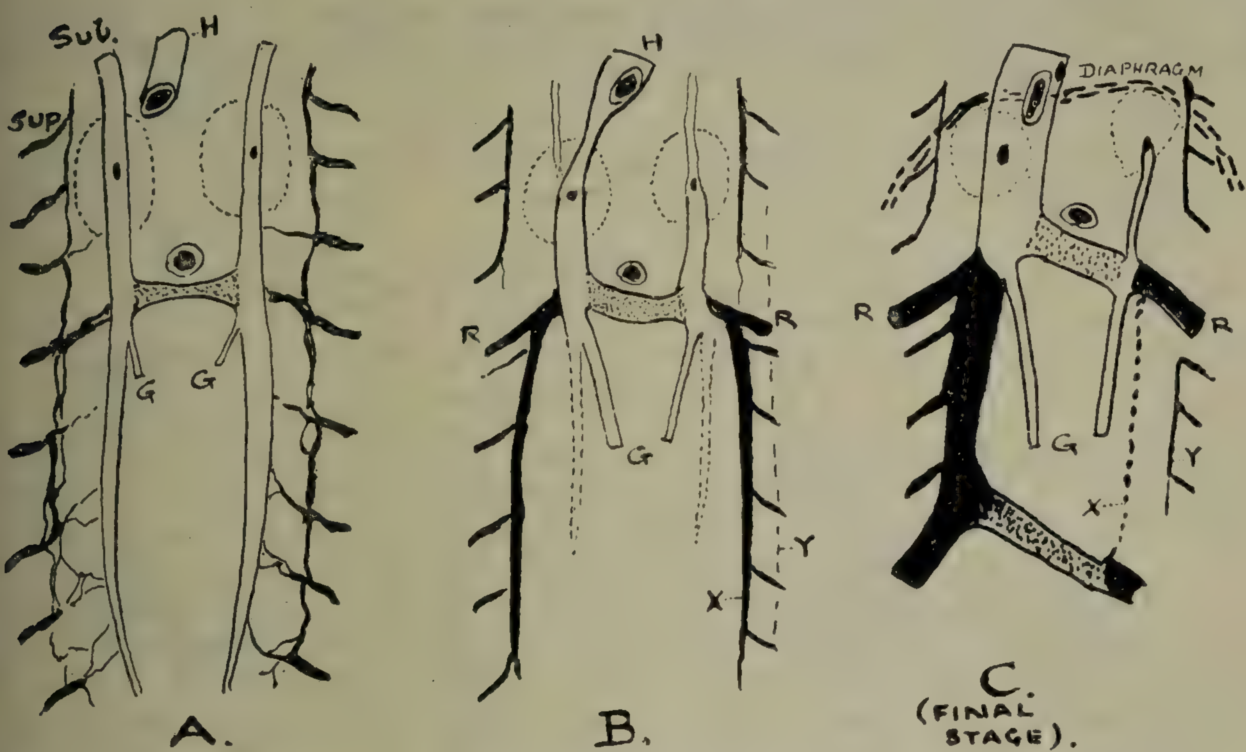


FIG. 684.—SCHEMES TO SHOW FORMATION OF INFERIOR VENA CAVA.

ardinals (Sub) are plain; supracardinals (Sup) black; posterior cardinals are not shown, as they are not concerned in the formation.

In A the supracardinal system is establishing its longitudinal vessel on each side, and so communicates with subcardinal. Subcardinals pass beyond suprarenals (dotted ovals) and there is no connection with the hepatic veins (H). They are joined by a transaortic (dotted) junction, and receive veins (G, G) from the gonads.

In B the supracardinal no longer communicates with subcardinal, except at R; here the renal vein is placed on each side. Subcardinals accordingly degenerate below entrance of gonad veins. Right subcardinal has now effected a junction with hepatic veins behind liver.

In C any upper continuation of subcardinal above suprarenal is cut off by diaphragm. Final values of parts of I.V.C. are apparent. The ascending supracardinal (X) on left is replaced by the deeper (Y). The junctional part of left common iliac is an intersupracardinal (periganglionic) formation.

tion of the **subcardinal,** where this remnant exists to receive the left supra- and left spermatic or ovarian veins.

he right and left **veins of the gonad** drain from the beginning into the *rdinals,* and thus, in the adult, reach the renal level because there is no ardinal remaining below this.

he **left suprarenal vein** is probably a remnant of the *left subcardinal,* corre-ding with the part of the vena cava formed by the subcardinal above the level; the current of blood in it, however, is reversed.

he posterior cardinal vein, having lost its intersegmental branches, disappears the abdomen by the middle of the second month, having *taken no part in rmation of the inferior vena cava.*

Thoracic Cardinal Formations.

The prolongation of the three cardinal systems into the thorax from abdomen is interrupted first by the rapid enlargement of the suprarenal gla This particularly affects the subcardinals, but these glands still, for a little t discharge some of their blood by small veins into the thoracic parts of the cardinals; soon, however, the extension of the diaphragm, over and be them, cuts them off finally from this way of discharge and leaves them only *abdominal* subcardinals for drainage.

The *terminal piece* of the **posterior cardinal** remains on both sides. persisting portion is the part above the entrance of the subcardinal, exten

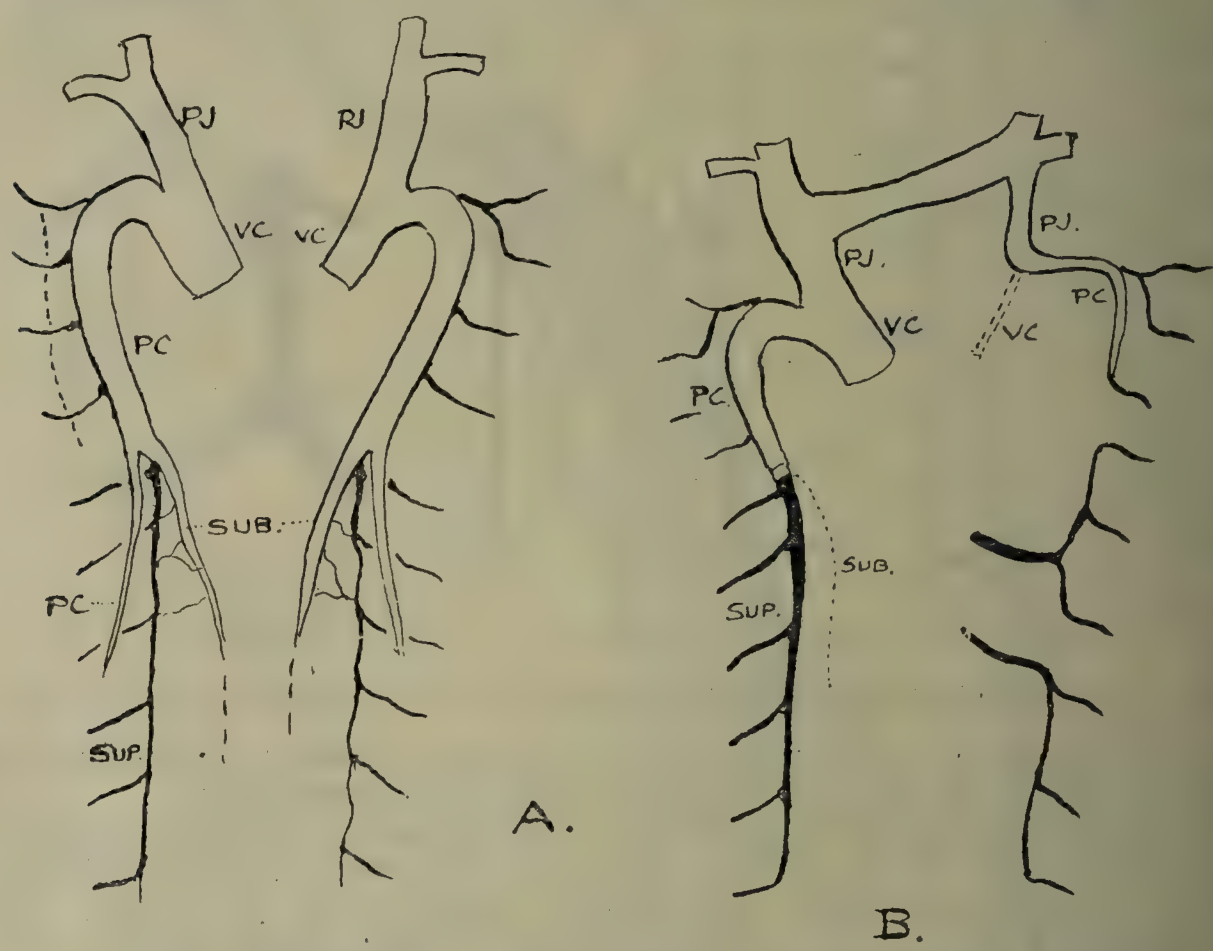


FIG. 685.—SCHEMES OF CARDINAL SYSTEMS IN THE THORAX.

On each side upper part of posterior cardinal (PC) persists. Longituc supracardinal (Sup), connected at first with subcardinal (Sub), only ret ultimately its terminal opening into this; thus this extreme terminal p of subcardinal persists, the rest of subcardinal and of postcardinal appearing below this point. On left side the original symmetry is fur broken up, and retro-aortic junctions cross to right supracardinal.

A is early condition, B the final state. VC, duct of Cuvier; PJ, primi jugular or anterior cardinal.

from this to the duct of Cuvier. The extreme terminal bit of the **subcard** also persists, joining the posterior cardinal; immediately below this term section the longitudinal **supracardinal** vessel joins the subcardinal, and the of the subcardinal disappears. This junction of the two veins corresponds m or less with the entrance of the sixth thoracic intersegmental vein into the of the supracardinal longitudinal vein. These details will be followed m easily, perhaps, with the aid of the diagrams in Fig. 685.

On the right the **azygos** vein is formed, below the sixth intercostal level, f *supracardinal* elements; at this level a very short ring of *subcardinal* come and above this it is persistent *posterior cardinal.*

On the left the conditions are at first symmetrical and similar, but as the innominate vein forms and the intersupracardinal junctions appear behind

, the system is broken in variable ways. The termination of the *posterior* *ıal* is in the left **superior intercostal vein,** but the terminal piece of this is *tive jugular* (anterior cardinal). The lower **hemiazygos** is always *supra-* *ıal.*

Development of the Lymphatic System.

ıe lymphatic system consists of lymphatic vessels and lymphatic glands des. There is also lymphoid or adenoid tissue, as in the thymus body, hoid follicles and villi of the intestinal mucous membrane, lymphatic es of the spleen, palatine tonsils, and pharyngeal tonsil. There are two s in the development of the lymphatic system—primary and secondary. *primary stage* is concerned in the formation of lymph-sacs, and the *secondary* consists in the formation of lymphatic vessels and lymph-glands.

ymph-Sacs.—There are two pair of lymph-sacs and two single sacs, as vs:

1. Jugular (2).
2. Retro-peritoneal (1).
3. Cisterna chyli (1).
4. Posterior (2).

pinions differ as to the development of these lymph-sacs. The view of nce R. Sabin will be stated first. According to this lady the sacs are oped as *sproutings from the endothelial lining of veins,* and this constitutes rimary stage in the development of the lymphatic system.

ıgular Sacs.—The jugular lymph-sacs, right and left, are the first to appear. is situated on the outer side of the lower part of the primitive anterior nal vein, which becomes the internal jugular vein. It is formed from part capillary venous plexus, connected in early life with the anterior cardinal A large part of this plexus disappears, whilst the connection of the inder with the anterior cardinal vein is severed. There thus results a hed collection of capillaries, lined with endothelium and in close proximity e outer side of the lower part of the anterior cardinal vein. These capillaries ne dilated, and subsequently join to form the jugular lymph-sac of each side, h is lined with endothelium, and which establishes a fresh connection with ower part of the anterior cardinal vein, where it is joined by the subclavian a valve being formed at the venous junction by a protrusion of part ıe lymph-sac at the place of junction. The jugular sac of each side is ected externally with peripheral lymphatic vessels which extend to the , neck, and fore-limb bud of the same side. The caudal end of the left sac mes connected with the thoracic duct, whilst the caudal end of the right becomes connected with the right lymphatic duct. The *dorsal part* of sac becomes converted into a plexus of lymphatic vessels, from which ıs of lymph-glands are developed.

Retro-peritoneal Sac.—The retro-peritoneal or pre-aortic lymph-sac is single, is formed from a capillary venous plexus in the root of *the mesentery,* which us is connected with the great pre-aortic transverse anastomotic vessel which nds between the two subcardinal veins. The capillary plexus in the root he mesentery becomes converted into a lymph-sac, without any venous ıection, and this constitutes the retro-peritoneal sac, which establishes a nunication with the cisterna chyli, and through it with the thoracic duct. ultimately replaced by a plexus of lymphatic vessels, and from this plexus ns of lymphatic glands are developed which lie along the ventral aspect of abdominal aorta. From the retro-peritoneal sac lymphatic vessels pass in the mesentery along the branches of the superior mesenteric artery, and e form another lymphatic plexus, from which the mesenteric lymphatic eal) glands are developed. Subsequently lymphatic (lacteal) vessels enter wall of the small intestine.

Posterior Sacs.—The sciatic lymph-sacs, right and left, are developed from llary venous plexuses in connection with the two primitive iliac veins. On

either side the sac extends from near the caudal end of the cisterna chyli alo
the outer side of the primitive iliac vein. It ultimately becomes convert
into lymphatic glands.

Cisterna Chyli.—The cisterna or receptaculum chyli is a single sac, situat
at the caudal end of the thoracic duct. It is developed from, and replaces
venous plexus. The thoracic duct connects the cisterna chyli with the
jugular lymph-sac, and the cisterna chyli communicates with each poster
sac. From each jugular sac a vessel grows caudalwards. On the *right* si
this vessel constitutes the **right lymphatic trunk,** and on the *left* side it forms t
thoracic duct. As the thoracic duct approaches the developing aortic arch
divides and gives rise to two thoracic ducts, which embrace that arch and th
pass to join separately the cisterna chyli opposite the mesonephroi. Subsequen
these two ducts fuse, and one duct is formed.

The thoracic duct is developed from a series of venous capillaries, origina
having a connection with veins.

Lymphatic Vessels.—The formation of these vessels, along with that
ymph-glands, constitutes the second stage in the development of the lympha

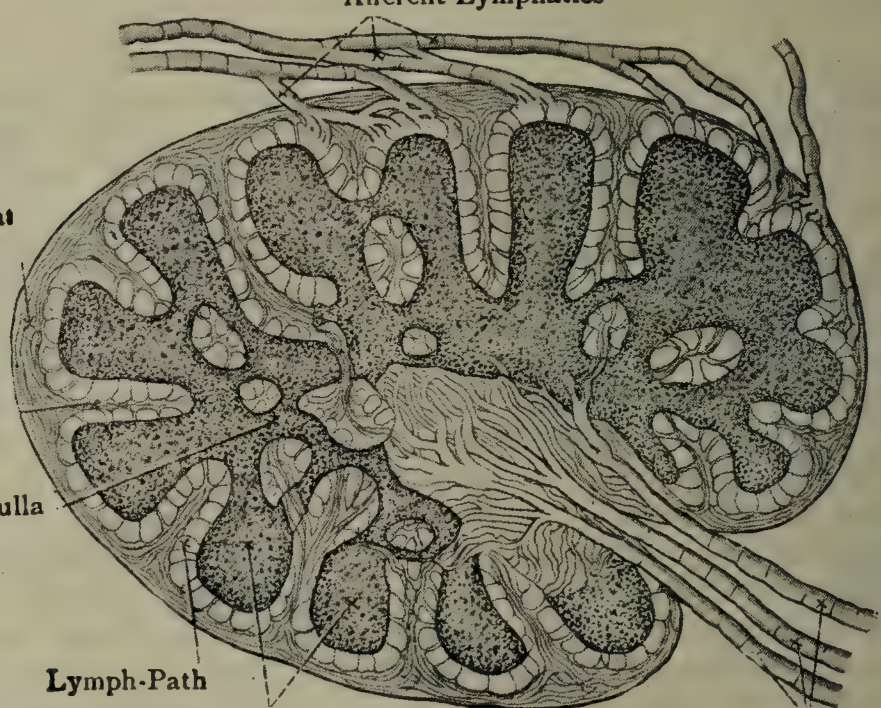


Fig. 686.—Diagrammatic Section of Lymphatic Gland (Sharpey, fr
Quain).

system. According to Sabin, the lymphatic vessels are formed *from the en
thelial lining of the lymph-sacs,* whilst the lymph-glands are developed *fr
plexuses of lymphatic capillaries.* The development of the **thoracic duct,** as stat
takes place from several groups of venous capillaries. It is the largest lympha
vessel, and it connects the cisterna chyli with the *left* jugular sac.

The lymphatics derived from the jugular lymph-sacs pass to the head, ne
and fore-limb buds; those from the posterior lymph sacs extend to the hi
limb buds; and those from the retro-peritoneal (mesenteric) lymph-sac en
the mesentery, within which lymph-glands (mesenteric) are developed
connection with them. From these mesenteric glands, in succession, fr
lymphatic vessels pass to the intestinal tube.

The other view of the development of the lymphatic system, held by Hu
ington amongst others, is that the connection of the lymphatic vessels with
venous system is *secondary,* and not primary, as Sabin holds. According
this other view the lymphatic vessels spring from *lymph-spaces,* which are forn
in the mesoderm (mesenchyme), and are lined with *mesothelium.* The endothe
cells of the lymphatic vessels are derived from this mesothelium, and not fr

ıous endothelium, according to Sabin, and the vessels establish a connection ıe venous system *at a later period.*

nph-Glands.—Some of these are formed in connection with the lymph- vhilst others are formed in connection with peripheral lymphatic vessels. are three stages in the development of a lymph-gland. The *first stage* s in the formation of a plexus of lymphatic capillaries pervaded by con- e-tissue septa. The *second stage* consists in the invasion of these septa od-capillaries, surrounded by lymphocytes. The *third stage* consists in mation of a **lymph-sinus** from the original plexus of lymphatic capillaries. e essential elements of a lymph-gland are thus threefold—namely: (1) a of lymph-capillaries; (2) blood-capillaries, surrounded by lymphocytes, connective-tissue septa; and (3) a lymph-sinus.

ch lymph-gland is connected with several lymphatic vessels. Those which the gland are known as *afferent vessels,* and they open into the peripheral tical part of the lymph-sinus. Those which emerge from the gland are l *efferent vessels,* and they arise in the central or medullary part of the -sinus. In no case does a lymphatic vessel pass uninterruptedly through ph-gland. The gland is a station in the path of a lymphatic vessel, which ents the terminus of that vessel, but not the terminus of the lymph. That after leaving the afferent vessel, flows in succession through the cortical edullary parts of the lymph-sinus, and from the medullary part it flows ıe efferent vessels. It is, therefore, so far as the lymph is concerned, a f, so to speak, changing carriages at a glandular station. During this s any injurious matter is taken up by the branched cells (phagocytes) of nph-sinus, and the lymph is furnished with a contingent of lymphocytes.

Structure of Lymphatic Vessels.

lymphatic vessel, of large size, consists of three coats—inner, middle, ıter. The *internal coat* (*tunica intima*) consists of a longitudinal network stic fibres lined with endothelial cells. The *middle coat* (*tunica media*) ts of plain muscular and elastic tissues disposed for the most part trans- y. The *external coat* (*tunica externa*) consists of (1) longitudinal bundles of ctive tissue, and (2) plain muscular and elastic fibres, disposed for the part longitudinally, lined with endothelium.

mphatic vessels are furnished with bloodvessels and nerves. Most of are also provided with **valves,** similar to those of the veins. Each valve ts of *two semilunar segments,* facing one another, which are foldings of the coat, containing connective and elastic tissues. They project slightly ds each other, and their free edges are directed *in the course of the lymph-*. The valves are situated at short intervals, and they serve to prevent of lymph. When a lymphatic vessel becomes distended it presents a d appearance, with constrictions between the projections, these constrictions ponding to the attached margins of the valvular segments.

velopment.—According to Sabin, the lymphatic vessels are developed from ıdothelial lining of the primitive lymph-sacs (see Development of Lymphatic m).

Structure of Lymphatic Glands.

lymphatic gland consists of a capsule, which encloses the glandular sub- e. The **capsule** is composed of connective tissue, containing elastic fibres.

ıe **glandular substance** presents two parts—superficial or cortical, and al or medullary. Each of these parts is permeated by a supporting frame- of trabeculæ derived from the capsule. These trabeculæ are composed of ctive tissue, with a few plain muscular fibres. They subdivide the cortex *follicles,* between which they form incomplete septa. In the medulla the culæ are arranged in a reticular manner.

he glandular substance is formed by *lymphoid* or *adenoid* tissue, which sts of retiform tissue, with lymphocytes in its meshes. In the cortex of

the gland this lymphoid tissue is disposed as *lymph-follicles*, and in the m
it forms *lymph-cords*. In both parts of the gland there are spaces betwe
glandular substance and the supporting trabecular framework. These s
which are for the passage of lymph, constitute the *lymph-sinus*. This si
broken up at all parts of the gland by retiform tissue, the meshes of whi
partially lined with branched cells of the nature of *phagocytes*. The glar
substance, except the lymph-sinus, is permeated by blood-capillaries.

Lymphatic glands are furnished with bloodvessels, nerves, and lym
vessels. The *arterioles* pass to the glandular substance, being at first enshe
by the supporting trabeculæ of connective tissue, and subsequently by the re
tissue of the glandular substance. The *nerves* are destined for the plain mu
tissue of the trabeculæ and bloodvessels.

The **lymphatic vessels** are of two kinds—afferent and efferent. The *a*
vessels enter the gland over its surface, whilst the *efferent vessels* emerge
definite part of the gland, where there is a slight depression, called the
The afferent vessels convey lymph *to* the cortical part of the lymph-sinus,
the efferent vessels convey lymph *from* the medullary part of that sinus.
much as the medullary part of the gland extends quite to the surface at the
where the depression, known as the hilum, exists, the efferent vessels e
from the gland through this hilum, which also gives passage to the arteri
veins.

Development.—Lymphatic glands are developed partly from the pri
lymph-sacs and partly from peripheral lymphatic vessels (see Developme
Lymphatic System).

CHAPTER XIV

THE HEAD AND NECK

BACK OF THE SCALP AND NECK.

andmarks.—The external occipital protuberance can, as a rule, be : out readily enough in the male, and the superior nuchal line, ell developed, may be felt extending outwards from it. The oid process of the temporal bone can be distinguished without ulty behind the auricle. The occipital artery, with the greater ital nerve on its inner side, lies about $1\frac{1}{2}$ inches to the outer side e external occipital protuberance. The occipital lymphatic gland, ands, may be felt, when enlarged, over the upper part of the zius or semispinalis capitis muscle. The spine of the seventh cal vertebra, or vertebra prominens, can easily be felt, and that ie sixth may also be made out. Extending from the external ital protuberance to the seventh cervical spine there is an elon-l depression, called the **nuchal furrow,** which indicates the position he ligamentum nuchæ. It is possible to feel the strong bifid : of the axis by sinking the finger deeply into the upper part of uchal furrow near the occipital bone, but the spines of the third, th, and fifth cervical vertebræ lie too deeply for detection. Lym-ic glands may be felt, when enlarged, along the posterior border ie sterno-mastoid muscle.

ack and Side of the Neck—Fasciæ.—The superficial fascia presents ing worthy of note. The deep fascia closely invests the cervical ion of the trapezius, and is then prolonged over the posterior igle of the neck to the posterior border of the sterno-mastoid, re it divides to ensheathe that muscle. It will be described in iection with the deep cervical fascia.

utaneous Nerves.—The nerves of this region are as follows: the ccipital; the greater occipital; the third occipital; the medial iches of the posterior primary rami of the third, fourth, and fifth ical spinal nerves; the lesser occipital; the great auricular; the rior cutaneous nerve of neck; and the descending superficial iches of the cervical plexus—namely, the supraclavicular nerves Fig. 687).

The **suboccipital nerve** is the posterior primary ramus of the first ical nerve; it only occasionally supplies the skin on the outer of the greater occipital area.

The **greater occipital nerve** is the medial branch of the posterior iary ramus of the second cervical nerve. It pierces the upper

part of the semispinalis capitis muscle, and sometimes the trapez about ½ inch from the middle line. It then runs upwards, with inclination outwards, and accompanies the occipital artery to the cra integument, lying on the inner side of that vessel. Its branches long, and have an extensive distribution, reaching as far as the ve of the skull. Laterally it communicates with the small occip nerve, and medially with the third occipital.

The **third occipital nerve** is a small offset from the me branch of the posterior primary ramus of the third cervical ne Having pierced the trapezius, it ascends medial to the gre occipital nerve, with which it communicates, and has a lim distribution to the occipital integument inside that nerve.

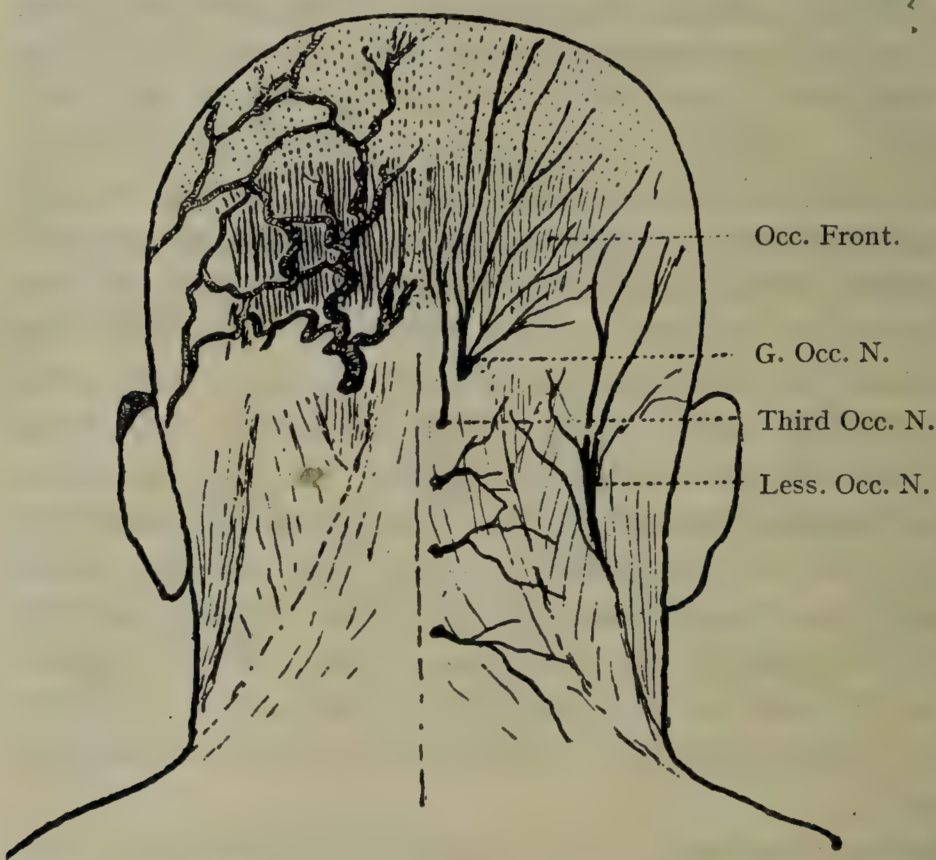


FIG. 687.—TO SHOW THE NERVES AND VESSELS ON THE BACK OF SCALP AND NECK.

The **medial bran of the posterior prin rami of the third, fou and fifth cervical ne** appear through trapezius close to middle line, and t outwards to supply skin of the back of neck, that of the t furnishing, as j stated, the third c pital nerve.

The **lesser occi nerve** is one of the cending superfi branches of the cerv plexus, and arises f the anterior prim ramus of the sec cervical nerve, so times receiving a bra from that of the third. It appears at the posterior border of the ster mastoid muscle, and ascends along that border to the occipital reg Here it divides into mastoid and occipital branches, which supply skin of the mastoid, outer part of the occipital, and adjacent port of the parietal regions. It furnishes an auricular branch to the s of the upper part of the inner surface of the auricle, and it commu cates with the greater occipital, the posterior branch of the gr auricular, and the posterior auricular branch of the facial. lesser occipital nerve is sometimes double, and in these cases one port of it usually pierces the anterior border of the trapezius.

The **great auricular nerve,** like the lesser occipital, is one of ascending superficial branches of the cervical plexus, and arises two roots from the anterior primary rami of the second and th cervical nerves. It turns round the posterior border of the ster

astoid immediately below the lesser occipital nerve, and passes wards and forwards upon that muscle towards the lobule of the ricle, on approaching which it divides into anterior and posterior anches. The *posterior branch* is distributed to the skin over the astoid region, the skin of the inner surface of the auricle, and sends e or two twigs through the cartilage of the auricle to the skin cover- g the lower part of the outer surface; and the *anterior branch* is dis-

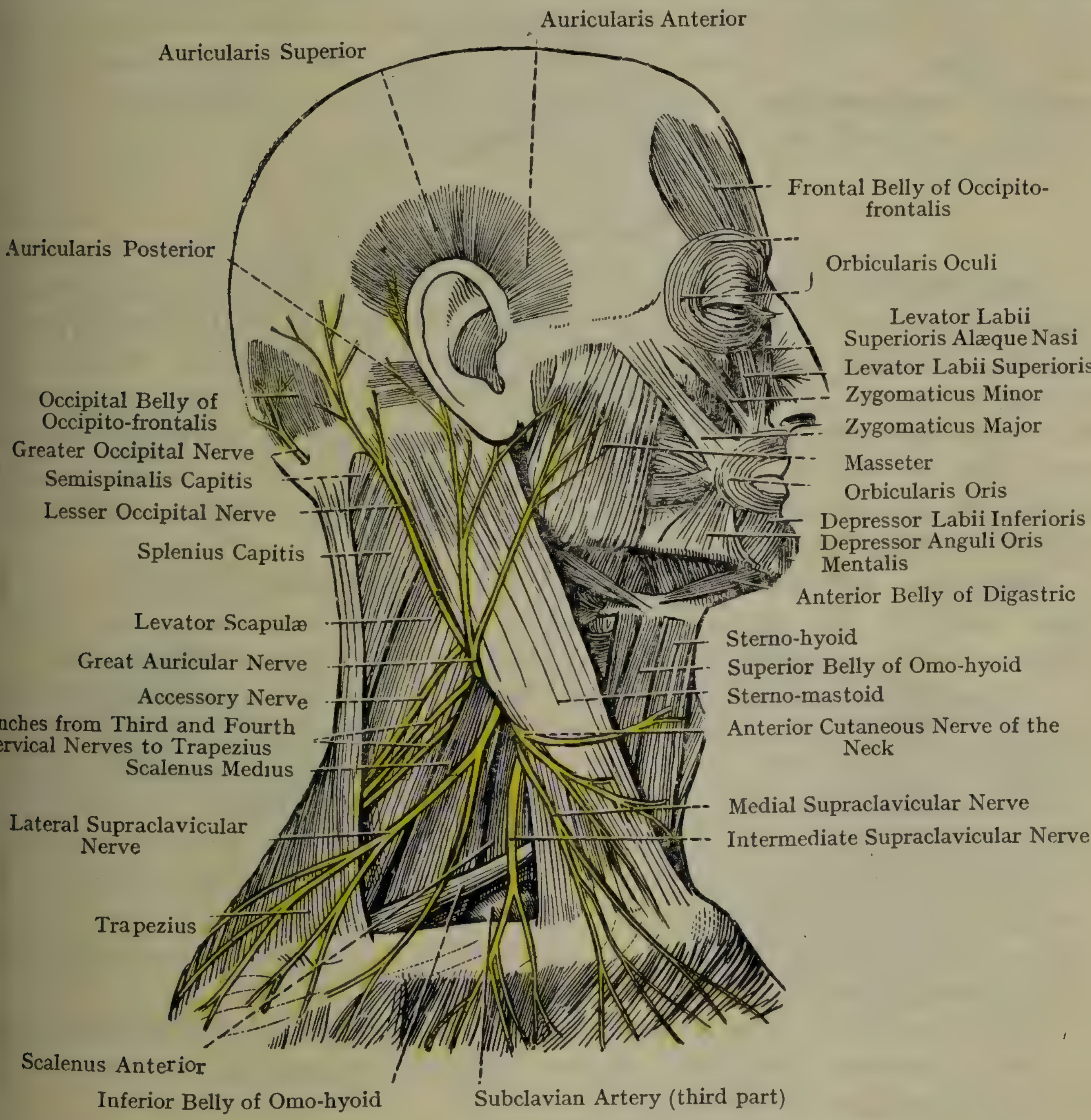


FIG. 688.—THE RIGHT SIDE OF THE HEAD AND NECK.
The platysma has been removed, and the nerves are shown.

ibuted to the skin over the parotid gland and angle of the jaw. The osterior branch communicates with the lesser occipital and posterior ricular nerves, and the anterior branch communicates in the parotid and with the facial nerve.

The **anterior cutaneous nerve of the neck (transverse cervical erve)**, like the lesser occipital and great auricular, is a superficial anch of the cervical plexus, and arises by two roots from the anterior

primary rami of the second and third or third and fourth cervic nerves. It appears at the posterior border of the sterno-masto close below the great auricular, and turns over that muscle deep the external jugular vein to reach the front of the neck, where it w be afterwards described.

The **supraclavicular nerves from the cervical plexus** appear at t posterior border of the sterno-mastoid below the accessory, usual as a single trunk which arises by two roots from the anterior prima rami of the third and fourth cervical nerves or from the fourth alor This trunk, as it descends, divides into three branches—namel **medial, intermediate,** and **lateral**—which pass downwards over t clavicle, and will be afterwards referred to.

Deeper Structures.

Ligamentum Nuchæ.—This is a strong fibrous band which occupi the median line of the neck. Its superficial fibres are attached superior to the external occipital protuberance, and inferiorly to the spi of the seventh cervical vertebra. Its deep fibres are attached the external occipital crest, and to the spines of cervical vertebr from the second to the sixth inclusive. They also extend into t interspinous intervals between the interspinales muscles, where th represent interspinous ligaments.

Muscles—Cervical Portion of the Trapezius—*Origin.*—(1) T inner third of the superior nuchal line of the occipital bone, and t external occipital protuberance; and (2) the ligamentum nuchæ.

Insertion.—(1) The posterior border of the outer third of t clavicle; and (2) the inner border of the acromion process of t scapula.

Nerve-supply. — (1) The accessory nerve (spinal root); a (2) branches from the cervical plexus, which are derived from t anterior primary rami of the third and fourth cervical nerves. T nerves enter the deep surface of the muscle after passing benea its anterior border a little above the clavicle, and they here for a plexiform communication with each other.

Blood-supply.—The **superficial branch (superficial cervical arter** of the transverse cervical artery ramifies on and gives branches the deep surface of the muscle.

The fibres are directed downwards, forwards, and outwards.

This part of the muscle lies on the semispinalis capitis just belo the occiput, and below this on the splenius and levator scapulæ; t superficial branch of the transverse cervical artery and superfici branch of the ramus descendens (arteria princeps cervicis) of t occipital artery anastomose deep to it, and its nerves enter it. As approaches its insertion its fibres lie over the supraspinatus, a fatt pad being interposed.

Action.—The cervical fibres, acting from their origin, elevate t outer end of the clavicle and the point of the shoulder. Acting fro

r insertion they extend the head, and incline the neck towards same side, the face being directed towards the opposite side.
The anterior border of the muscle forms the posterior boundary he posterior triangle of the neck.

)ccasionally a small muscle, called the **transversus nuchæ,** is met with, nding from the external occipital protuberance to the tendon of insertion ıe sterno-mastoid. It may be fleshy or tendinous.

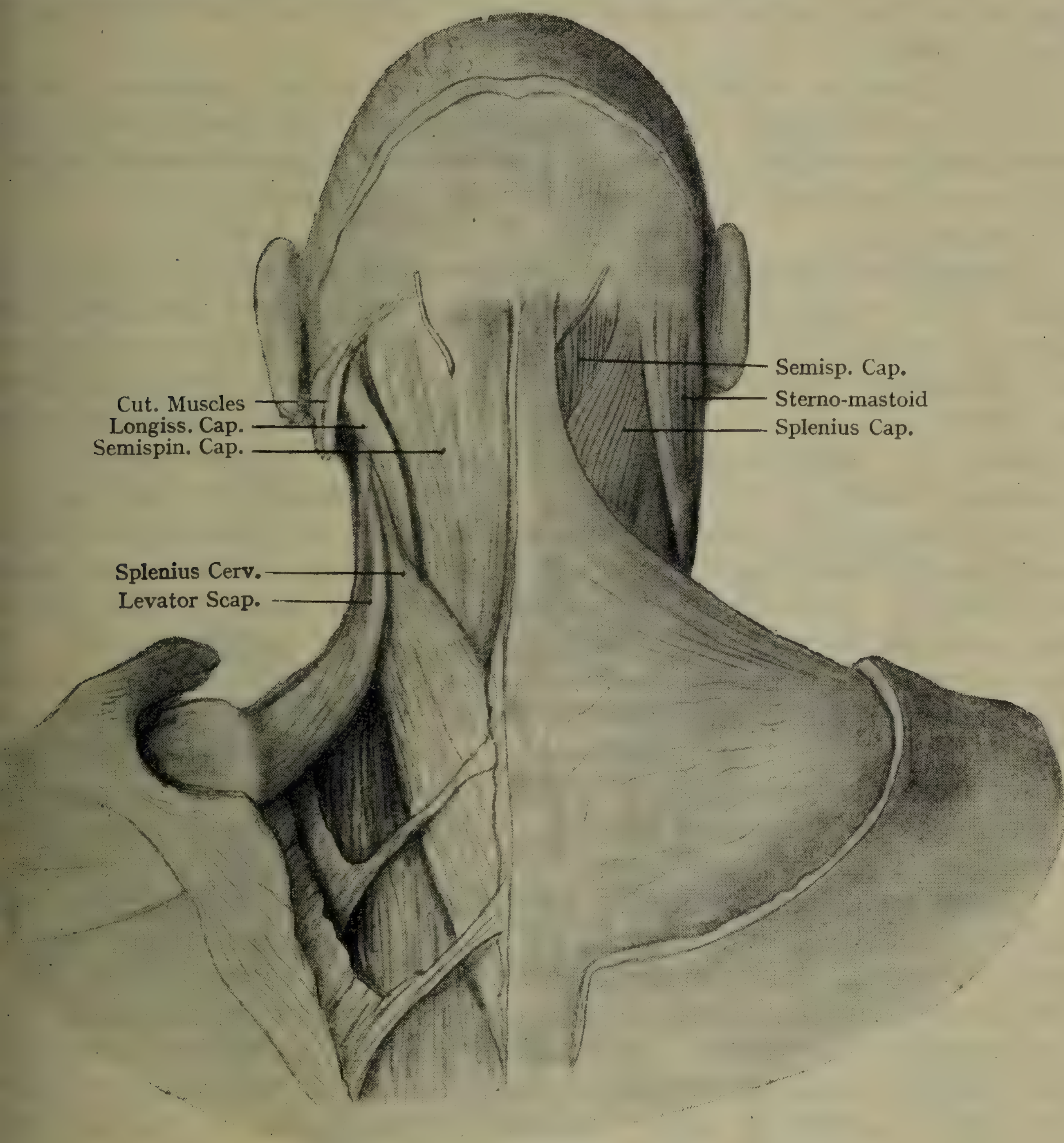


FIG. 689.—DISSECTION TO SHOW MUSCLES ON BACK OF NECK.

Insertion and Posterior Border of the Sterno-mastoid.—This muscle nserted into (1) the outer surface of the mastoid process of the ıporal bone, and (2) the superior nuchal line of the occipital bone r about its outer half, or more. The posterior border of the scle forms the anterior boundary of the posterior triangle of the k, and has the following nerves related to it: (1) the lesser occipital ends along it to the head; (2) the great auricular passes upwards

and forwards superficial to it towards the lobule of the auricle; (3) anterior cutaneous nerve of the neck crosses it in a forward directi (4) the accessory appears from behind it, along with the branc of the third and fourth cervical nerves to the trapezius; and (5) supraclavicular branches of the cervical plexus emerge from unc neath it.

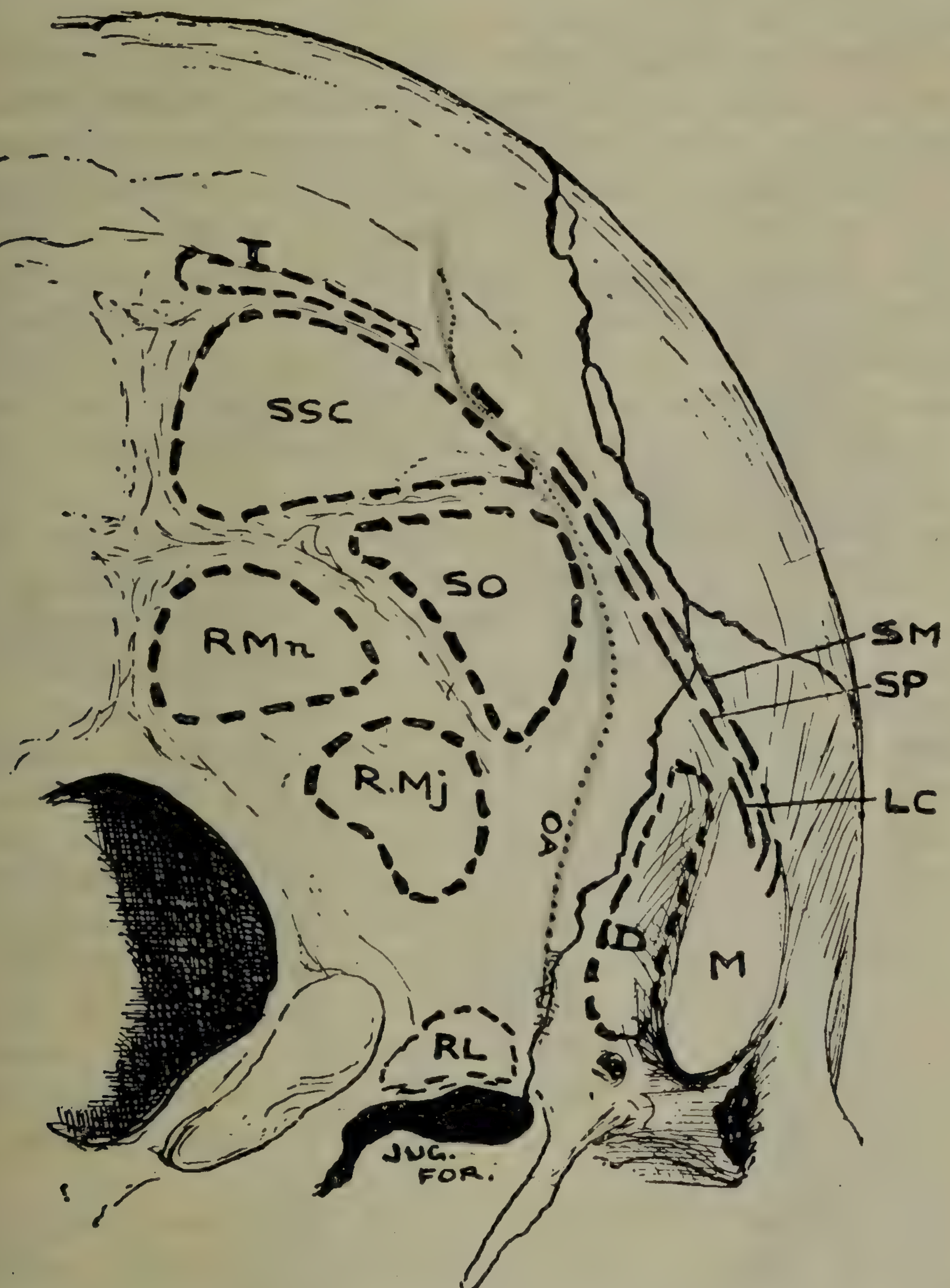
Some deep cervical lymph glands are situated along the poste border of the sterno-mastoid muscle. They will be described l (see p. 1199).

The levator scapulæ, rhomboids, serratus posticus super splenius, semispinalis capitis, longissimus cervicis, longissimus cap semispinalis cervicis, intertransversales, and interspinales muscles be found described in connection with the muscles of the back p. 400 *et seq.*).

Second and Third Parts of the Occipital Artery.—At the mast process this vessel lies very deeply. Having crossed the rectus cap lateralis muscle, it enters the occipital groove on the inner aspec the mastoid process, where it is covered by the following structu in order from the surface inwards: (1) sterno-mastoid; (2) splen capitis; (3) longissimus capitis; (4) mastoid process; and (5) posterior belly of the digastric. In its backward course the ve rests in succession upon the insertions of the obliquus capitis supe and semispinalis capitis, and it escapes from beneath the mus covering it in the following order: posterior belly of the digast longissimus capitis, splenius capitis, and sterno-mastoid. A emerging from beneath the last-named muscle, it lies for a littl the posterior angle close to the apex, and then, frequently pierc the occipital origin of the trapezius, it enters upon the third par its course. This part ascends along with the greater occipital ne to the occipital region, where it divides into several long tortu branches (Figs. 690 and 691).

Branches.—The branches of the second and third parts are follows: mastoid, meningeal, descending, communicating, muscu and occipital. The **mastoid branch** passes through the mast foramen when there is one on the outer surface of the mastoid proc and supplies the diploë and mastoid air-cells, as well as the adjac dura mater. The **meningeal branches** enter the cranial cavity thro the jugular foramen, and take part in the supply of the dura ma of the posterior fossa. The **descending branch** (**arteria princeps cervi** arises under cover of the splenius capitis, and at the outer bor of the semispinalis capitis it divides into a superficial and deep bran The *superficial branch* is distributed to the splenius capitis and trapez and anastomoses in the latter muscle with the superficial branch the transverse cervical artery. The *deep branch* passes deep to semispinalis capitis, and anastomoses upon the semispinalis cerv with (1) the deep cervical artery, a branch of the costo-cervical tru and (2) branches of the vertebral artery. The **communicating branc** enter the suboccipital triangle, where they anastomose with branc

the vertebral artery. The **muscular branches** supply the contiguous
scles. The **occipital branches,** which are the terminal branches,
at first two in number, but these soon divide into several long
tuous branches, which supply the occipital belly of the occipito-
ntalis and the integument as high as the vertex. They anastomose



G. 690.—To show Course of Occipital Artery (OA) as a Dotted Line on the Under Side of Skull.

passes deep to mastoid process and muscles attached to this (digastric, longissimus capitis, sterno-mastoid, and splenius). It is lateral to rectus lateralis (RL), rectus major (R.Mj), superior oblique (SO), and semispinalis capitis (SSC). It emerges between splenius and trapezius (T).

th one another, with the posterior auricular, the posterior branch
the superficial temporal, and their fellows of the opposite side.

The **occipital venous plexus** communicates with the posterior
ricular and the posterior branch of the superficial temporal veins.
receives the *parietal emissary vein,* which emerges through the

parietal foramen, and so a communication is established with tl superior sagittal sinus; a communication is also formed with tl sigmoid sinus by means of the mastoid emissary vein through tl mastoid foramen. Sometimes it receives a small *occipital emissa vein* which emerges through an opening at the external occipit protuberance, and then a communication would be established wi the confluence of the sinuses.

Two or three **occipital veins** leave the occipital plexus. Tl external vessel is known as the **posterior external jugular vein.** Havi been reinforced by tributaries from the superficial structures at tl upper part of the back of the neck, the posterior external jugular ve passes on to the sterno-mastoid, where it opens into the extern jugular. The **middle occipital vein** (inconstant) accompanies tl occipital artery, and usually opens into the internal jugular. Tl **internal occipital vein,** having in some cases pierced the trapeziu passes beneath the semispinalis capitis, and enters the suboccipit triangle. In this situation it joins the suboccipital plexus, from whi the deep cervical and vertebral veins emerge.

Occipital Lymph Glands.—These glands are usually two in numbe and lie superficial to the occipital portion of the trapezius, or the upp part of the semispinalis capitis. They receive their afferent lymphati from the back part of the scalp, and their efferent lymphatics pass the deep cervical glands.

Deep Cervical Artery.—This vessel is in most cases a branch of tl costo-cervical trunk of the second part of the subclavian. Havi passed backwards between the transverse process of the seven cervical vertebra and the neck of the first rib, it ascends upon tl semispinalis cervicis, under cover of the semispinalis capitis, towar the level of the spine of the axis, where it anastomoses with the dee branch of the ramus descendens of the occipital. In its course furnishes a *spinal branch,* which enters the vertebral canal throug the intervertebral foramen for the eighth cervical nerve, and *mu cular branches,* which anastomose with branches of the vertebr artery.

The **deep cervical vein** begins within the suboccipital triangle the suboccipital plexus, which receives the internal occipital vei It descends in company with the deep cervical artery to the low part of the neck, where it passes forwards between the transver process of the seventh cervical vertebra and the neck of the first ri and ends by joining the vertebral vein just before that vessel terminat in the innominate vein.

In addition to the muscular branches of the occipital and dee cervical arteries, the deep muscles of the back of the neck recei twigs from the second part of the vertebral artery, which travers the foramina transversaria of the upper six cervical vertebræ. The twigs pass backwards through the intertransverse spaces, and anast mose with branches of the ramus descendens of the occipital arte and the deep cervical artery.

Suboccipital Region—Muscles—Rectus Capitis Posterior Major
)rigin.—The ridge leading to one of the tubercles in which the ne of the axis ends.

Insertion.—The outer part of the inferior nuchal line of the occipital ne, and the subjacent area.

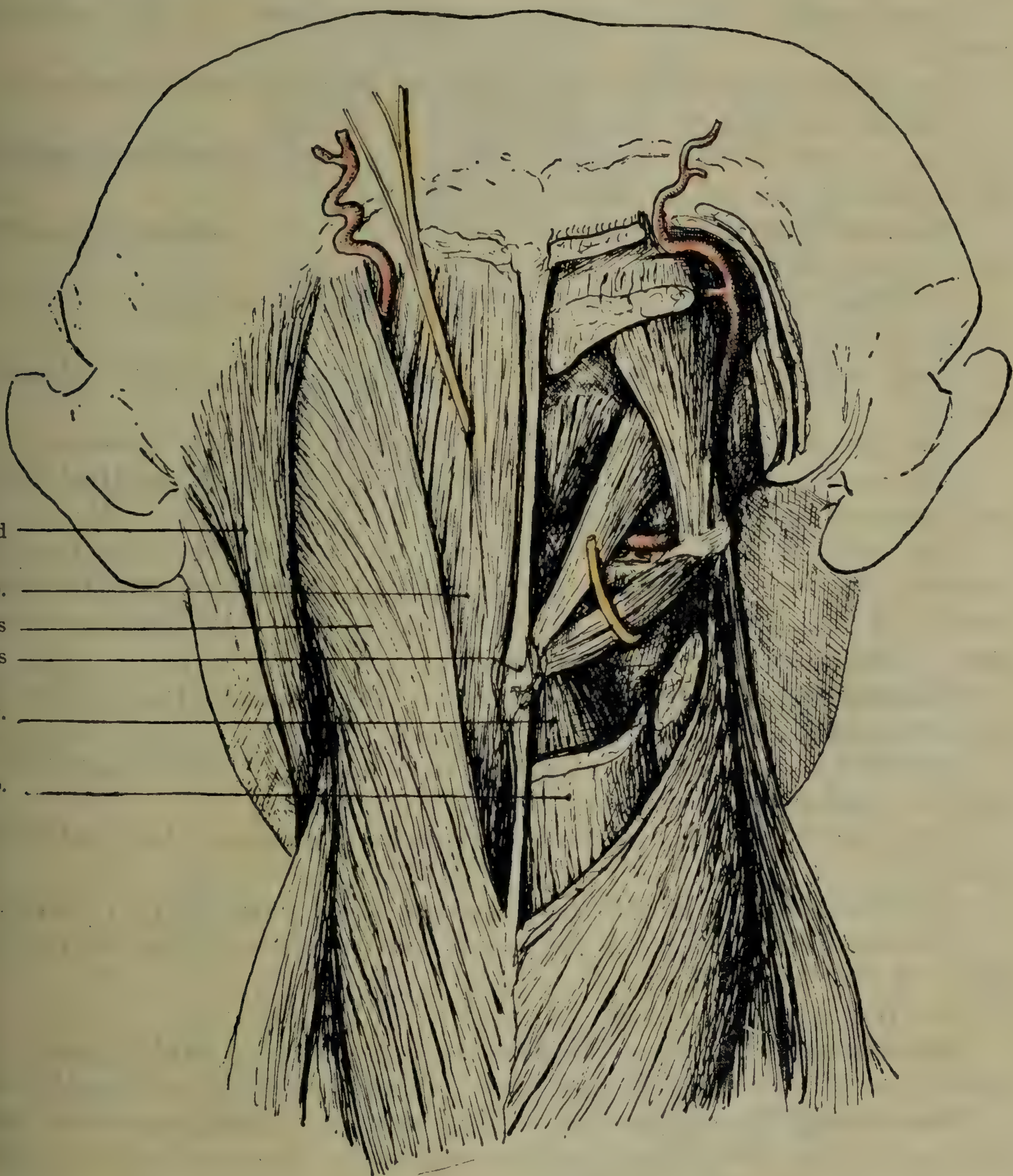


FIG. 691.—DISSECTION OF SUBOCCIPITAL REGION.

Nerve-supply.—The posterior primary ramus of the suboccipital rve.

The direction of the fibres is upwards and outwards, in spite of its me.

Action.—(1) To rotate the face towards the same side; and (2) to tend the head.

The muscle is pyramidal, and its insertion is largely covered the obliquus capitis superior.

Rectus Capitis Posterior Minor—*Origin.*—The posterior arch the atlas close to the tubercle.

Insertion.—The inner third of the inferior nuchal line of the occipi bone, and the subjacent area as low as the foramen magnum.

Nerve-supply.—The posterior primary ramus of the suboccipi nerve.

The direction of the fibres is upwards in an expanded manner.

Action.—To extend the head.

The muscle is fan-shaped, and lies deeper than, and medial the rectus capitis posterior major.

Obliquus Capitis Inferior—*Origin.*—The outer and upper aspect the spine of the axis.

Insertion.—The lower surface of the transverse process of the at at its back part.

Nerve-supply.—The posterior primary ramus of the suboccipi nerve.

The direction of the fibres is outwards and slightly upwards.

Action.—To rotate the atlas along with the head, so that the fa looks towards the same side.

The muscle is thick and fleshy. At its origin it is interpos between the rectus capitis posterior major superiorly and the high bundle of the semispinalis cervicis inferiorly. The greater occipi nerve winds round its lower border.

Obliquus Capitis Superior—*Origin.*—The upper surface of the tra verse process of the atlas at its back part.

Insertion.—The occipital bone between the outer parts of superior and inferior nuchal lines.

Nerve-supply.—The posterior primary ramus of the suboccipi nerve.

The direction of the fibres is upwards and very slightly inwards.

Action.—(1) To extend the head, and (2) to act as a slight late flexor of the head.

The muscle is triangular.

Suboccipital Triangle.—This triangle is situated under cover of upper part of the semispinalis capitis close below the occipital bone.

Boundaries—*Supero-medial.*—The rectus capitis posterior maj *External.*—The obliquus capitis superior. *Inferior.*—The obliqu capitis inferior. The **roof** is formed by the semispinalis capitis a longissimus capitis, and the **floor** by half of the posterior arch the atlas and half of the posterior atlanto-occipital membrane. **contents** are (1) the third part of the vertebral artery, (2) the su occipital plexus of veins, and (3) the posterior primary ramus of first cervical nerve. The greater occipital nerve turns upwards rou the inferior oblique and crosses the inner part of the triangle deep the semispinalis capitis, and the deep division of the ramus descend of the occipital artery runs down near this.

ird Part of the Vertebral Artery.—The vertebral artery, having
d through the foramen transversarium of the atlas, enters upon
hird part of its course, and takes a winding course backwards

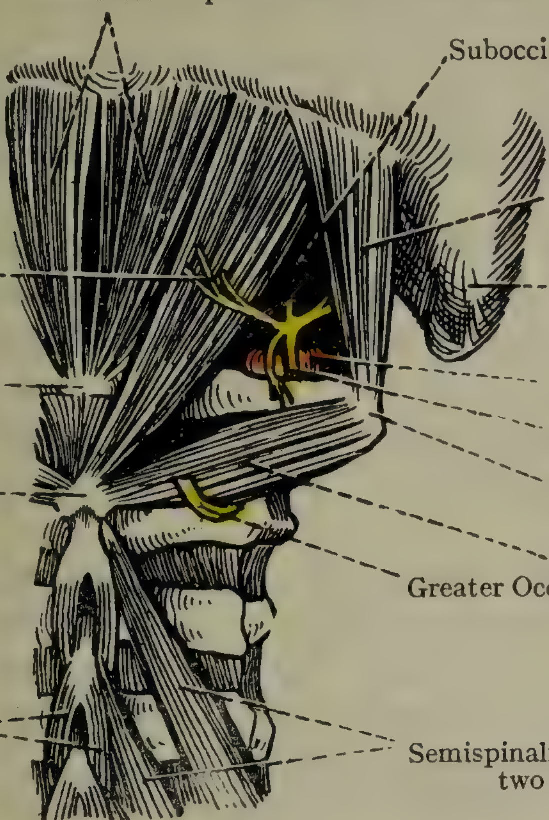
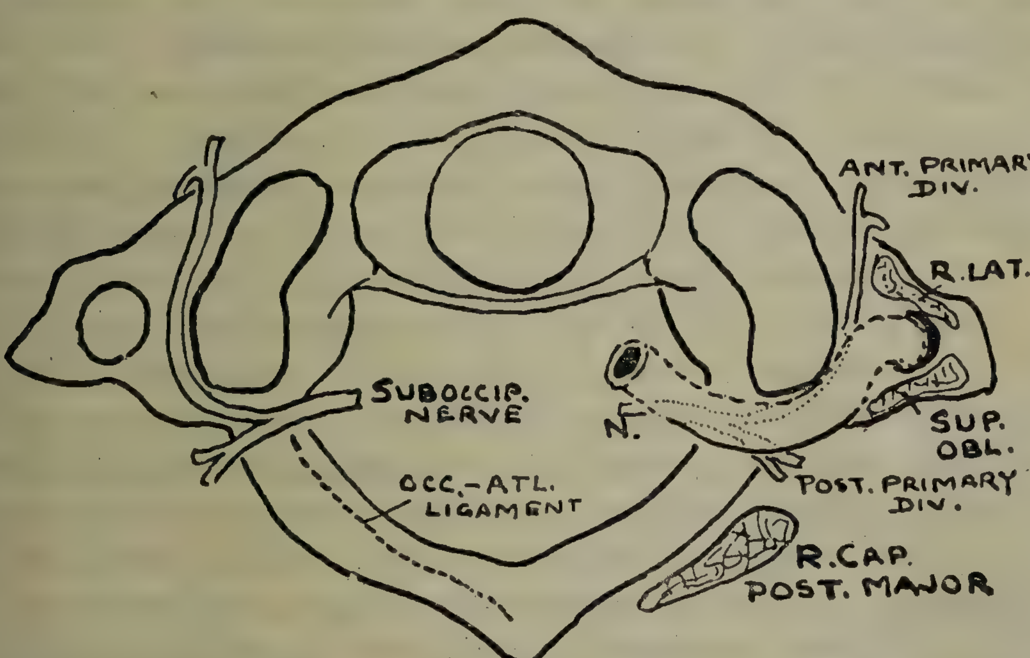


FIG. 692.—THE SUBOCCIPITAL TRIANGLE.

inwards. It lies in the vertebrarterial groove of the atlas, the
erior primary ramus of the first cervical nerve being beneath it,
it passes under an arched band of the posterior atlanto-occipital



693.—ATLAS SEEN FROM ABOVE, TO SHOW POSITION OF VERTEBRAL ARTERY AND SUBOCCIPITAL NERVE.

brane, which is sometimes ossified. It thus leaves the suboccipital
gle, pierces the dura mater, and enters the cranial cavity through
oramen magnum. The third part of the vessel furnishes *muscular*

branches to the adjacent muscles, which anastomose with the ra descendens of the occipital and the deep cervical of the costo-cerv trunk.

Suboccipital Plexus of Veins.—This plexus is formed by branc which proceed from (1) the vertebral venous plexuses, (2) the adjac muscles, and (3) the occipital periosteum. It receives the inte occipital vein, and the blood is conveyed away from it by the d cervical vein, already described, and the vertebral vein, which wil afterwards considered.

Posterior Primary Division of the First Cervical or Suboccip Nerve.—This division passes backwards as a single nerve in the ve brarterial groove of the atlas, lying between the bone and the t part of the vertebral artery. On entering the suboccipital triangl divides into branches which supply the obliqui, recti posteriores, semispinalis capitis muscles. A filament joins the greater occip nerve.

Posterior Primary Rami of the Cervical Spinal Nerves.— cervical nerves are eight in number, the first being known as the s **occipital nerve.** Each breaks up into an anterior and a poste primary ramus. The posterior primary ramus of the first or s occipital is single, and has just been described. The posterior prim rami of the lower six arise in the intervertebral foramina, and e soon divides into a lateral and medial branch. The upper two cerv nerves make their exit behind the articular masses, and their poste primary rami cross the vertebral arches behind these; the second div into medial and lateral branches. The *lateral branches* of all are tributed to the deep muscles, and do not become cutaneous. *medial branch* of the posterior primary ramus of the second, whic of large size, constitutes the **greater occipital nerve.** It winds ro the lower border of the obliquus capitis inferior, and pierces semispinalis capitis, to which it gives branches. Later it r pierce the trapezius to reach its cutaneous distribution, which been already described. The *medial branches* of the third, fou and fifth are directed inwards superficially to the semispin cervicis, to which, as well as to the semispinalis capitis, they g branches. Close to the cervical spines they pass backwards me to the spinalis capitis (biventer cervicis), and, having pierced splenius and trapezius, they reach the integument, which they sup The medial branch of the posterior primary ramus of the third, be piercing the trapezius, gives off a small ascending branch, known the **third occipital.** It passes upwards, lying at first under cove the trapezius, and then passing through it to reach the occipital inte ment. The *medial branches* of the posterior primary rami of sixth, seventh, and eighth are directed inwards towards the cerv spines *beneath* the semispinalis cervicis, and are distributed to adjacent muscles. They do not furnish any branches to the inte ment.

The Scalp and Temporal Region.

asciæ.—The place of the deep fascia beneath the skin may be to be taken by the epicranial aponeurosis of the occipito-frontalis :le. The aponeurosis becomes thin and fascial over the temporal ns. Where it is thick and aponeurotic it is firmly attached to overlying skin by fibrous processes, between which are small lobules, so that the subcutaneous layer is firm and somewhat ular in appearance. The vessels and nerves are distributed in this :, which loses its fibrous nature in the temporal regions and becomes perficial soft fatty layer.

uperficial Nerves and Vessels.—The superficial nerves of the ero-lateral aspect; the greater, small, and third *occipital* nerves; the mastoid branch of the *great auricular*, have been described idy. In the fronto-parietal region two sensory nerves are met —namely, the *supra-orbital* and *supratrochlear*—both of which lerived from the frontal nerve, which is one of the branches of the halmic division of the fifth cranial nerve. In the temporal region the *temporal branches* of the *facial nerve*, the *auriculo-temporal*

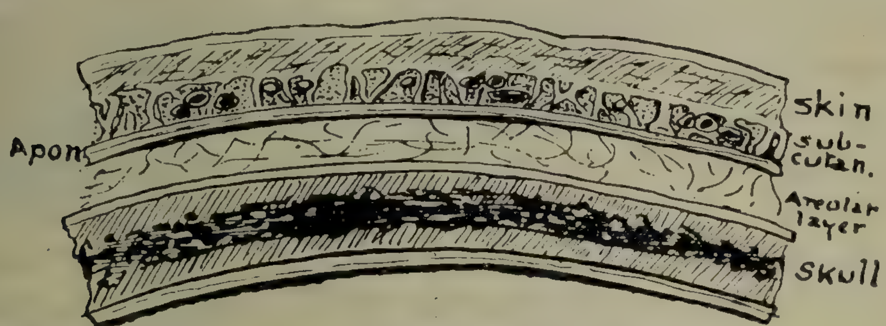


FIG. 694.—DIAGRAM OF SECTION THROUGH SCALP.

e, and the *zygomatico-temporal nerve*. Of the **arteries** of the p, the third part of the *occipital* artery, in the posterior region, has 1 described. Those of the fronto-parietal region are three in ber—namely, the *supra-orbital*, *supratrochlear*, and anterior branch he *superficial temporal*. The superficial temporal artery ramifies he side of the head in the temporal region.

The **supra-orbital nerve,** which is of large size, leaves the orbit ugh the supra-orbital foramen. It then ascends, lying at first to the upper part of the orbicularis oculi and the frontal belly he occipito-frontalis muscle, but subsequently piercing the latter cle in two branches, *medial* and *lateral*. The lateral branch is the er of the two, and its offsets extend as far back as the lambdoid ire. As the supra-orbital nerve passes through the supra-orbital :h it furnishes one or two twigs to the mucous membrane of the tal sinus and to the diploë of the frontal bone, and after leaving notch it sends downwards branches to the integument of the upper id. After this the nerve supplies the integument of the fronto- etal region.

The medial and lateral branches of the supra-orbital nerves sometimes leave orbit separately, and each may form a notch or foramen of its own.

The **supratrochlear nerve,** which is of small size, is medial to supra-orbital nerve. It leaves the orbit close to the medial ang process of the frontal bone, where it lies above the pulley of the supe oblique muscle of the eyeball. It then ascends deep to the upper of the orbicularis oculi and the frontal belly of the occipito-front muscle, and, piercing the former muscle, it has a limited distribu to the frontal integument close to the median line. As the ne leaves the orbit it furnishes twigs to the inner part of the integum of the upper eyelid.

The **supra-orbital artery** is a branch of the ophthalmic, and eme from the orbit with the supra-orbital nerve. It is distributed to structures covering the frontal bone, and anastomoses with the su trochlear branch of the ophthalmic artery and the anterior branc the superficial temporal artery. In the supra-orbital notch it furni one or two branches to the mucous membrane of the frontal sinus to the diploë of the bone, and after leaving the notch it sends do wards branches to the integument of the upper eyelid (Fig. 698).

The **supra-orbital vein** passes downwards and inwards to a p just above the medial angle of the orbit, where it joins the su trochlear vein. In this manner the angular vein is formed, whic the commencement of the anterior facial vein. The supra-orbital receives tributaries from the frontal region and the upper eyelid, in the region of the medial angle of the orbit it communicates with superior ophthalmic vein. It also communicates with the supe ophthalmic vein through the supra-orbital notch, and this commun tion receives the frontal diploic vein, which returns the blood from diploë of the frontal bone and mucous membrane of the frontal si

The **supratrochlear artery (frontal artery)**, like the supra-orbita a branch of the ophthalmic, and leaves the orbit with the supratroch nerve. It is distributed to the structures over the frontal bone me to the supra-orbital artery, with which it anastomoses, as well as its fellow of the opposite side.

The **supratrochlear vein (frontal vein)**, of large size, passes do wards near the median line, and at a point just above the medial a of the orbit is joined by the supra-orbital vein, the resultant ve being the angular vein. At the root of the nose it communicates its fellow of the opposite side by a transverse vessel, called the n **arch.**

The supra-orbital and supratrochlear veins communicate with e other, and with the tributaries of the anterior branch of the superfi temporal vein.

Occipito-frontalis.—This muscle consists of the following pa (1) two occipital bellies, (2) two frontal bellies, and (3) the epicra aponeurosis.

Each **occipital belly** arises from (1) the highest nuchal line of occipital bone; and (2) the outer surface of the mastoid process of temporal bone immediately above the insertion of the sterno-mas muscle.

Insertion.—The epicranial aponeurosis.

Each belly forms a thin, broad sheet, the length of the fasciculi ıg about $1\frac{1}{2}$ inches. The two bellies, right and left, are separated ards the median line by a portion of the epicranial aponeurosis, ch here dips down between them.

Each **frontal belly,** right and left, is separated superiorly by a :ow angular portion of the epicranial aponeurosis, but inferiorly y are in contact. *Origin.*—(1) The subcutaneous tissue of the

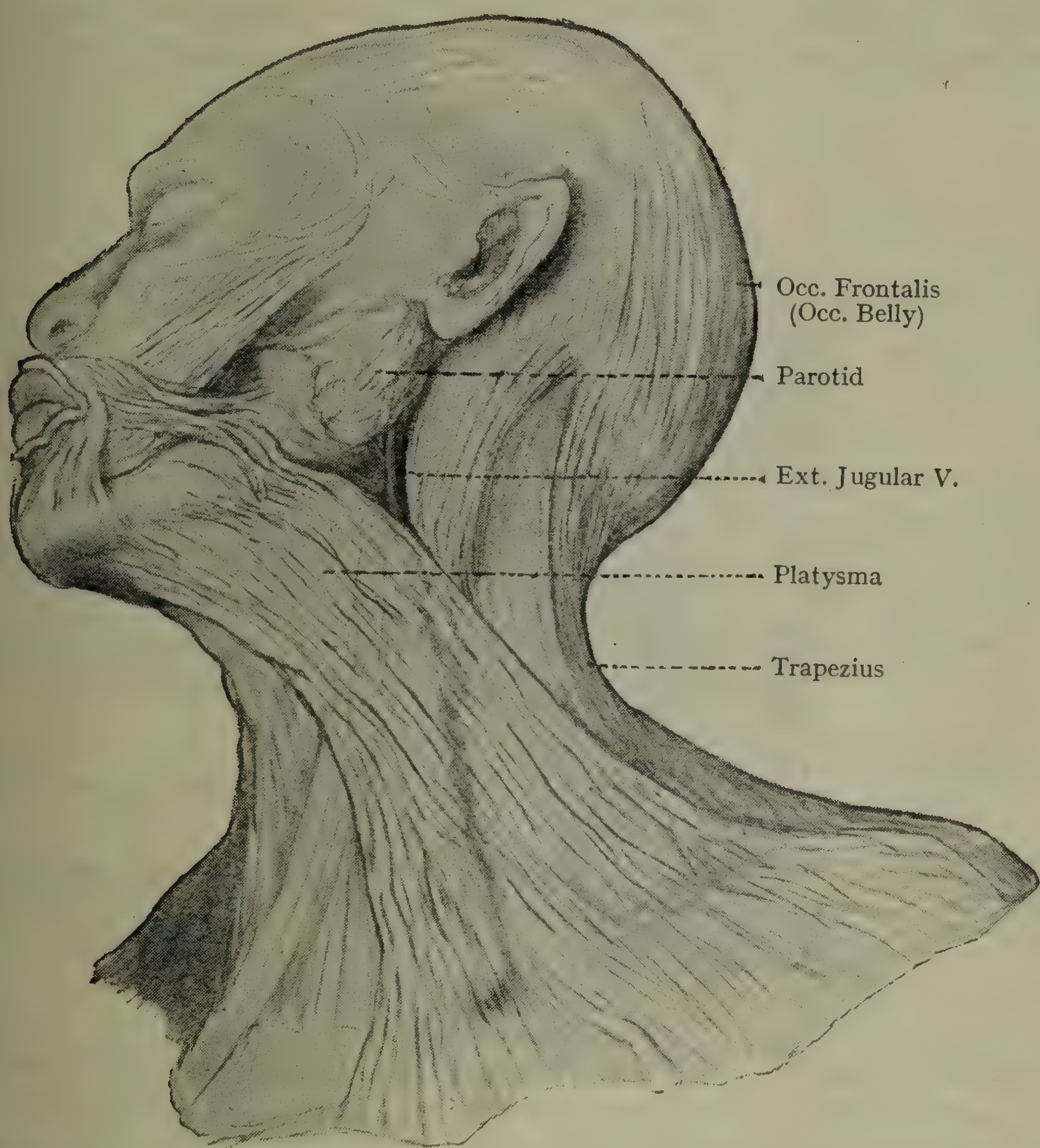


FIG. 695.—TO SHOW OCCIPITAL BELLY OF OCCIPITO-FRONTALIS.

›row and root of the nose, where the fibres blend with the upper : of the orbicularis oculi and the corrugator supercilii; and (2) slightly ı the zygomatic process of the frontal bone, and from the nasal e.

Insertion.—The epicranial aponeurosis a little below the level of fronto-parietal suture.

The fasciculi are about $3\frac{1}{2}$ inches long, and the innermost fibres riorly are regarded by some as being prolonged downwards upon nasal bone as the procerus muscle.

Epicranial Aponeurosis.—This is the intermediate tendon of occipito-frontalis muscle. It forms an aponeurotic stratum bene the superficial fascia, and is connected firmly to the skin by fib processes, which separate the subcutaneous tissue into lobules. deep surface is loosely connected by areolar tissue to the subja periosteum. Posteriorly it gives insertion to the two occipital be and in the interval between these it dips down to be attached to inner part of the superior nuchal line of the occipital bone and external occipital protuberance. Anteriorly it gives insertion to two frontal bellies. Laterally, below the superior temporal it is prolonged downwards over the temporal fascia as a deli

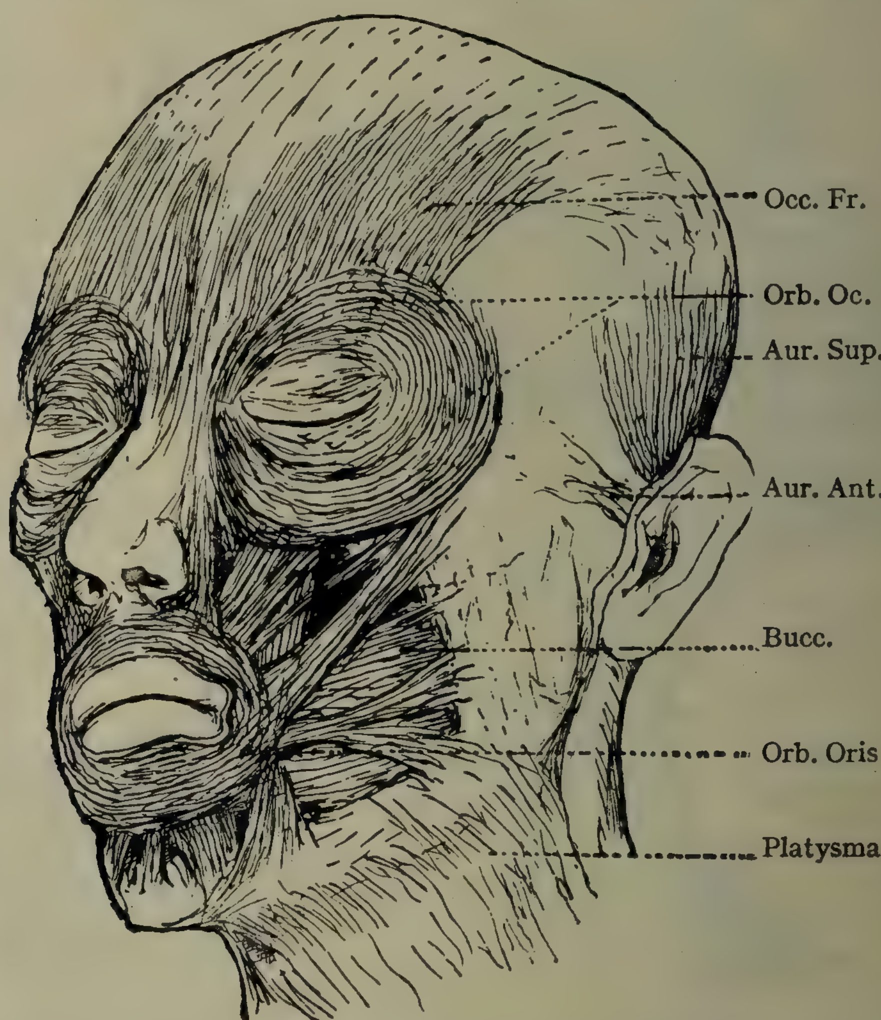


FIG. 696.—SHOWS FRONTAL PORTION OF OCCIPITO-FRONTALIS.

expansion, which gives origin to the auricularis superior and auricul anterior muscles. It is connected to the superior temporal line b thickening of the loose areolar tissue between it and the bone.

Nerve-supply.—Each occipital belly is supplied by the poste auricular branch of the facial nerve, and each frontal belly is supp by the temporal branches of the facial nerve.

Action.—The two occipital bellies draw backwards the epicra aponeurosis, and along with it the scalp. The two frontal bellies from above, elevating the eyebrows, and throwing the skin of frontal region into transverse wrinkles. When the occipital and fro bellies act simultaneously the scalp is drawn backwards, and eyebrows are forcibly raised. In certain cases the frontal bellies

n the reverse direction, their lower attachment being fixed by other muscles, such as the orbicularis oculi, corrugator supercilii, and erus. When this is done the scalp may be alternately twitched ard and backward, a simian habit which may be acquired by tice.

Pericranium.—This is the periosteum of the cranium, and it is ely connected by areolar tissue to the superjacent epicranial neurosis.

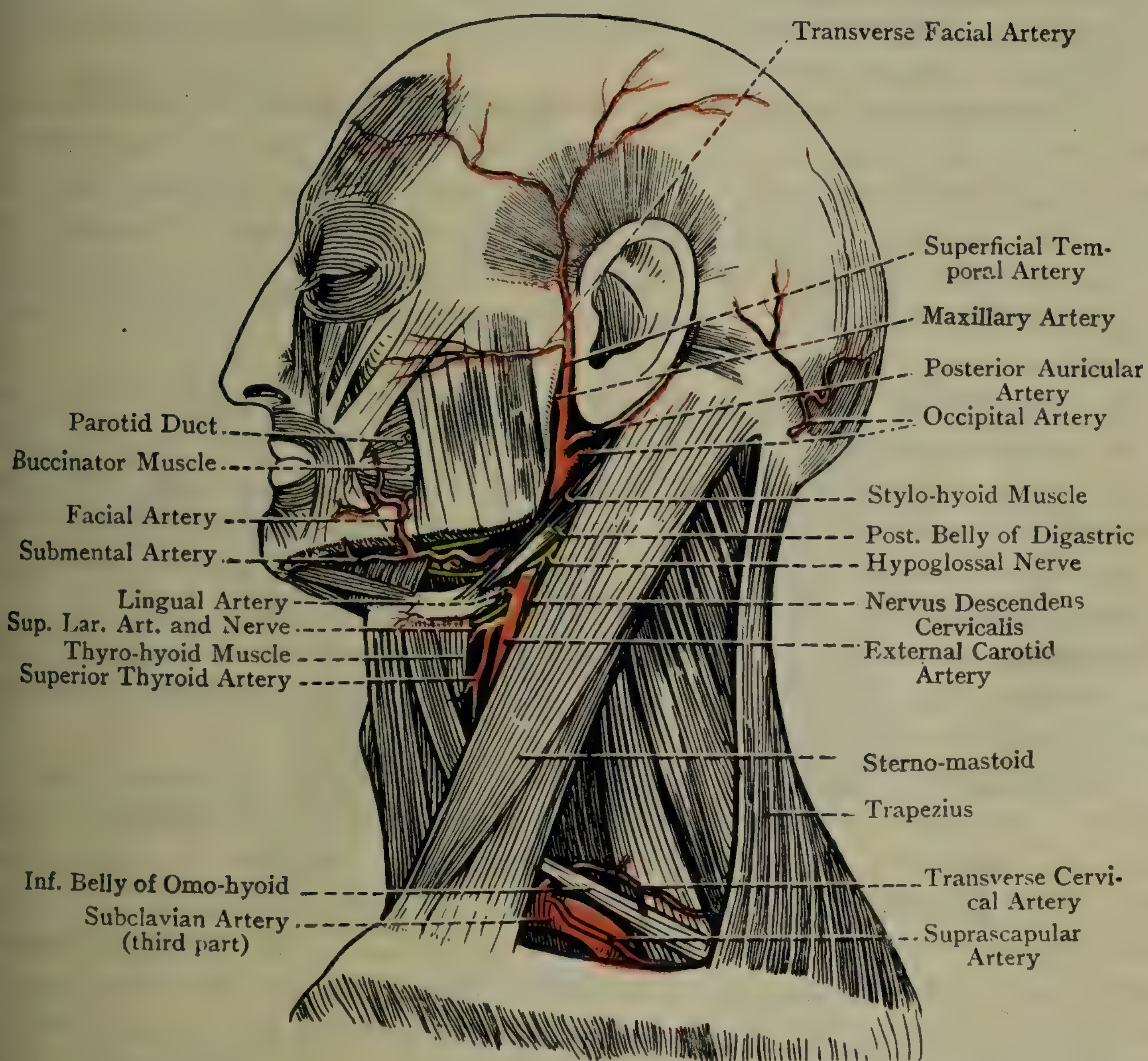


FIG. 697.—THE LEFT SIDE OF THE HEAD AND NECK. The platysma has been removed.

The **temporal branches of the facial nerve** pass upwards a little in t of the auricle, and supply the following muscles: the frontal y of occipito-frontalis, upper part of the orbicularis oculi, corruor supercilii, auricularis superior and auricularis anterior. They municate with the auriculo-temporal, zygomatico-temporal, and a-orbital nerves.

The **auriculo-temporal nerve** is a branch of the mandibular nerve, ch is the third division of the fifth cranial nerve. It emerges just nd the capsule of the mandibular joint, turns upwards round the of the zygoma, and ascends immediately in front of the auricle in

company with the superficial temporal artery, lying between that ve
and the auricle.

Branches.—In this part of its course the nerve furnishes
following branches: (1) two *branches to the external auditory meat*
which enter the canal between its osseous and cartilaginous walls,
supply the integument of the meatus, the upper of the two branc
giving an offset to the tympanic membrane; (2) two *auricular branc*
which supply the skin of the tragus and outer aspect of the aur
over less than its upper half; and (3) *superficial temporal branc*
which supply the integument above and in front of the auricle, and
the temporal region generally.

The **zygomatico-temporal nerve (temporal branch of temporo-ma
nerve)** from the maxillary is of small size, and pierces the tempo
fascia about 1 inch above the anterior part of the zygoma, and c
behind the frontal process of the zygomatic bone. Having co
municated with one of the temporal branches of the facial nerve
has a limited distribution to the integument of the anterior part
the temporal region.

The **superficial temporal artery** is one of the terminal branches
the external carotid artery, from which it arises within the paro
gland on a level with the neck of the mandible. Leaving the gla
it ascends in front of the auricle in company with the auriculo-tempo
nerve, which lies between the vessel and the auricle, and after a cou
of about 2 inches it divides into its two terminal branches.

Branches.—These are as follows: (1) transverse facial; (2) articul
(3) auricular; (4) middle temporal; (5) zygomatic; and (6) termina
namely, anterior and posterior.

The **transverse facial artery** will be described in connection w
the face. It arises within the parotid gland, and in its course furnis
glandular branches. The **articular branches** supply the mandibu
joint. The **auricular branches** supply the outer aspect of the auri
and in part the external auditory meatus. The **middle tempo
artery** pierces the temporal fascia immediately above the zygoma,
then ascends in a groove on the outer surface of the squamous p
of the temporal bone deep to the temporalis. It gives branches to
temporalis, and anastomoses with the deep temporal branches of
maxillary artery. The **zygomatic artery** passes forwards close above
zygoma, where it lies between the two layers of the temporal fas
It is distributed to the outer part of the orbicularis oculi muscle.
anterior branch passes forwards and upwards in a tortuous mann
and is distributed to the structures covering the frontal bone, wher
anastomoses with the supra-orbital and supratrochlear branches of
ophthalmic artery, and with its fellow of the opposite side.
posterior branch takes an arched course upwards and backwa
above the auricle, supplying the adjacent structures, and anas
mosing with the posterior auricular and occipital arteries, and w
its fellow of the opposite side (see Fig. 698).

The arteries of the scalp are peculiar in many ways. In the f

e they are very superficial, lying in the fatty layer of the scalp deep to the skin; they are thus very liable to injury, and in old le, where their walls are hardening and the superficial fat diminish- they may easily be seen in the temporal region.

n the second place they are very tortuous, a condition which is lly associated with arteries supplying movable parts, and in ge this tortuosity increases.

hirdly, they not only anastomose with one another, as most ies do, but they anastomose freely across the middle line, thus g wonderful vitality to a piece of scalp which has been torn away st completely.

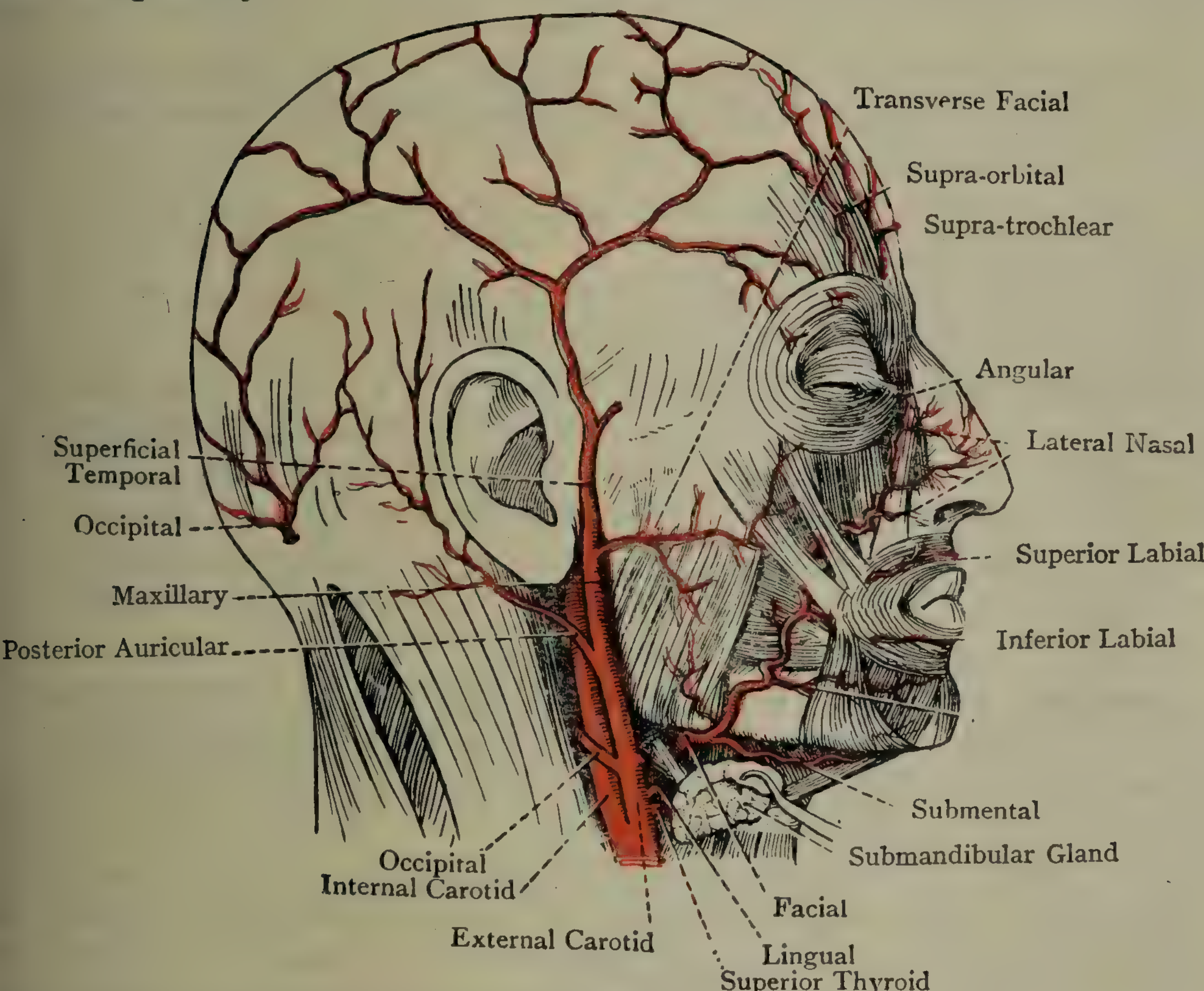


FIG. 698.—THE ARTERIES OF THE RIGHT SIDE OF THE HEAD (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

ourthly, when cut they bleed most profusely, because their walls prevented from collapsing by the dense connective tissue between skin and the epicranium in which they lie. For this reason, too, difficult to pick them up when they have to be tied.

he **superficial temporal vein** is formed in front of the auricle by union of an anterior and a posterior branch, the former communi- ng freely with the supra-orbital and supratrochlear veins, and the er with the posterior auricular vein and the occipital venous plexus. ve the zygoma it is joined by the middle temporal vein, which inates in a plexus in the temporal fossa, and pierces the temporalis temporal fascia, receiving in its course the zygomatic vein. The erficial temporal vein then descends over the zygoma and enters

the parotid gland, within which it receives the auricular, articu
and transverse facial veins. Finally, it joins the maxillary vein ab
the level of the neck of the mandible to form the posterior facial v
(temporo-maxillary vein).

Extrinsic Muscles of the Auricle.—These are three in number,
follows: (1) auricularis superior; (2) auricularis anterior; and (3) aur
laris posterior.

Auricularis Superior (Attollens Aurem)—*Origin.*—The lateral par
the epicranial aponeurosis and temporal fascia.

Insertion.—The inner or cranial surface of the auricle over
convexity corresponding to the fossa of the antihelix on its ou
surface.

Nerve-supply.—The temporal branches of the facial nerve.
posterior part of the muscle may be supplied by the posterior auricu
branch of the facial nerve.

The muscle is very thin, pale, and fan-shaped, and its fibres c
verge in a downward direction.

Action.—To raise the auricle, though all the auricular muscles
vestigial in man and practically functionless.

Auricularis Anterior (Attrahens Aurem)—*Origin.*—The lateral p
of the epicranial aponeurosis in front of the auricularis superior, w
which muscle it is continuous. Also from the temporal fascia.

Insertion.—The anterior part of the helix of the auricle.

Nerve-supply.—The temporal branches of the facial nerve.

The muscle is directed backwards.

Action.—To draw forwards the auricle.

Auricularis Posterior (Retrahens Aurem)—*Origin.*—The upper p
of the outer surface of the mastoid process of the temporal bone.

Insertion.—The inner or cranial surface of the auricle over
convexity of the concha.

Nerve-supply.—The posterior auricular branch of the facial nerv

The muscle is directed forwards.

Action.—To draw back the auricle.

The auricularis posterior is more distinct than the other two musc
and is usually arranged in two bundles.

Behind the ear, in the **mastoid region,** which is not a part of
scalp proper, there are certain structures which have some connect
with the scalp. These comprise posterior auricular nerves (branc
of the facial and vagus), posterior auricular vessels, and poste
auricular lymph glands.

Posterior Auricular Nerve.—This is a branch of the facial ne
immediately after it emerges from the facial canal through the st
mastoid foramen. It passes upwards between the mastoid pro
and the auricle, where it lies deeply in company with the poste
auricular artery, and it divides into two branches—auricular
occipital. The *auricular branch* supplies the auricularis poste
muscle on its deep aspect, and those intrinsic muscles of the au
which lie on its inner or cranial aspect. It may also send a bra

vards beneath the auricularis posterior to supply the posterior t of the auricularis superior. The *occipital branch* passes back-rds, lying deep to the lesser occipital nerve and posterior branch the great auricular, and supplies the corresponding half of the ipital belly of the occipito-frontalis muscle. The posterior auricular ve communicates with the lesser occipital and great auricular ves, and also with the auricular branch of the vagus.

The Auricular Branch of the Vagus Nerve (Nerve of Arnold).—This ι branch of superior ganglion of the nerve. Having traversed the stoid canaliculus in the petrous part of the temporal bone, it erges through the tympano-mastoid fissure between the mastoid cess and tympanic plate, and then divides into two branches. One nch takes part in the supply of the inner or cranial surface of the icle, and also supplies the lower and back part of the external litory meatus; and the other branch joins the posterior auricular ve.

Posterior Auricular Artery.—This vessel is one of the two posterior nches of the external carotid artery, the other branch being the ipital artery. Having passed backwards and upwards on the loid process under cover of the parotid gland, it lies deeply between mastoid process and the auricle in close relation to the posterior icular nerve, and divides into two branches—auricular and occipital. e *auricular branch* supplies the inner or cranial surface of the auricle l adjacent structures, and it anastomoses with the posterior branch the superficial temporal artery. The *occipital branch* passes back-rds to the occipital belly of the occipito-frontalis muscle, and istomoses with the occipital artery.

The **posterior auricular vein** is of fairly large size, and returns the od from the lateral portion of the scalp posteriorly and the inner face of the auricle. Its radicles communicate with the occipital xus and with the posterior branch of the superficial temporal vein. e vessel passes downwards and forwards over the upper part of the rno-mastoid muscle, and terminates on this muscle about the level the angle of the mandible by joining the posterior division of the sterior facial vein to form the external jugular vein.

Mastoid Lymph Glands (Posterior Auricular Lymph Glands).—These all glands lie close to the insertion of the sterno-mastoid muscle. ey receive their afferent lymphatics from the lateral part of the back the scalp and the back of the auricle, and their efferent lymphatics ss to the upper deep cervical lymph glands.

Temporal Fascia.—This is a strong aponeurosis which covers the nporalis. Superiorly it is attached from before backwards to the nporal border of the zygomatic bone, the superior temporal line of frontal and parietal bones, and the supramastoid crest of the nporal bone. Inferiorly it divides into two laminæ, which are ached to the outer and inner margins of the upper border of the gomatic arch. Between these two laminæ there are a small amount adipose tissue, and the zygomatic branch of the superficial temporal

artery, and the zygomatico-temporal nerve. Superficial to the fasc there are the delicate prolongation of the lateral portion of the ep cranial aponeurosis and the auriculares superior et anterior muscl with the superficial temporal vessels and auriculo-temporal nerv Superiorly the fascia gives origin by its deep surface to superfic fibres of the temporalis, but it is separated from that muscle towar the zygoma by fat.

The **temporalis muscle** is described on p. 1302.

Lymphatic Vessels of the Scalp—Frontal Region.—These pass the parotid lymph glands. The *anterior lymphatics* pass directly the parotid lymph glands, and the *posterior lymphatics* terminate in t mastoid lymph glands.

The Scalp as a Whole.—Before leaving the scalp it may be w to review its general structure and to notice that it is made up of fi layers.

(1) The *skin* is very thick, and needs a firm incision to penetrate

(2) The *subcutaneous tissue* binds the skin closely to the epicrani aponeurosis, with which it moves; it contains lobular, granulated f in which are the bloodvessels and nerves as well as the roots of t hair follicles. On account of the presence of the nerves as well as of t density of the connective tissue any suppuration in this layer will strictly localized and very painful.

(3) The *epicranial aponeurosis* is formed by the very thin, flatten tendon of the occipito-frontalis muscle.

(4) The *subaponeurotic layer*, sometimes known to surgeons as t '*dangerous layer*' of the scalp, is composed of very loose connecti tissue, and is little more than a lymph space. The looseness of t cellular tissue allows the first three layers to move freely over t skull, and if septic matter reaches it and suppuration follows, t pus readily spreads all over the space and tends to bag at the mo dependent points in front and behind. The absence of nerves and t looseness of the tissue account for the little pain which accompani suppuration in this layer.

(5) The periosteum or pericranium covers the skull bones, and continuous with the dura mater at the sutures as long as these a unclosed. For this reason a subpericranial collection of blood pus will be limited to the area of one skull bone, while a subepicrani collection, as has been seen, has no such definition.

Basal Part of the Cranial Cavity.

Dura Mater on the Base of the Skull.—A full and general accou of the membranes of the brain will be found on p. 1598 *et seq.*; short description of the dura mater, as it is seen on the base of t skull after removal of the brain, will be given here.

The dura mater is seen to be continuous with the falx cerebri in t middle line in front. Just outside this it covers the cribriform pla of the ethmoid at the bottom of a well-marked hollow which contai

olfactory bulb. External to this it covers the irregularities of the
tal plate of the frontal and the lesser wing of the sphenoid behind
. In the middle fossa it lines the so-called 'optic groove,' and at
ı end of this is carried into the optic foramina. Behind the groove
ɔrms the *diaphragma sellæ*, covering the hypophyseal fossa, while
; pierced by the internal carotid artery just behind the foramen.
diaphragma sellæ shows a central hole for the infundibulum of
hypophysis cerebri. The membrane is attached to the clinoid
cesses and the interclinoid ligaments, and stretches outwards from
se to line the hollow of the greater wing and upper surfaces of the
rous bone. It is carried upwards and forwards here to cover the
erior orbital fissure and gain the lower aspect of the lesser wing.
mall fold of dura mater projects from the edge of the lesser wing
he sphenoid, the *sphenoidal fold*, and a small 'lunula' overhangs
optic foramen. At the upper border of the petrous bone the
nbrane projects upwards and inwards as the *tentorium cerebelli*,
ch is a two-layered reflection of the dura mater. Below the
torium it lines the posterior fossa, and presents apertures through
ch all the nerves which come from the pons and medulla pass to
ch their bony foramina. A small fold, the falx cerebelli, projects
he middle line behind. The dura mater becomes continuous with
spinal dura at the foramen magnum, but the exact position of this
ımen is not easily distinguished when the membrane is in position,
ng to the smooth, continuous slope formed by it as it passes from
basi-occiput over the odontoid process and its ligaments into the
tebral canal.

Certain structures lie deep to the dura mater, between it and the
ıy skull—*i.e.*, between the *inner layer*, which we have been consider-
, and the *outer* layer, which covers the bones. These are venous
ıses, nerves, and arteries. The venous sinuses on the base of the
ll are (see p. 1603 *et seq.* for further details):

The *sigmoid*, running downwards and then forwards in the posterior
sa to reach the jugular foramen.

The *inferior petrosal*, passing forwards and upwards from the
ular foramen to the apex of the petrous bone along its lower edge.

The *superior petrosal*, running forward along the upper edge of the
rous bone at the base of the tentorium cerebelli.

The *cavernous*, placed on the side of the body of the sphenoid
ere this joins the greater wing, and formed by the junction of the
ɔ petrosal sinuses; in front it is continuous with the superior oph-
lmic vein and with the *spheno-parietal sinus*, which lies in the fold
lura mater along the lesser wing of the sphenoid.

The *circular sinus* is a spongy venous network which surrounds
pituitary body and connects the two cavernous sinuses.

The *transverse sinus* lies under the central basal dura mater, and
n the form of a network joining the inferior petrosal sinuses.

The cranial nerves must necessarily pierce the dura mater to
ch and pass through the base of the skull, and the situations of the

points of passage through the membranous and bony parts do n always correspond. Those nerves which leave the skull in relati with the greater wing of the sphenoid pass through the dura mat at points some distance behind their bony foramina, and in the inte vening parts of their courses lie deep to the inner layer of dura mate lying near or in relation with the cavernous sinus. These nerv

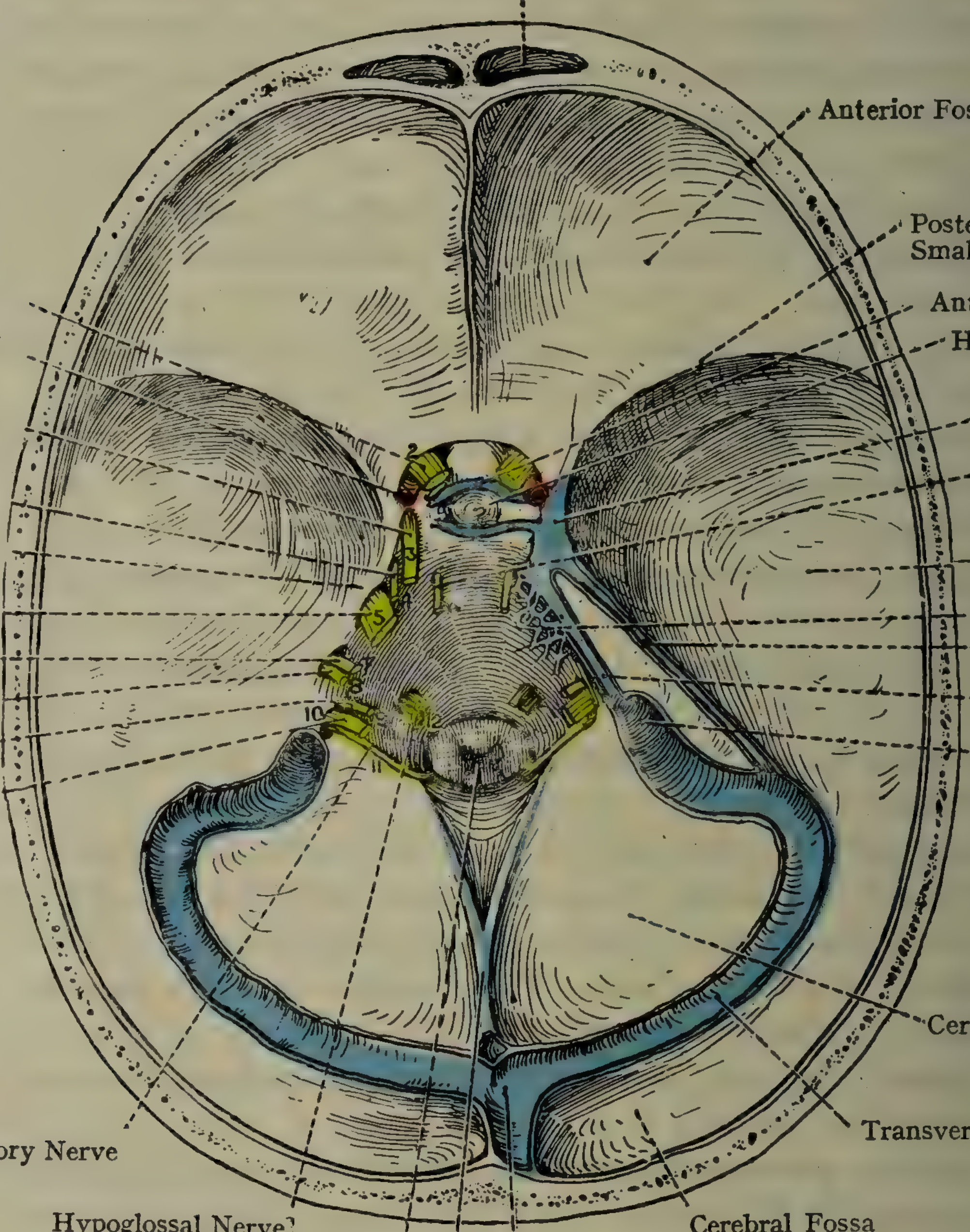


Fig. 699.—The Internal Base of the Skull, showing the Cranial Nervi and Venous Sinuses.

are the oculo-motor, trochlear, trigeminal, and abducent; the oth cranial nerves pierce the dura mater opposite their bony foramina.

It is not quite correct to say that the cranial nerves 'pierce' the dura mat at the places where their apertures of exit are seen; they carry out with the a covering from the membrane, so that they could be described rightly evaginating it. The covering layer, however, is so thin in most cases, and so soon lost in the ordinary fibrous sheath of the nerve, that little exceptic is taken to the descriptive expression 'piercing.' In the case of the trigemin nerve, however, the evaginated covering of dura mater is better marked, and

:he whole, looser; it envelops the roots of the nerve and the trigeminal glion, and is known as the *cavum trigeminale* (*Meckel's cave*). The cavum ;minale, therefore, lies between the dura and the skull. The optic nerve, eover, should not be described as ' piercing ' the membrane, for the eye and iervous stalk are developmentally parts of the brain itself, and the dura er is carried along the nerve to become directly continuous with the sclerotic : of the eye, which represents the same layer.

Some other nerves, such as the superficial petrosals and the naso- ıry in a part of its course, lie deep to the dura mater, and will be cribed later.

All the *meningeal vessels* lie between skull and dura mater, and do pierce the inner membranous layer. The only things which pass ough this layer are the *cranial* nerves and the *cerebral* vessels; se last are represented by (*a*) the internal carotid, which, lying irst between dura and bone with the cavernous sinus, pierces the nbrane medial to the anterior clinoid process to reach the brain; . (*b*) the vertebral arteries, which pierce the membrane below the ll and run up through the foramen magnum to reach the brain. tain cerebral veins pierce the dura mater at various points (see p. 8) to open into extradural sinuses.

The aqueduct of cochlea is described as passing through the dura to reach subarachnoid space, and the endolymphatic duct lies between the membrane the bone.

Cranial Nerves at the Base of the Skull.—The cranial nerves are ınged in twelve pairs, and as they leave the cranial cavity they eive sheaths from the meninges of the brain.

The **olfactory bulb** rests upon one half of the cribriform plate of ethmoid bone, with dura mater interposed. Through the fora- ıa of that plate it receives about twenty **olfactory filaments,** which se as the axons of the olfactory cells of the olfactory mucous nbrane of the nasal fossa.

The **optic nerve** passes forwards and outwards from the optic asma to the optic foramen, through which it enters the orbit. It ccompanied by the ophthalmic artery, which lies below and lateral t. Before reaching the foramen it is crossed by the anterior cerebral ery, and the internal carotid comes through the dura mater just ind and lateral to it.

The **third** or **oculo-motor nerve** pierces the dura mater, which ms the upper and outer wall of the cavernous sinus, a little in front the posterior clinoid process of the sphenoid bone.

The **fourth** or **trochlear nerve,** of small size, pierces the dura mater a point a little behind the posterior clinoid process of the sphenoid ie, lateral to the third nerve, and in or just beneath the free margin the tentorium cerebelli. Afterwards it traverses the outer wall of cavernous sinus.

The **fifth** or **trigeminal nerve** consists of two roots—sensory and tor. These two roots pierce the dura mater near the apex of the rous part of the temporal bone below the tentorium, and enter

a recess of the dura mater, called the *cavum trigeminale* (*Meckel's cav*
where they will be presently described.

The **sixth** or **abducent nerve** pierces the dura mater $\frac{3}{4}$ inch behi
the level of the posterior clinoid process, and near the apex of t
petrous bone, where it enters the inferior petrosal sinus. It lies
little to the inner side of the fifth nerve.

The **seventh** or **facial nerve,** the **eighth** or **auditory nerve,** acco
panied by the internal auditory artery, enter the internal meatus.

The **ninth** or **glosso-pharyngeal nerve,** the **tenth** or **vagus ner**
and the **eleventh** or **accessory nerve** pass through the middle compa

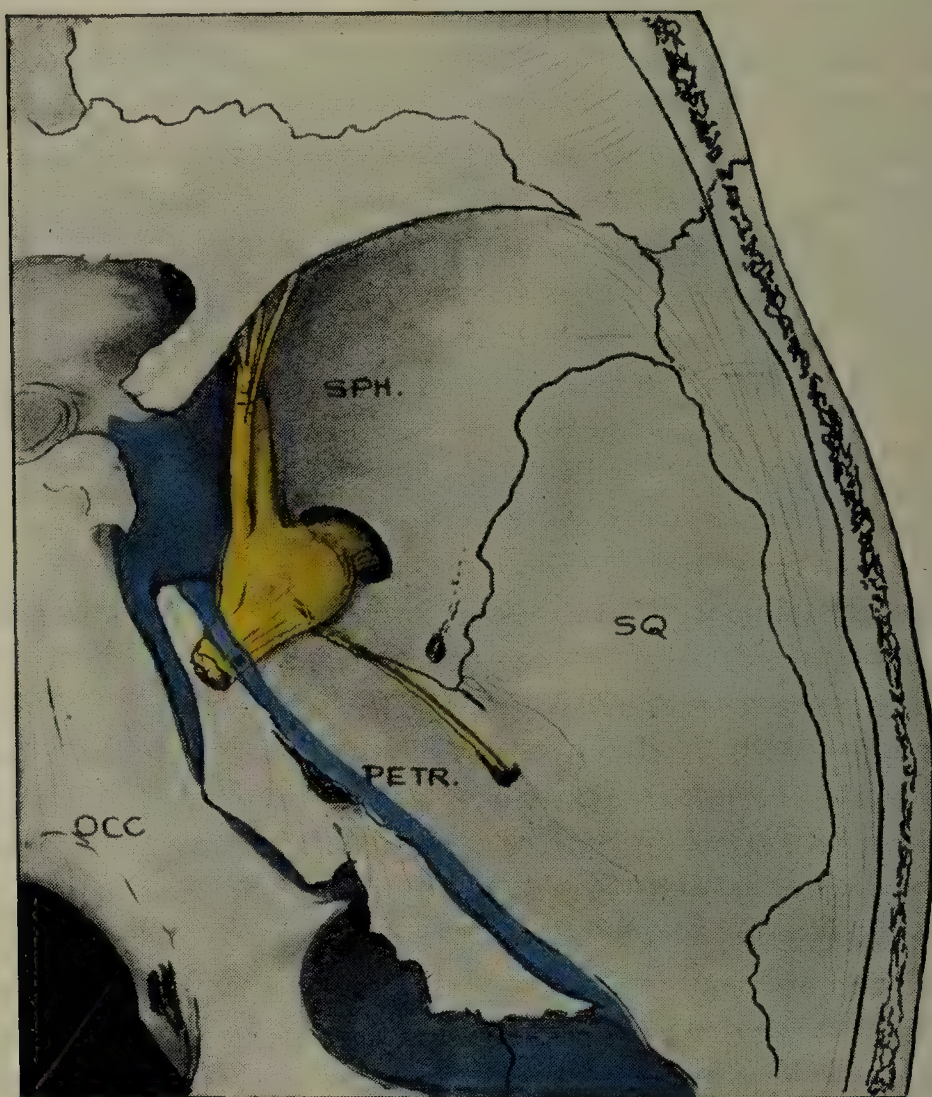


Fig. 700.—Showing the Venous Sinuses on the Petrous Bone, and
Relation with the Trigeminal Nerve.

Also shows great superficial petrosal nerve.

ment of the jugular foramen. This foramen is divided into th
compartments—namely, antero-medial, middle, and postero-later
The *antero-medial compartment* gives passage to the inferior petro
sinus. The *middle compartment* transmits the glosso-pharyngeal, vag
and accessory nerves, in this order from before backwards. T
glosso-pharyngeal nerve pierces the dura mater separately, a
receives special sheaths from the dura mater and arachnoid membra
The vagus and accessory nerves pass together through a sin
aperture in the dura mater, and receive common sheaths from t
dura and arachnoid membrane. The *postero-lateral compartment* tra

s the sigmoid sinus, which terminates in the internal jugular vein. the vein is deep to the dura, this part of the foramen cannot be ı directly when the dura mater is in position.

The **twelfth** or **hypoglossal nerve** pierces the dura mater in two ıdles, which pass through separate apertures. As these bundles s through the anterior condylar canal they unite to form one nerve. ween the points of exit of the hypoglossal and the last three nerves jugular tubercle is seen, forming a very useful landmark.

Structures passing through the Foramen Magnum.—(1) The medulla ɔngata, with its membranes, passes out and becomes the spinal d. (2) The *spinal root* of the accessory nerve of either side, having ɜnded from the interval between the posterior roots of the cervical ıal nerves and the ligamentum denticulatum, enters the cranial ity. It then turns outwards behind the jugular tubercle to the ldle compartment of the jugular foramen, where it meets the *ıial root* of the nerve, with which it becomes closely connected it passes through the foramen. (3) The vertebral artery of each ː enters the cranial cavity after having pierced the dura mater. The two anterior spinal branches of the vertebral arteries descend the front of the medulla oblongata, and, inclining inwards towards h other, they unite in passing through the foramen magnum to n the anterior spinal artery, the membrana tectoria, and the apical ment of the odontoid process.

Trigeminal Ganglion (Gasserian Ganglion) (Fig. 700).—The tri- ıinal ganglion occupies the trigeminal impression (Gasserian im- ssion) on the superior surface of the petrous part of the temporal ıe near the apex, where its posterior part lies in a recess of the a mater, called the *cavum trigeminale* (*Meckel's cave*). It is some- ıt semilunar, being convex in front and concave behind, and measures y ½ inch from before backwards. It is associated with the sensory t of the fifth nerve, which, before entering the posterior concave ect of the ganglion, becomes expanded, its fasciculi at the same e becoming separated and assuming a plexiform arrangement. dially the ganglion is intimately related to the back part of the ernous sinus, and by its inner and lower aspect to the internal otid artery in the foramen lacerum, and on this aspect it receives icate filaments from the internal carotid sympathetic plexus. The tor root of the fifth nerve, small in size, lies below the deep surface the ganglion; but there is no blending of the two sets of fibres, the tor root passing independently in an outward direction to the amen ovale. The greater superficial petrosal nerve, on its way to foramen lacerum, passes beneath the ganglion, though not in the um trigeminale.

The ganglion contains cells similar to those of a spinal ganglion, l it receives its blood from the middle and accessory meningeal eries. It is important in connection with modern surgery to notice t the front part of the ganglion does not lie in the cavum tri- ninale, but has a close investment of dura mater. Hence the front

part may be removed without opening the subarachnoid space allowing cerebro-spinal fluid to escape.

Branches.—The branches of the ganglion arise from its anteri convex aspect, and are known as *divisions*. They are as follow the first or ophthalmic division; the second or maxillary divisio and the third or mandibular division. The ophthalmic and maxilla nerves are entirely sensory, but the mandibular nerve, being join by the motor root, is both sensory and motor.

The **first division of the trigeminal nerve,** or the **ophthalmic nerv** is the smallest of the three branches of the ganglion. It passes fo wards in the outer wall of the cavernous sinus, where it lies below t fourth nerve. On approaching the superior orbital fissure it divid into branches in the following order from behind forwards: (1) **nas ciliary (nasal),** (2) **lacrimal,** and (3) **frontal.** All these three branch enter the orbit through the superior orbital fissure. As the ophthalm nerve passes forwards it receives a communicating branch from t internal carotid sympathetic plexus, and it furnishes the *nervus tento* to the tentorium cerebelli. It also communicates with each of t oculo-motor, trochlear, and abducent nerves.

The naso-ciliary nerve, having passed through the orbit, re-ente the skull by running between the orbital plate of the frontal and t upper surface of the ethmoid. It then lies deep to the dura mater the cribriform plate near its anterior extremity, and soon disappea by passing down between this bone and the nasal area of the fronta

The **second division of the trigeminal nerve,** or the **maxillary ner (superior maxillary nerve),** passes horizontally forwards for a sho distance in the lower part of the outer wall of the cavernous sinus, a it leaves the cranial cavity through the foramen rotundum, whi leads to the pterygo-palatine fossa. Before leaving the cranial cavi it furnishes the delicate *meningeal nerve* to the dura mater of t middle fossa.

The **third division of the trigeminal nerve,** or the **mandibular ner (inferior maxillary nerve),** is the largest of the three branches of t ganglion. It passes downwards to the foramen ovale, through whi it leaves the cranial cavity, and so enters the infratemporal foss It is accompanied by the motor root of the fifth nerve, which joi it as it passes through the foramen ovale. The *nervus spinosus* fro the mandibular nerve is not given off until after the parent trun has issued through the foramen ovale, and it enters the cranial cavi through the foramen spinosum in company with the middle meninge artery. It then divides into two branches, anterior and posterior. T *anterior branch* supplies the dura mater over the greater wing of t sphenoid bone, and the *posterior branch* passes through the fissu between petrous and squamous parts of the temporal bone to supp the mucous membrane of the mastoid air-cells.

Greater Superficial Petrosal Nerve.—This nerve is a branch of the gangli of the facial nerve in the facial canal. It enters the middle fossa of the ba of the skull through its hiatus, and passes forwards and inwards in a groove

anterior surface of the petrous part of the temporal bone. Having passed ath the trigeminal ganglion embedded in the dura mater, it enters the upper of the foramen lacerum, where it is placed on the outer side of the internal tid artery, and it joins the deep petrosal nerve from the internal carotid pathetic plexus. In this manner the nerve of the pterygoid canal is formed, h enters the latter canal by its opening on the anterior aspect of the foramen rum, and so reaches the spheno-palatine ganglion in the pterygo-palatine a. The greater superficial petrosal nerve is accompanied by the superficial osal branch of the middle meningeal artery.

Lesser Superficial Petrosal Nerve.—This nerve represents the continuation ugh the tympanic plexus of the tympanic branch (Jacobson's nerve) of the so-pharyngeal nerve. It is reinforced by a small branch from the ganglion he facial nerve, which joins it as it traverses a small canal in the petrous of the temporal bone beneath the canal for the tensor tympani muscle. nerve enters the middle fossa through a small opening on the lateral side he hiatus for the greater superficial petrosal nerve. It then passes for a forwards and inwards, and leaves the cranial cavity through the canaliculus minatus (when present), or through the fissure between the petrous temporal the greater wing of the sphenoid, or, it may be, through the foramen ovale, which it terminates in the otic ganglion.

External Petrosal Nerve.—This nerve, which is inconstant, passes from the pathetic plexus on the middle meningeal artery backwards and outwards he anterior surface of the petrous part of the temporal bone, and it leaves cranial cavity through a minute aperture situated within the thin margin he hiatus for the greater superficial petrosal nerve. It ends in the ganglion he facial nerve.

Interior of the Cavernous Sinus.—The interior of this sinus is ken up by a network of delicate trabeculæ. The outer wall of sinus contains the following ial nerves, in order from above nwards: the oculo-motor, the hlear, the ophthalmic division he trigeminal, and the maxil- division of the fifth. These ves, as they pass forwards, separated from the blood- rent by the endothelial lining the outer wall of the sinus. cavity of the sinus is trav- d by (1) the cavernous portion the internal carotid artery, rounded by a plexus of sym- hetic filaments; and (2) the ucent nerve, which lies in

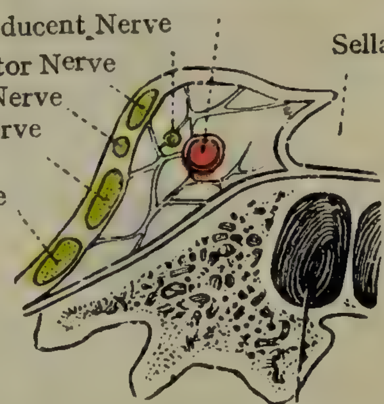


FIG. 701.—DIAGRAM OF THE LEFT CAVERNOUS VENOUS SINUS AND ITS OUTER WALL, SHOWING THE RELATIVE POSITIONS OF THE CONTAINED STRUCTURES (POSTERIOR VIEW).

e contact with the outer side of the artery. These structures are separated from the blood-current by the endothelial lining of the is.

For the processes and other sinuses of the dura mater see p. 1601.

Cavernous Portion of the Internal Carotid Artery.—This part of the rnal carotid artery lies within the cavernous sinus, which occupies carotid groove on the lateral aspect of the body of the sphenoid e. It is separated from the blood-current by the endothelial

lining of the sinus. The course of the vessel is at first upwarc between the lingula of sphenoid and the posterior petrosal process the sphenoid; then forwards as far as the anterior clinoid process the sphenoid; and finally upwards medial to the anterior clinc process. In the latter situation it pierces the dura mater, whi forms the roof of the cavernous sinus, and enters upon the cerebı part of its course.

The vessel is accompanied by the internal carotid sympathe plexus, and the abducent nerve lies in close contact with its out side, all being invested by the endothelial lining of the sinus.

FIG. 702.—RIGHT INTERNAL CAROTID PUT IN POSITION ON BASE OF SKUL AND CROSSED BY SIXTH NERVE.

Great superficial petrosal nerve is also seen.

Branches.—These are as follows: *hypophysial,* to the hypophys cerebri; *ganglionic,* to the trigeminal ganglion; *cavernous,* to the wa of the cavernous sinus, and to the oculo-motor, trochlear, trigemina and abducent nerves; *meningeal,* to the dura mater of the midd cranial fossa; and the *ophthalmic artery.* The latter vessel arises fro the cavernous portion of the internal carotid on the inner side of tl anterior clinoid process, and it enters the orbit, with the optic nerv through the optic foramen, lying at first beneath the nerve, and the on its outer side.

The Medial Part of the Internal Carotid Sympathetic Plexus (Caverı ous Plexus).—This plexus is situated principally on the inner and low aspects of the bend which the cavernous portion of the internal caroti

·y describes medial to the anterior clinoid process. Its branches as follows: (1) *vascular,* to the internal carotid artery and its ches; (2) *hypophysial,* to the **hypophysis cerebri**; (3) *communi-g,* to the oculo-motor, trochlear, ophthalmic division of the tri-inal, and abducent cranial nerves; and (4) the *sympathetic root* of ciliary ganglion. The last-named branch enters the orbit through superior orbital fissure.

The **hypophysis cerebri** (**pituitary body**) is a small oval mass which tuated in the hypophysial fossa, or sella turcica, of the sphenoid . It lies under cover of a circular fold of the dura mater, called the *hragma sellæ,* in the centre of which is an opening for the passage ie infundibulum. Its long measurement extends transversely, and nsists of two lobes—anterior and posterior. The anterior lobe is larger of the two, and the posterior lobe is connected with the rior part of the tuber cinereum by means of the infundibulum.

The **infundibulum** projects downwards from the anterior part of tuber cinereum to the posterior lobe of the pituitary body. Its er part is hollow, and contains innel-shaped diverticulum of the ty of the third ventricle.

tructure.—The **anterior lobe** consists of ral tubules lined with epithelium, and sted by capillary bloodvessels. The **erior lobe,** though developed from the 1, is destitute of nervous elements. It mposed of a reticulum of connective e, which contains branched cells. Be-n the two lobes is the **middle part.**

Development.—The **anterior lobe** is de-ped from a diverticulum of the buccal tomatodæal ectoderm, which is known ie **pouch of Rathke.** The diverticulum 's upwards, and, when the cranio-yngeal canal of early life becomes closed, connection of the diverticulum with the al ectoderm is severed. The diver-.um later on becomes converted into les, which form the anterior lobe. The **erior lobe** of the pituitary body and the ndibulum, which is connected with it, are loped as a diverticulum which grows nwards from that part of the diencephalon h forms the floor of the third ventricle. cavity of the diverticulum remains permanent in the upper part of its ndibular portion, but elsewhere it becomes obliterated. The lower part of diverticulum thereafter becomes converted into a reticulum of connective ie with branched cells, which forms the posterior lobe.

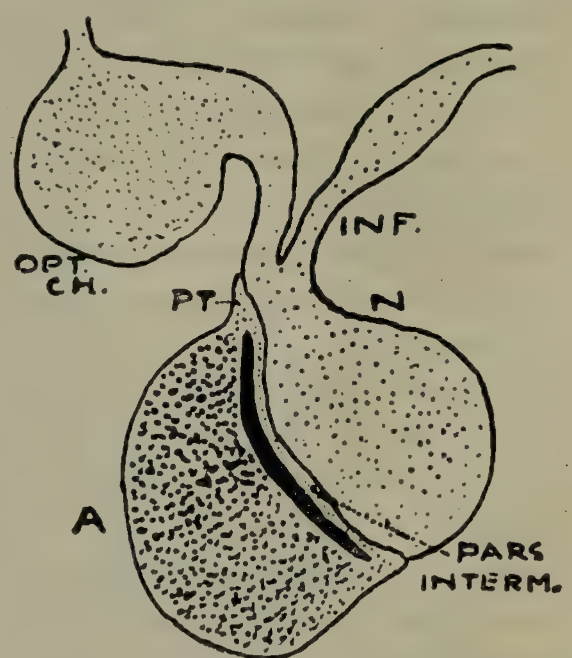


FIG. 703.—DIAGRAM OF ANTERO-POSTERIOR SECTION THROUGH THE HYPOPHYSIS.

A, anterior lobe: PT, its pars tuberalis. PARS INTERM., pars intermedia. N, neural or posterior lobe. INF, infundibulum. OPT. CH, optic chiasma.

Side of the Neck.

The side of the neck has a quadrilateral outline, the boundaries which are as follows: *superior,* the lower border of the mandible . a line prolonged from the angle of that bone over the mastoid

process to the inner third of the superior nuchal line of the occipi bone; *inferior*, the clavicle and one half of the upper border of t manubrium sterni; *anterior*, the middle line of the neck; and *posteri* the outer border of the trapezius in the neck.

Landmarks.—The body and angle of the mandible can easily felt, and the clavicle, together with the upper border of the manubri sterni, is conspicuous. A deep depression, called the supraster fossa, is perceptible above the upper border of the manubrium ster lying between the sternal heads of origin of the sterno-mastoid muscl The outline of the sterno-mastoid muscle is readily discernible when t head is turned so as to direct the face towards the opposite should The muscle extends in a diagonal direction from the sterno-clavicu joint to the mastoid process and outer half or two-thirds of the super nuchal line of the occipital bone, and it divides the side of the ne into two triangles—anterior and posterior. A small triangular inter may be felt between the sternal and clavicular heads of origin of t sterno-mastoid just above the inner end of the clavicle, in which t common carotid artery and internal jugular vein lie deeply. T external jugular vein crosses the sterno-mastoid muscle in the directi of a line extending from a point just behind the angle of the mandil to a point above the centre of the clavicle, and it is accompanied the superficial cervical glands. The common carotid artery lies unc cover of the anterior border of the sterno-mastoid muscle in the directi of a line drawn from the sterno-clavicular joint to a point midw between the angle of the mandible and the tip of the mastoid proc of the temporal bone. The vessel extends along this line as high the level of the upper border of the thyroid cartilage, above which is replaced by the external carotid artery. The internal jugular ve is close to the outer side of the common carotid artery, and the vag nerve lies deeply between the two vessels. If deep pressure is ma over the common carotid artery on a level with the cricoid cartila of the larynx, the anterior tubercle of the transverse process of t sixth cervical vertebra may be felt. It is known as the *carotid tuber* (*of Chassaignac.*)

The bifurcation of the innominate artery lies behind the upp border of the right sterno-clavicular joint, and the left common carot artery lies behind the left sterno-clavicular joint, while the lower pa of the internal jugular vein on each side is behind the inner end the clavicle. Near the middle line of the neck the anterior jugul vein descends vertically. The spinal root of the accessory ner passes downwards and outwards beneath the anterior border of t sterno-mastoid to pierce the deep part of that muscle at about t junction of the upper fourth and lower three-fourths. The nerve met with fully 1 inch below the tip of the mastoid process, and in t direction of a line let fall vertically from the mastoid tip. It is ve nearly on a level with the body of the hyoid bone. Along the posteri border of the sterno-mastoid some superficial cervical lymph glan may be felt.

Important structures occupy the middle line of the neck, and can usually distinguished without difficulty. These are as follows, in er from above downwards: (1) the body of the hyoid bone, lying : below the mandible, and having the greater horn projecting kwards and upwards on either side; (2) the thyro-hyoid membrane; the thyroid cartilage, with its laryngeal prominence (pomum ımi) in the middle line, leading up to the V-shaped thyroid notch the upper border, and its expanded ala on either side, each of which s behind in a superior and an inferior horn; (4) the crico-thyroid ment; (5) the narrow anterior part of the cricoid cartilage, which ıcides with the level at which the superior belly of the omo-hyoid

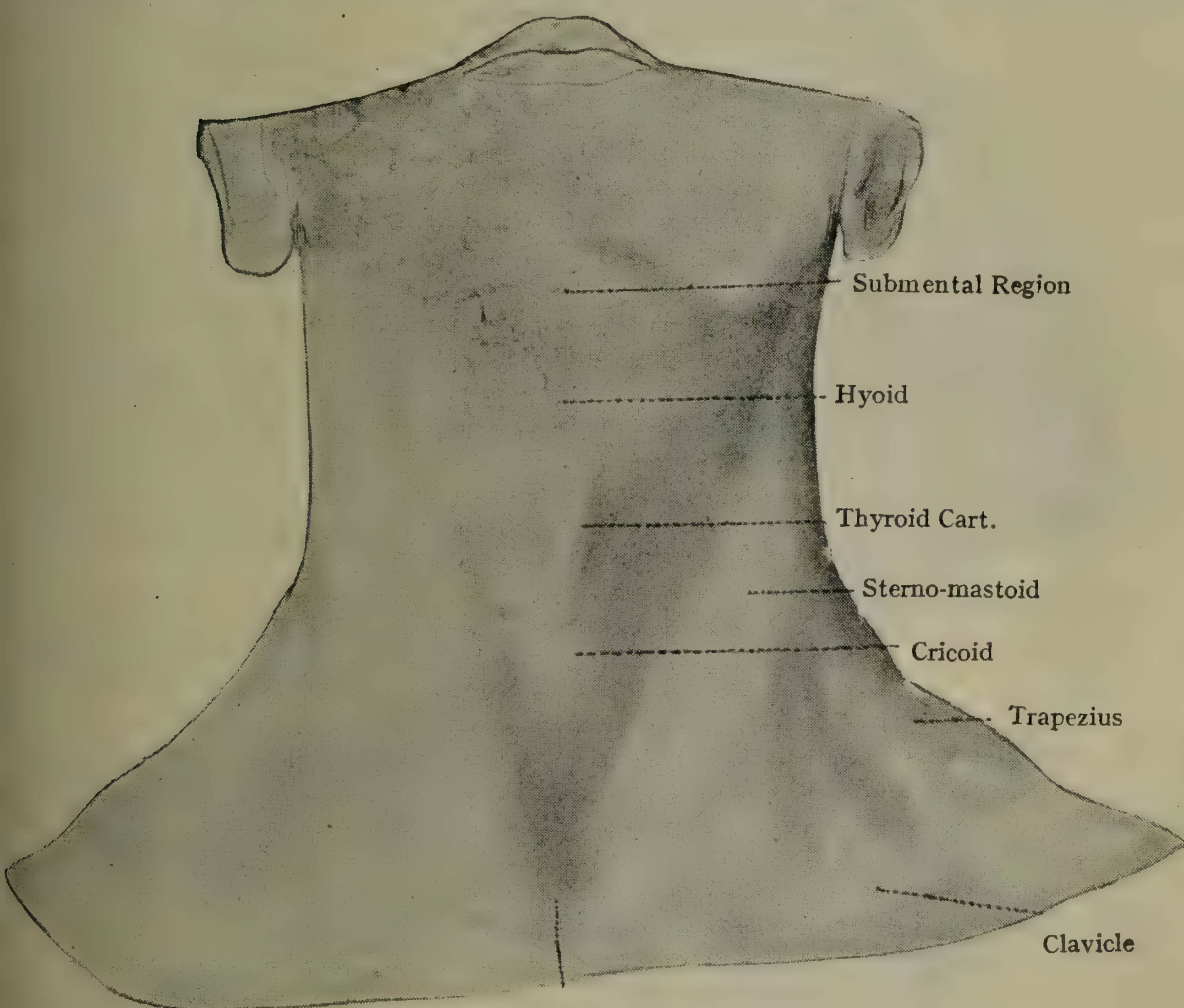


FIG. 704.—ANTERIOR VIEW OF NECK.

scle crosses the carotid sheath; and (6) the rings of the trachea, ich, however, are covered superiorly by the isthmus of the thyroid nd, and inferiorly by the sterno-hyoid and sterno-thyroid muscles l adipose tissue.

The lateral lobes of the thyroid gland may be felt on either side of larynx and trachea as low as about the fifth ring; and in young ldren the thymus extends upwards upon the trachea for some tance above the manubrium sterni.

The greater horn of the hyoid bone is the guide to the lingual artery hypoglossal nerve for operative purposes, the structures lying just ve the greater horn.

The upper border of the thyroid cartilage is on a level with the di between the bodies of the third and fourth cervical vertebræ.

The narrow anterior part of the cricoid cartilage is on a level wi the disc between the bodies of the fifth and sixth cervical vertebræ, which level the pharynx becomes the œsophagus. In this situatior foreign body, when swallowed, is liable to become impacted.

Below the cricoid, in the middle line, one or two rings of the trach may be felt above the thyroid isthmus, and it is here that a hi tracheotomy is performed, an easy operation since the windpipe is

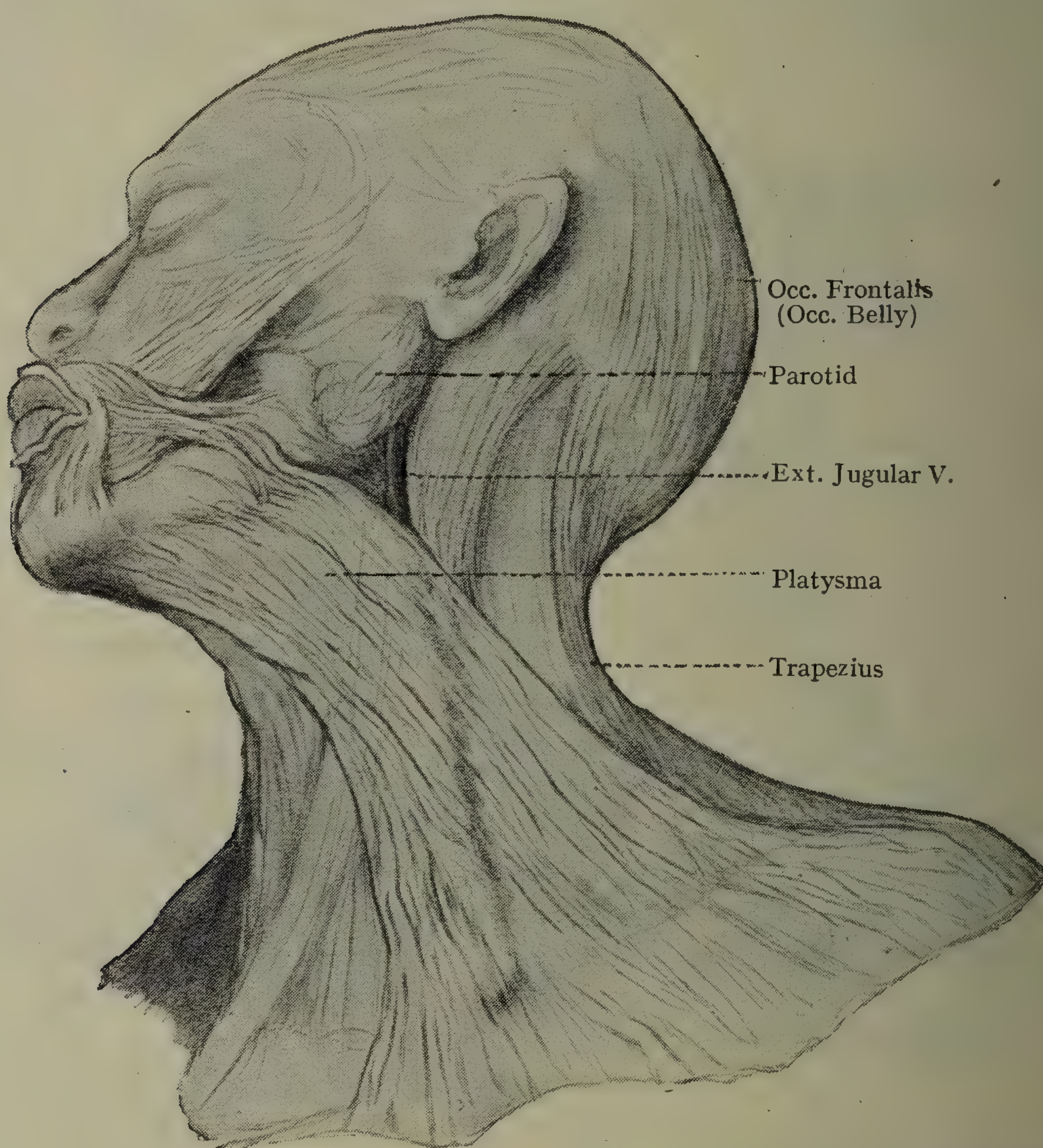


FIG. 705.—SUPERFICIAL DISSECTION.

close to the skin. Below the isthmus the trachea rapidly recedes, that a low tracheotomy is often a difficult and sometimes a ve dangerous operation; dangerous because, often in children and son times in the adult, the left innominate vein lies in the suprasterı region above the level of the manubrium sterni, and so in the way the knife. Ignorance of this fact has meant, and may mean aga the loss of a life.

Above the middle third of the clavicle, between the sterno-mastc and trapezius muscles, there is a depression known as the grea

aclavicular fossa, which indicates the position of the subclavian ıgle, with the third part of the subclavian artery and the trunks ıe brachial plexus of nerves.

Platysma (Platysma Myoides)—*Origin.*—The superficial fascia which ɜrs the clavicular parts of the pectoralis major and deltoid muscles.

Insertion.—(1) The outer part of the body of the mandible from symphysis menti to the anterior border of the masseter muscle; (2) the angle of the mouth, where the fibres blend with those of depressor anguli oris and orbicularis oris.

Nerve-supply.—The cervical branch of the facial nerve, which communicates with branches of the anterior cutaneous nerve of the neck.

The fibres are directed upwards and forwards or inwards over the ɾicle and side of the neck.

Action.—(1) To draw the angle of the mouth downwards and outrds; (2) to act as a feeble depressor of the mandible; (3) to raise the ı of the neck and upper pectoral region as far out as the acromion cess, throwing it into obliquely-disposed folds.

The muscle forms an extensive, thin, pale sheet, which is embedded hin the superficial fascia. In the region of the symphysis menti innermost fibres decussate across the middle line with those of the posite side, the fibres of the right muscle being superficial. The scle covers the external and anterior jugular veins, the superficial nches of the cervical plexus of nerves, the subclavian triangle, and sterno-mastoid, sterno-hyoid, omo-hyoid, and digastric muscles.

The platysma in man is a remnant of a subcutaneous muscular sheet, called *panniculus carnosus*, which exists in many animals, and by which the twitch- of the skin is produced.

Jugular Veins.—The jugular veins are four in number on either e—anterior, external, posterior external, and internal.

The **anterior jugular vein** begins in the roof of the digastric triangle, ıere it is formed by the union of radicles which communicate with ɜ submental vein, and are joined by radicles which have descended ɔm the structures over the body of the mandible. It descends rtically near the median line, lying at first superficial to the deep ɾvical fascia, but subsequently entering the suprasternal space. It en describes a bend, and, passing outwards behind the sterno-astoid muscle, and in front of the scalenus anterior, it opens to the lower part of the external jugular vein. It may, however, ɔen into the subclavian vein. It communicates with the external gular vein by one or more tributaries, and usually receives a branch ɔm the facial vein which descends along the anterior border of the erno-mastoid and joins it towards the lower part of the neck. urther, it communicates with its fellow of the opposite side by a ansverse branch, the **jugular arch,** which crosses in front of the achea, and lies in the suprasternal space.

The anterior jugular veins are usually asymmetrical, one or other ɜing of small size. Occasionally there is only one vein, which divides

into two vessels inferiorly. The anterior jugular vein is destitute
valves.

The **external jugular vein** commences close behind the angle of th
mandible in the substance of the parotid gland, where it is formed b
the union between the posterior division of the posterior facial ve
and the posterior auricular vein. On leaving the parotid gland
descends almost vertically to a point above the centre of the clavicl
In its course the vessel crosses the sterno-mastoid muscle, lying supe
ficial to its sheath, and deep to the superficial fascia containing th
fibres of the platysma. At this level the main part of the anteri

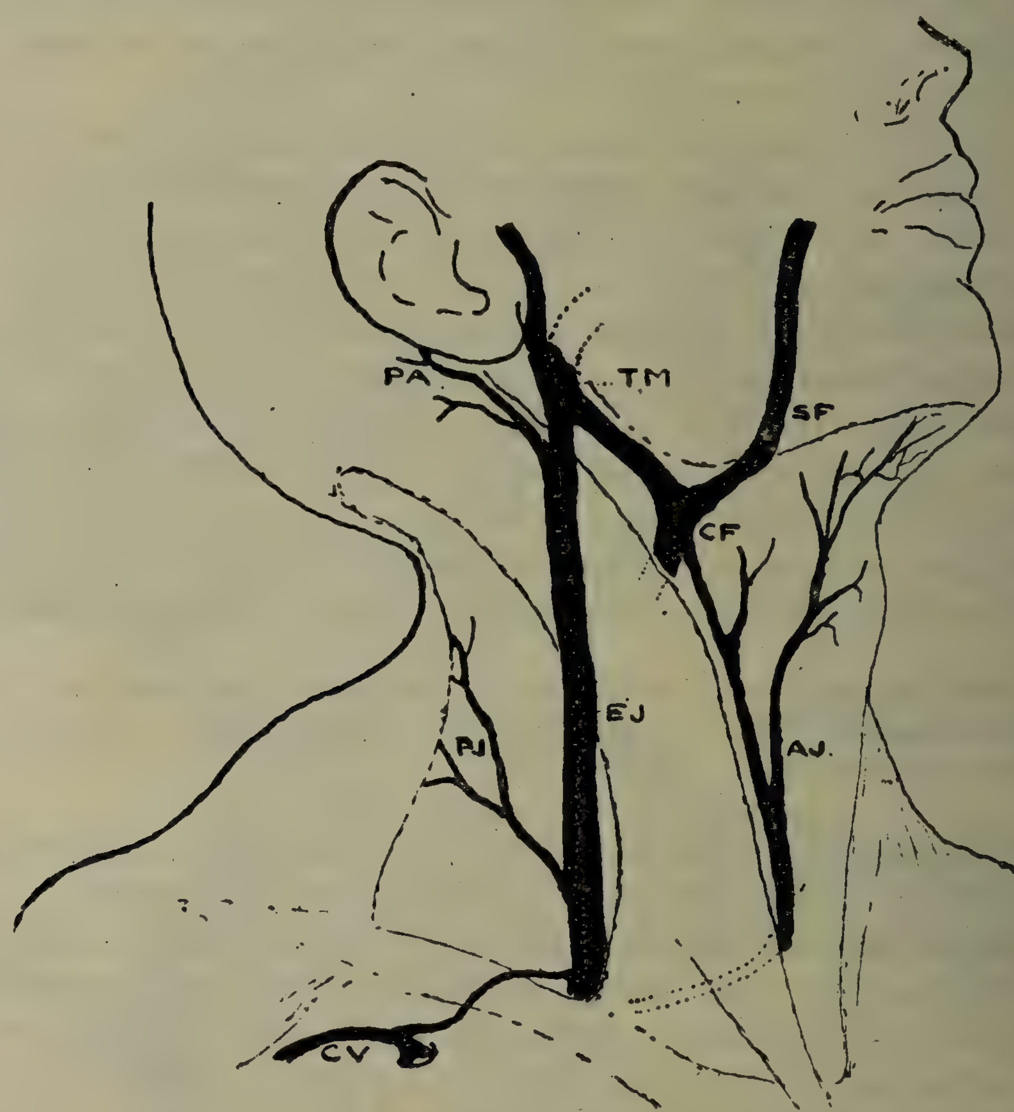
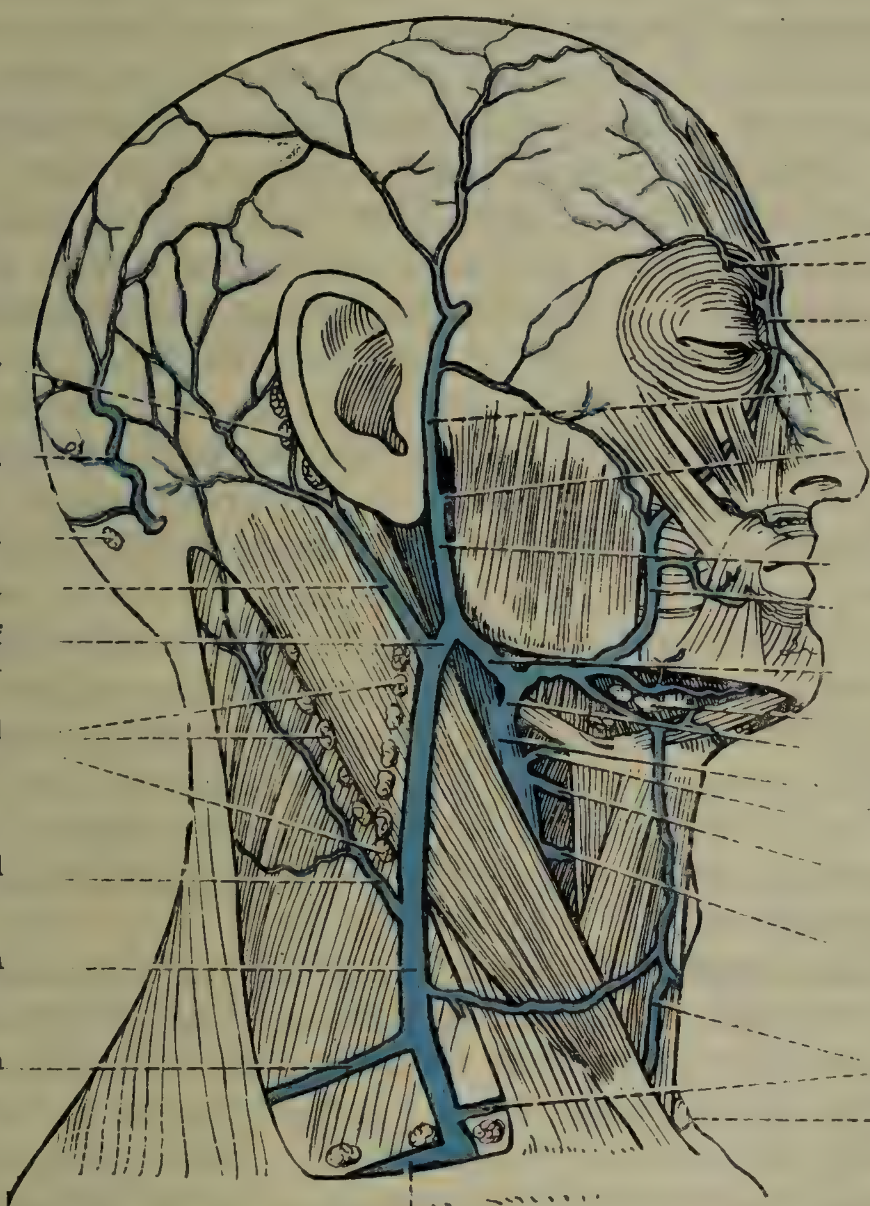


Fig. 706.—Superficial Veins of Neck.
SF, CF, superficial and common facial. TM, posterior facial or temporo-maxillar
PA, posterior auricular. PJ, EJ, AJ, posterior, external, and anterior jugula

cutaneous nerve of the neck runs forward deep to the vein, and offse
of the nerve pass superficial to it. Having crossed the sterno-masto
muscle, the vein descends not far from its posterior border, where
lies in the roof of the subclavian triangle over the third part of th
subclavian artery. Up to this point the vessel is superficial to th
deep cervical fascia, but it now pierces that fascia and opens into th
subclavian vein.

The course of the external jugular vein is indicated by a line draw
from a point close behind the angle of the mandible to a point abo
the centre of the clavicle. Its tributaries are as follows: (1) posteri

ernal jugular, which joins it about the middle of the neck; (2) trans-
se cervical; (3) suprascapular; and (4) anterior jugular, the latter
ee joining it not far from its termination. It also communicates
n the anterior jugular vein by one or more branches. The vessel
rovided with valves, both at its termination and about $1\frac{1}{2}$ inches
ve this point, and the transverse cervical and suprascapular veins



. 707.—The Superficial Veins and Superficial Lymph Glands of the Right Side of the Head and Neck.

The platysma muscle has been removed.

also furnished with valves where they open into the external
gular vein, or near their orifices.

The external jugular vein is sometimes very small, or even absent;
d it may communicate with the cephalic vein by a vessel which
sses over the clavicle.

Development.—The external jugular vein was formerly regarded as being
eloped from the anterior cardinal vein; but according to most authorities
anterior cardinal vein gives rise to the internal jugular vein, the external
ular being of later development.

The **posterior external jugular vein** represents the most exter occipital vein, and is formed by tributaries which issue from the ou part of the occipital plexus, reinforced by veins from the superfic structures at the back of the neck. It usually receives the mast emissary vein and passes downwards and forwards, joining the exter jugular vein about the middle of the neck.

The internal jugular vein will be found described on p. 1211.

Superficial Cervical Lymph Glands.—These are about six in numb and they lie upon the sterno-mastoid muscle, along the course of external jugular vein, and deep to the superficial fascia and platys muscle. They receive their afferent lymphatics from the adjac superficial structures, the occipital and mastoid lymph glands, a some of those of the parotid and submandibular lymph glands. Th efferent lymphatics pass to the deep cervical lymph glands.

Deep Cervical Fascia.—The deep cervical fascia is divided i (1) a superficial investing layer, which completely invests the neck the form of a collar; and (2) deep processes or laminæ, which inv the muscles, viscera, and chief bloodvessels and nerves.

Investing Layer.—This layer is attached posteriorly to the li mentum nuchæ; superiorly to (1) the superior nuchal line of the oc pital bone, (2) the mastoid process of the temporal bone, (3) the zy matic arch, and (4) the body of the mandible, under cover of platysma, as far forwards as the symphysis menti; and inferiorly the clavicle and upper border of the manubrium sterni, being pierc above the centre of the clavicle by the external jugular vein. Alo the middle line of the neck anteriorly it is continuous with the invest layer of the opposite side.

The investing layer invests the cervical portion of the trapezi and from the anterior border of that muscle it passes forwards o the posterior triangle of the neck to the posterior border of the ster mastoid. In doing so it furnishes a deep process, which ensheat the inferior belly of the omo-hyoid muscle. This process also embra the intermediate tendon of that muscle, after which it passes dov wards and inwards to be attached to the back of the inner end of clavicle and the first rib. In this manner the horizontal position the inferior belly of the omo-hyoid is accounted for. When the vesting layer of the deep cervical fascia reaches the posterior bor of the sterno-mastoid it splits into two laminæ, which ensheathe t muscle, the superficial lamina being underneath the external jugu vein and platysma. At the anterior border of the sterno-mastoid two laminæ reunite, and the fascia passes forwards over the anter triangle of the neck to the median line, where it is continuous with corresponding layer of the opposite side.

Between the upper part of the anterior border of the sterno-mast and the angle of the mandible the investing layer is of considera strength, and draws that border of the muscle forwards and upwar so as to render it convex and keep it over the line of the leading vess Between the mastoid process and the angle of the mandible the

ting layer is prolonged upwards over the parotid gland as the parotid cia, which is very dense, and is attached superiorly to the lower der of the zygomatic arch.

Below the level of the thyroid gland the investing layer divides o two laminæ, anterior and posterior, both of which are superficial the infrahyoid muscles. At the middle line these laminæ are con- uous with those of the opposite side, and inferiorly they are attached the anterior and posterior margins of the upper border of the nubrium sterni. Between them there is an interfascial interval, led the **suprasternal space (space of Burns).** This interval contains olar tissue, one or more lymphatic glands, the lower portions of the terior jugular veins, with the jugular arch which here connects m, and the sternal heads of the sterno-mastoid muscles.

Deep Processes or Laminæ.—The deep laminæ, as stated, invest the iscles, viscera, and chief bloodvessels and nerves. The most im- rtant are derived from that lamina of the investing layer which ms the posterior wall of the sheath of the sterno-mastoid muscle, d they are three in number—namely, carotid sheath, pretracheal cia, and prevertebral fascia—all of which have an intimate initial nnection.

The **carotid sheath** contains in separate compartments (1) the mmon carotid artery and the constituents of the ansa hypoglossi, the internal jugular vein, and (3) the vagus nerve, the latter being ntained within the back part of the septum, which separates the tery from the vein.

The **pretracheal fascia,** which is at first intimately connected with e anterior wall of the carotid sheath, passes forwards behind the frahyoid muscles, in which situation it splits to ensheathe the yroid gland, trachea, and œsophagus, and then it passes to the edian line, where it is continuous with the pretracheal fascia of the posite side. The pretracheal fascia is attached superiorly to the dy of the hyoid bone, and inferiorly it descends over the trachea d bloodvessels into the superior mediastinum of the thorax, where it ends with the fibrous pericardium.

The **prevertebral fascia,** which is at first intimately connected with e posterior wall of the carotid sheath, passes forwards behind the arynx and œsophagus, and in front of the prevertebral muscles. t the middle line it is continuous with the corresponding fascia of e opposite side; superiorly it is attached to the base of the skull; d inferiorly it descends over the longus cervicis muscle into the sterior mediastinum of the thorax. Along a line corresponding to e inner wall of the carotid sheath the pretracheal fascia furnishes a condary lamina, called the **bucco-pharyngeal fascia,** which covers e constrictor muscles of the pharynx and the buccinator muscle. etween the bucco-pharyngeal and prevertebral fasciæ there is an terval, called the **retro-pharyngeal space,** which contains the loosely ranged connective tissue uniting the two fasciæ. This space extends high as the base of the skull, and inferiorly is continuous with the

posterior mediastinum of the thorax. Another process of the pr
vertebral fascia passes downwards and outwards in front of t
scalenus anterior muscle. After this it invests the third part of t
subclavian artery and subclavian vein, together with the nerve-trun
of the brachial plexus, and, passing behind the clavicle, it becom
continuous with the axillary sheath, which latter blends with t
posterior aspect of the clavi-pectoral fascia. In the region of the su
clavian triangle there is an interfascial space between this proce
of the pretracheal fascia and the investing layer of the deep cervic
fascia. This space extends downwards behind the clavicle to the poi
where the axillary sheath and clavi-pectoral fascia join. It contai

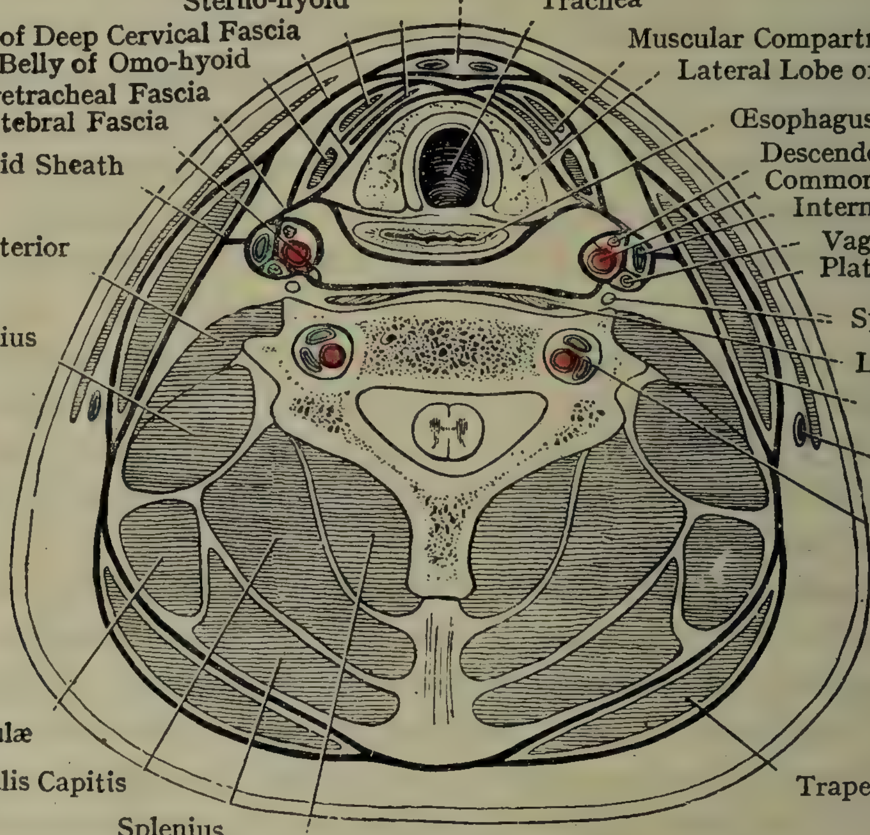


FIG. 708.—DIAGRAM OF A TRANSVERSE SECTION OF THE NECK AT THE LEV
OF THE SIXTH CERVICAL VERTEBRA, SHOWING THE ARRANGEMENT OF T
DEEP CERVICAL FASCIA AND THE POSITIONS OF OTHER STRUCTURES.

the inferior belly of the omo-hyoid muscle, the suprascapular ar
transverse cervical vessels, the lower part of the external jugular vei
and the terminal portion of the anterior jugular vein.

Interfascial Compartments.—It has been stated that the dee
cervical fascia reaches the median line of the neck anteriorly in thr
layers—namely, investing (in two divisions), pretracheal, and pr
vertebral. It is therefore evident that there are four interfasci
compartments as follows: (1) the **suprasternal space (space of Burns**
which is situated between the two divisions of the investing layer, ar
contains the structures already enumerated; (2) the **muscular com
partment,** which is situated between the investing layer and the pr
tracheal layer, and contains the infrahyoid muscles; (3) the **viscer**

partment, which lies between the pretracheal and prevertebra
rs, and contains the larynx, trachea, thyroid gland, pharynx,
phagus, and carotid sheath, the retro-pharyngeal space being in
subdivision of this compartment behind the bucco-pharyngeal
ia; and (4) the **vertebral compartment,** which lies between the
ertebral layer and the attachment of the fascia to the ligamentum
hæ posteriorly, and contains the vertebral column, spinal cord, and
ertebral and postvertebral muscles.

The suprasternal and muscular compartments are shut off from
thoracic cavity. The visceral compartment in front of the trachea
ntinuous with the superior mediastinum of the thorax, and behind
œsophagus it, along with the retro-pharyngeal space, is continuous
the posterior mediastinum.

Parotid Process of the Deep Cervical Fascia.—This process is given
a little below the angle of the mandible, and it passes upwards on
deep surface of the parotid gland to the skull. Along with the
otid fascia superficial to the gland it forms a dense sheath which
ely invests the glandular substance. The parotid process furnishes
aths to the posterior belly of the digastric, styloid, and pterygoid
scles, and it also gives an investment to the superficial part of the
mandibular gland. Connected with the parotid process there are
eral bands, usually called ligaments, which are as follows: (1) spheno-
ndibular; (2) stylo-mandibular; (3) pterygo-mandibular; and
pterygo-spinous.

The **spheno-mandibular ligament** will be described in connection
h the mandibular joint, of which it is sometimes regarded as an
essory medial ligament (see p. 1316).

The **stylo-mandibular ligament** extends from the styloid process of
temporal bone near its tip to the angle and adjacent part of the
terior border of the ramus of the mandible, where it is placed
ween the masseter and internal pterygoid muscles.

The **pterygo-mandibular ligament** is a narrow band which extends
m the hamulus of the medial pterygoid plate of the sphenoid bone
the posterior extremity of the mylo-hyoid line of the mandible
se to the last molar socket. Anteriorly it gives origin to fibres of
buccinator muscle, and posteriorly to fibres of the superior con-
ctor muscle of the pharynx.

The **pterygo-spinous ligament** is a narrow band which extends from
harp spine on the posterior border of the lateral pterygoid plate of
sphenoid bone, towards its upper part, to the spine process of the
enoid. This ligament is liable to become ossified.

The foregoing description is orthodox and traditional, and every fact stated
be demonstrated by a good dissector; but there are some observers who
ard the whole of these fascial planes as artifacts, and believe that all the
rstices between the structures in the neck are filled with loose connective
ue which, when it is cleaned from the surrounding parts, collapses into
y definite sheets. If this is the case, it should be possible, by varying the
ction of the incisions, to produce sheets in any plane. As a matter of fact,
can be done.

Sterno-mastoid—*Origin.*—The **sternal head,** which is narrow ar round, arises from the upper and outer part of the anterior surfa of the manubrium sterni. It is tendinous in front, and fleshy behin The **clavicular head,** which is broad and flat, arises from a rough rid about $1\frac{1}{2}$ inches long on the upper surface of the clavicle at its inn end.

Insertion.—The outer surface of the mastoid process of the ter poral bone, and the superior nuchal line of the occipital bone ov about its outer half or two-thirds.

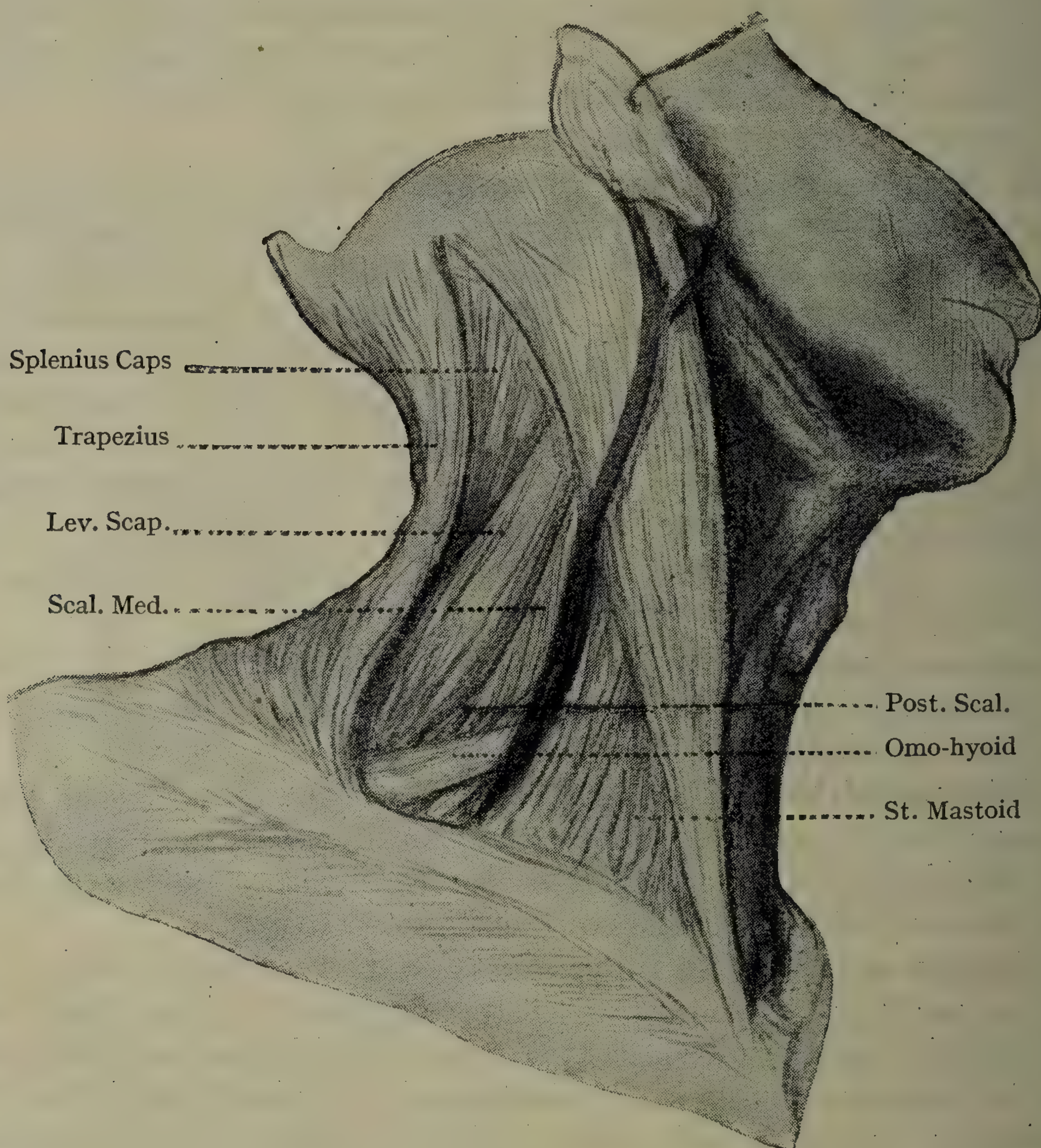


Fig. 709.—Showing Sterno-mastoid and the Muscular Floor of Posterior Triangle.

Nerve-supply.—The accessory nerve, and a branch from the cervic plexus, more particularly from the anterior primary ramus of the secor cervical nerve.

The spinal root of the accessory nerve passes deep to the anteri border of the muscle fully 1 inch below the tip of the mastoid proces and in passing downwards and backwards it pierces the deep part the muscle, giving off as it does so its branches to it.

The muscle is directed upwards, outwards, and backwards.

Action.—To flex the head towards the side on which the musc

aced, the face being turned towards the opposite side. This is position of the head in *torticollis* or *wry-neck*, a condition which be due to an organic contraction to the muscle, affecting both s, or, it may be, the sternal head alone. When both muscles act ther from their origin they flex the head towards the thorax. when the head has been already thrown back the sterno-mastoid is capable of extending it still farther instead of flexing it. It t be remembered, however, that a certain amount of flexion of head may take place between any of the cervical vertebræ. When muscles act together from their insertion they elevate the upper of the anterior thoracic wall in forced inspiration.

The sternal and clavicular heads are separated by a triangular lar interval for a short distance above the sterno-clavicular joint, before their junction the fibres of the clavicular head to a large nt pass behind those of the sternal head, so that overlapping s place. The muscle is surrounded by a strong sheath, which is ed by the deep cervical fascia. The platysma covers a large part , and the external jugular vein, the anterior cutaneous nerve of and great auricular nerves, and the superficial cervical lymph ds are related to its superficial surface under cover of the platysma. principal deep relations are as follows: in the lower part of the it covers the first and second parts of the subclavian artery, the no-hyoid, sterno-thyroid, omo-hyoid, and scalenus anterior muscles, the phrenic nerve lying upon the last-named muscle. In this ation it also covers the anterior jugular vein, and the transverse ical and suprascapular arteries. Higher up it covers the cervical us of nerves, the levator, scapulæ, scalenus medius, and scalenus erior muscles, and the accessory and the hypoglossal nerves. At insertion it covers the splenius capitis, longissimus capitis, and erior belly of the digastric muscles, and a portion of the occipital ry, in this order from the surface downwards. The anterior border he muscle forms the posterior boundary of the anterior triangle of neck, and covers the carotid sheath, with its contents, as high as level of the upper border of the thyroid cartilage; and above that l it covers the external and internal carotid arteries. This border overlaps slightly the lateral lobe of the thyroid gland. The erior border forms the anterior boundary of the posterior triangle he neck, and along it there lie the following structures: the super- l cervical lymph glands, the lesser occipital nerve, great auricular, erior cutaneous nerve of neck, the accessory, and the descending erficial branches of the cervical plexus of nerves, and a portion of external jugular vein.

The sterno-mastoid muscle, from its diagonal position upon the of the neck, divides the quadrilateral space into two triangles— terior and anterior.

Posterior Triangle.—This is the region which lies behind the sterno- stoid muscle.

Boundaries—*Anterior.*—The posterior border of the sterno-mastoid.

Posterior.—The anterior border of the trapezius. *Inferior* (**base**).—middle third of the clavicle. The **apex** is at the superior nuchal of the occipital bone, where the sterno-mastoid and trapezius may n but the apex is usually truncated. The **roof** is formed by the superficial and deep fasciæ, and for a short distance inferiorly by platysma. The lesser occipital nerve lies in the upper part of roof, and the descending superficial branches of the cervical pl and the external jugular vein lie in the lower part of the roof. **floor** is formed by the following muscles, in order from above do wards: (1) small angle of the semispinalis capitis, provided the trape

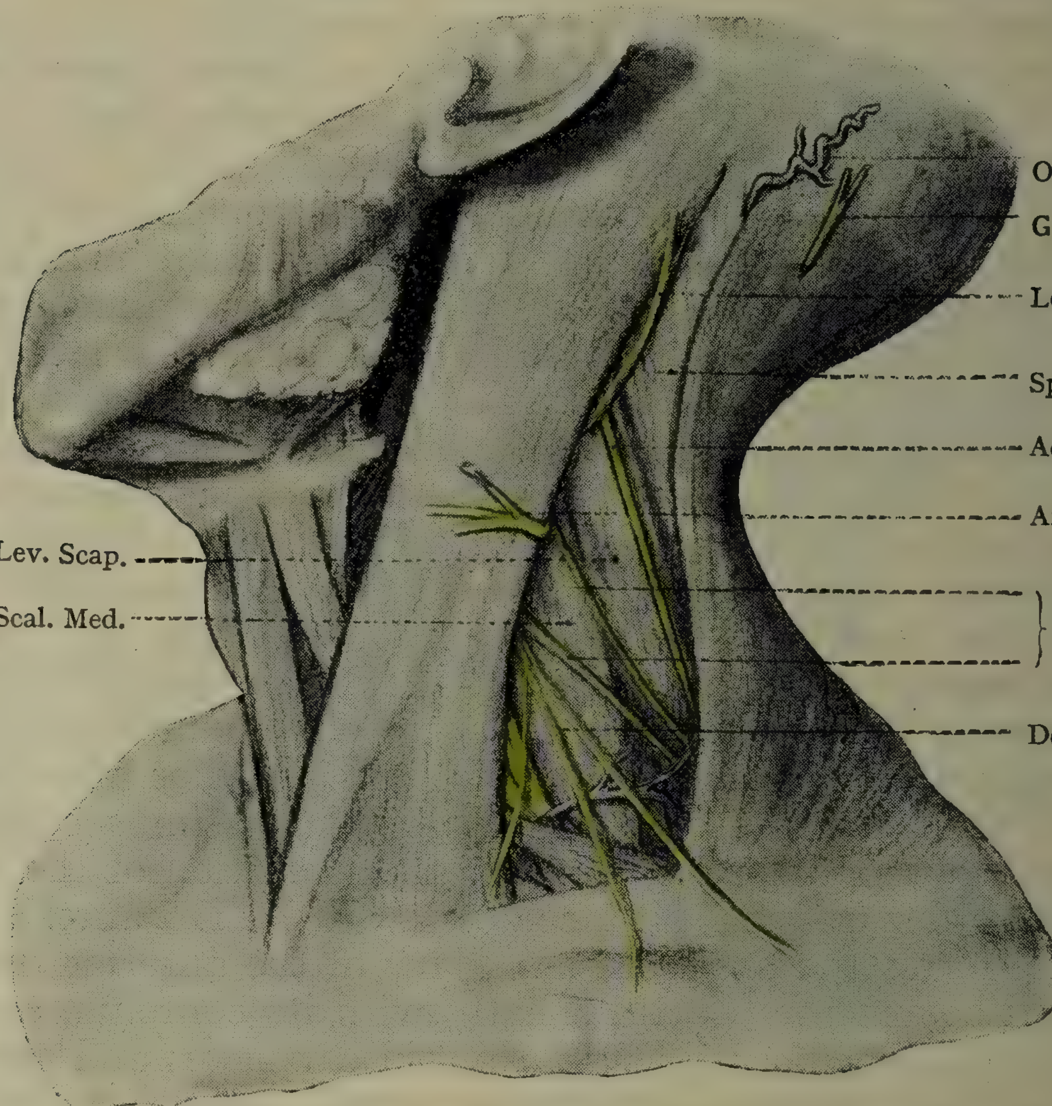


Fig. 710.—The Nerves in the Posterior Triangle.

is not well developed at the occiput; (2) the splenius capitis; (3) levator scapulæ; (4) the scalenus medius and scalenus poster (5) the scalenus anterior; and (6) the first digitation of the serra anterior if the clavicle is depressed.

The posterior triangle is subdivided by the inferior belly of omo-hyoid into a large upper portion, called the occipital trian and a small lower portion, called the subclavian triangle.

Occipital Triangle—Boundaries—*Anterior.*—The posterior bo of the sterno-mastoid. *Posterior.*—The anterior border of trapezius. *Inferior* (**base**).—The inferior belly of the omo-hy The muscles in its floor are (1) a small angle of the semispinalis cap

onstant), (2) splenius capitis, (3) levator scapulæ, and (4) scalenus ius and posterior. The **contents** are the superficial branches of the ical plexus, the accessory nerve, the branches of the cervical us to the levator scapulæ and trapezius, a small part of the occipital ry close to the apex, and some superficial cervical lymph glands.

t should be realized that the foregoing gives a picture of the triangle as seen ne dissected body. In life and in the undissected part it is little more than tter, the anterior edge of the trapezius being only about ½ inch from the erior border of the sterno-mastoid.

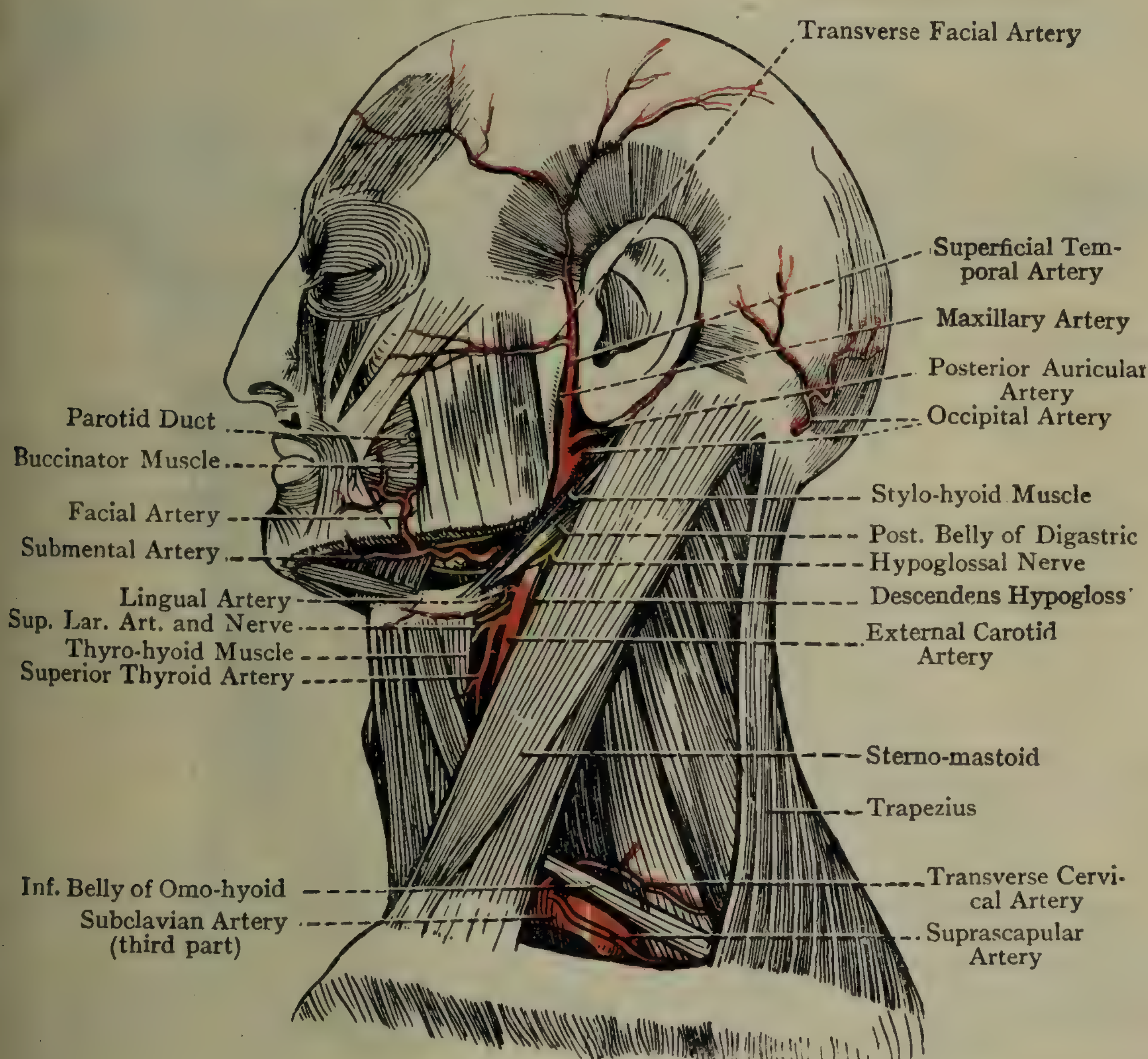


FIG. 711.—THE LEFT SIDE OF THE HEAD AND NECK.
The platysma has been removed.

Cervical Plexus.—The cervical plexus lies deep to the upper part he sterno-mastoid muscle, and immediately in front of the slips rigin of the scalenus medius. It is formed by the anterior primary i of the first three cervical nerves and the greater part of that of fourth, a small branch of the latter descending to join the anterior nary ramus of the fifth, and so taking part in the brachial plexus. h of the anterior primary rami of the first four cervical nerves is nected with the superior cervical ganglion of the sympathetic by ey ramus communicans.

The *anterior primary ramus of the first cervical nerve* lies at f in the vertebrarterial groove of the atlas below the vertebral arte It then passes forwards in a groove on the outer surface of the supe articular process of the atlas, having the vertebral artery on its ou side. It next emerges between the rectus capitis lateralis mus (to which it gives a branch) and the rectus capitis anterior, descends in front of the root of the lateral mass of the atlas to join ascending branch of the second nerve. From the loop so forn

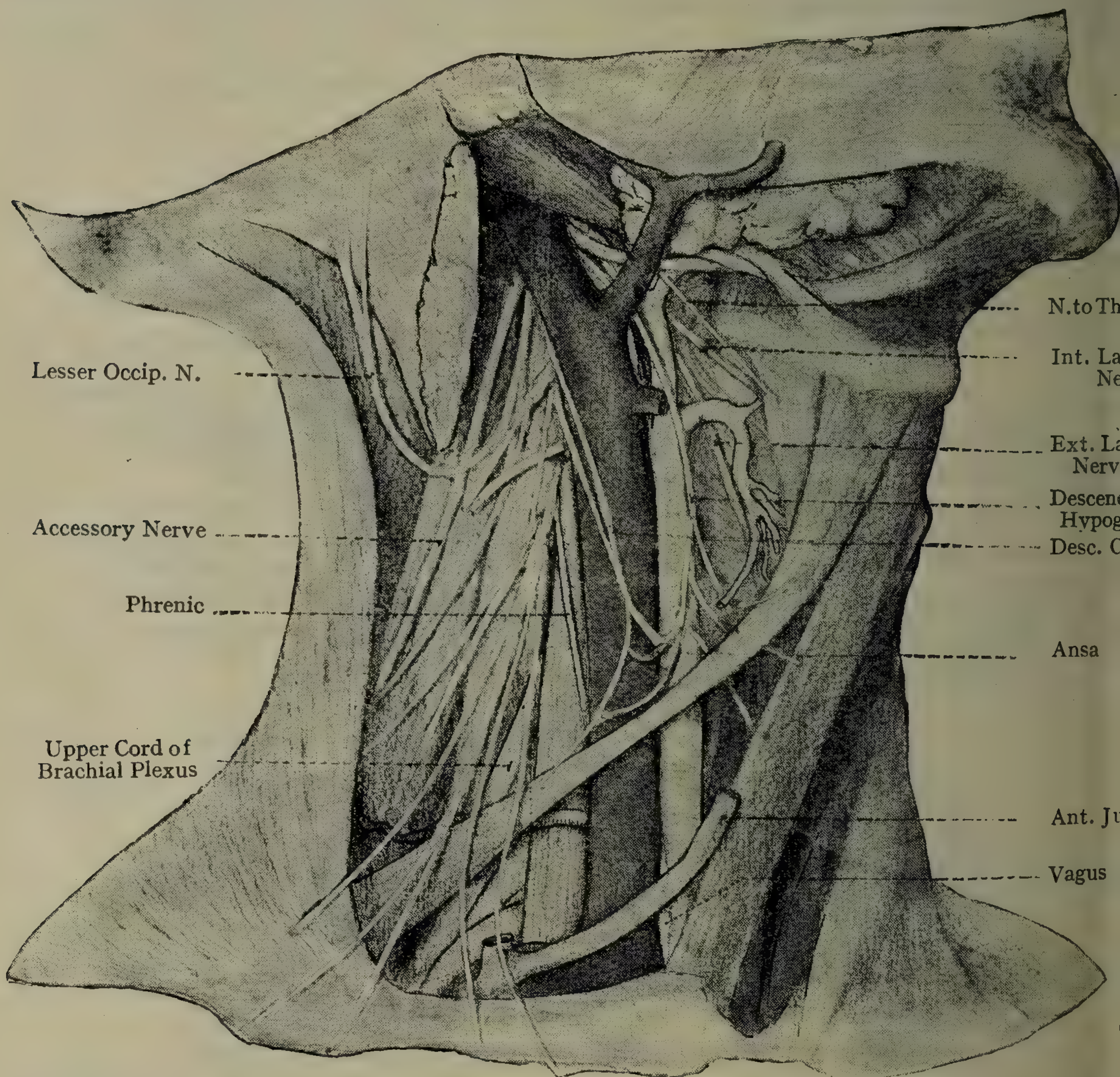


FIG. 712.—DEEP RELATIONS OF STERNO-MASTOID, SHOWING CERVICAL PLEXUS, ETC.

branches are given to the rectus capitis anterior and the longus cap muscles, and one or more branches pass to the hypoglossal nerve, destination of their fibres being the ramus descendens cervicalis a the nerves to thyro-hyoid and genio-hyoid.

The *anterior primary rami of the second, third, and fourth cervi nerves,* having emerged between the corresponding intertransversa muscles, form a superficial and a deep part of the plexus, of wh the superficial is altogether cutaneous, while the deep is divided i

tor and communicating branches. It will also be found that the
p plexus consists of an external and an internal set of branches.

Superficial Group.—The branches of this group are ascending, nsverse, and descending.

The ascending and transverse branches arise from the second and rd cervical nerves.

The *ascending nerves* are the lesser occipital and great auricular e p. 1141). The *transverse branch* is the anterior cutaneous nerve he neck.

The **anterior cutaneous nerve of the neck (superficial cervical nerve)** ses by two roots from the anterior primary rami of the second and

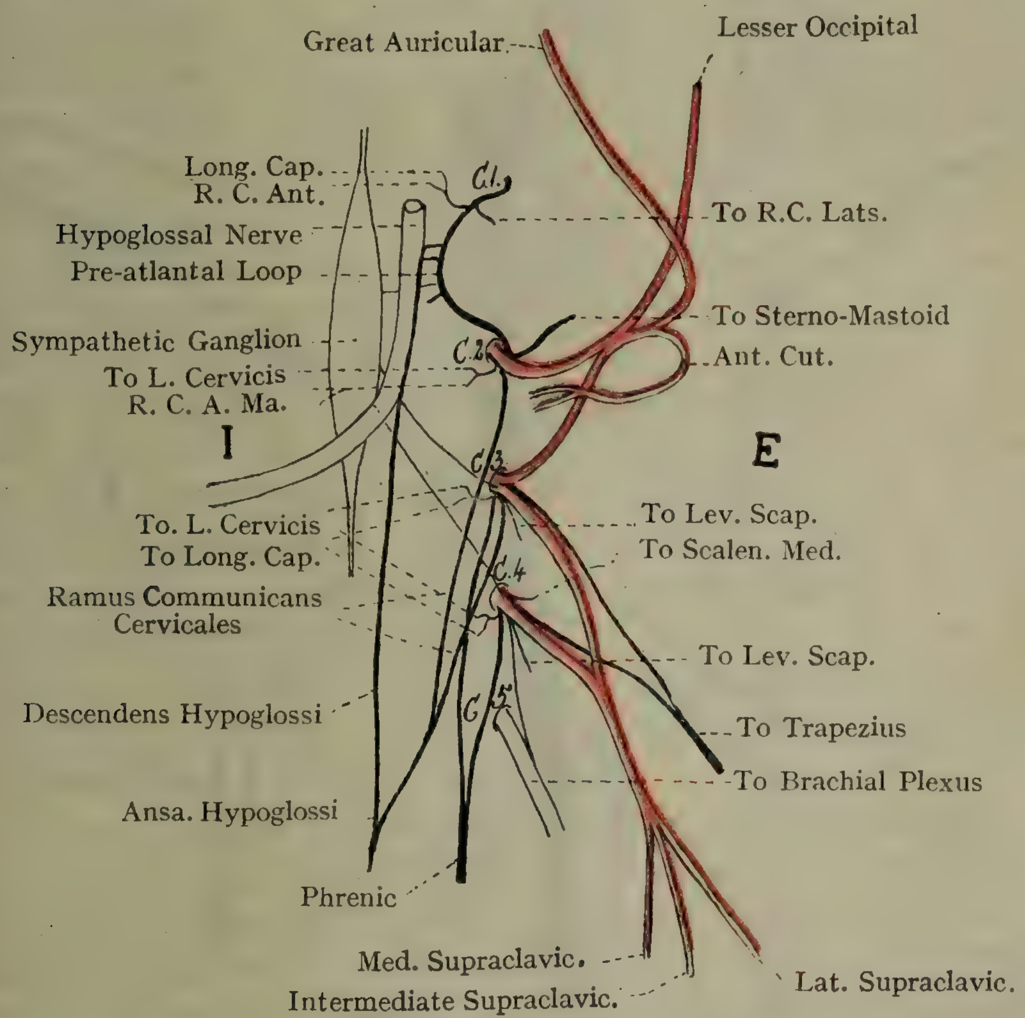


FIG. 713.—SCHEME OF CERVICAL PLEXUS.
Superficial plexus *red*; deep plexus *black*. I., E., medial and lateral sides.

rd cervical nerves, and, turning round the posterior border of the rno-mastoid muscle, it passes forwards superficial to that muscle, ng deep to the platysma and the external jugular vein. Having ched the anterior triangle of the neck, it divides into two branches, cending and descending, which are distributed to the integument er the anterior triangle. The offsets of the ascending branch com-nicate freely with the cervical branch of the facial nerve deep to the tysma.

The *descending branches* are the medial, intermediate, and lateral praclavicular nerves, and they arise in common from the third and rth cervical nerves. As they descend they form distinct nerves,

which lie on the roof of the subclavian triangle under cover of t platysma. For their distribution see p. 412.

Deep Group.—The nerves of this group are arranged in two sets external and internal.

External Set.—These nerves are muscular. The second ner furnishes a branch to the sterno-mastoid, which communicates in th muscle with the branch of the accessory nerve. The third and four

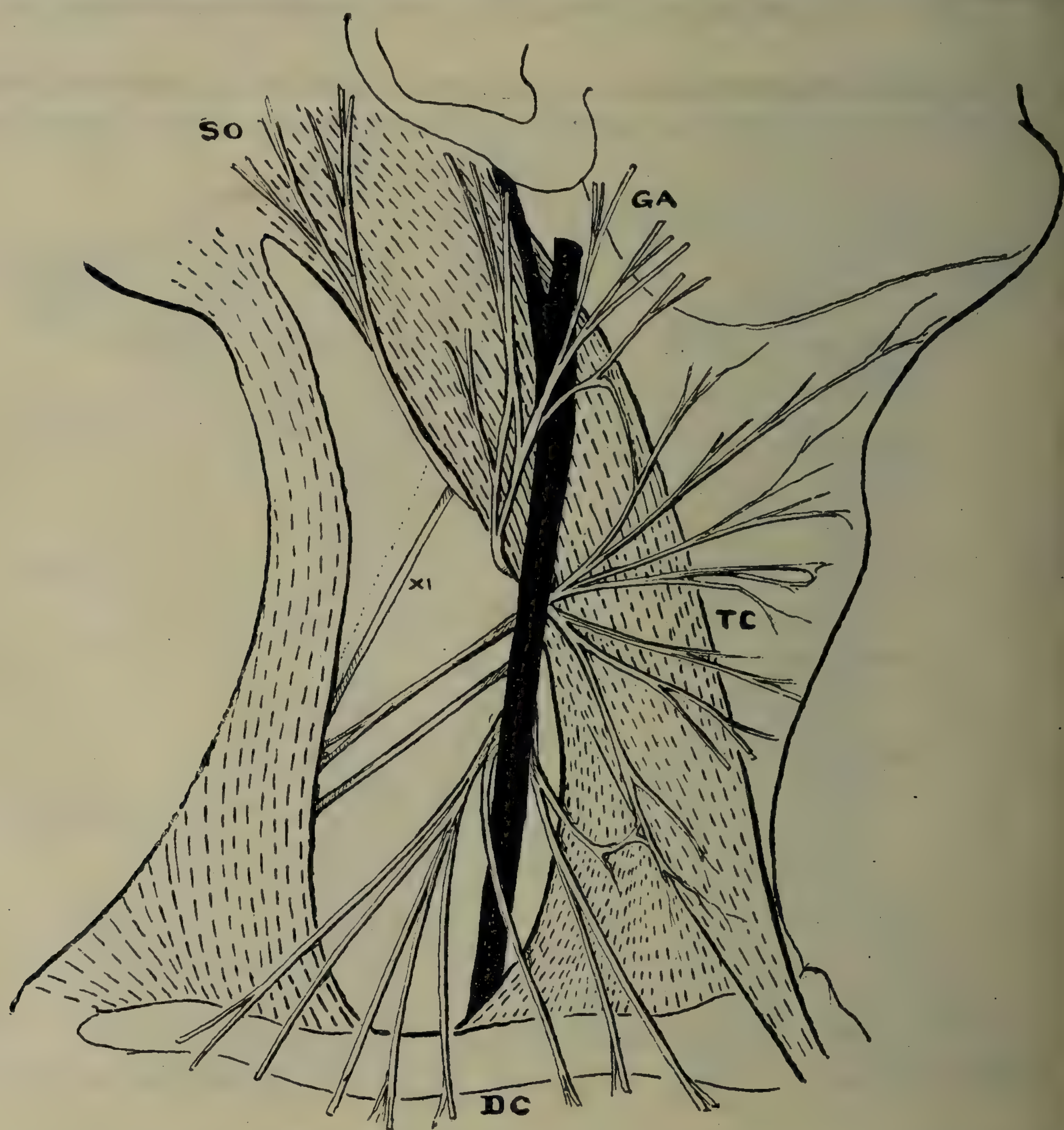


FIG. 714.—SUPERFICIAL BRANCHES OF CERVICAL PLEXUS.
SO, lesser occipital; GA, greater auricular; TC, anterior cutaneous; DC, descending supraclavicular; XI, accessory nerve.

nerves furnish (*a*) two branches to the trapezius, which communica with the accessory nerve deep to the upper part of the muscle formi the subtrapezial plexus; (*b*) two branches to the levator scapulæ; a (*c*) branches to the scalenus medius.

Internal Set.—The nerves of this set are communicating a muscular.

The *communicating branches* are as follows: (1) connecting branc (grey rami communicantes) pass from the superior cervical gangli

the sympathetic; (2) communicating branches pass to the vagus d hypoglossal nerves from the highest loop of the plexus; and two rami communicantes cervicales pass from the second and third rves forwards and downwards, usually superficial, but sometimes ep to the internal jugular vein, and join the descendens hypoglossi, gether or separately, to form the ansa hypoglossi.

The *muscular branches* are distributed to the rectus capitis lateralis, ctus capitis anterior and longus capitis, upper part of the scalenus terior, longus cervicis, and the diaphragm. The nerve to the aphragm is the phrenic, which, from its importance, requires a special scription.

The **phrenic nerve** arises, as a rule, by two roots, the larger of hich is derived from the anterior primary ramus of the *fourth* cervical rve, and the other from that of the third. In some cases the fifth rvical nerve, which enters into the brachial plexus, furnishes an ditional small root. In the neck the nerve descends in front of the alenus anterior muscle, which it crosses obliquely downwards and wards, passing deep to the intermediate tendon of the omo-hyoid uscle, the transverse cervical and suprascapular arteries, the anterior gular vein, and, on the left side, the thoracic duct. At the root of e neck the nerve, having left the scalenus anterior, passes behind e terminal part of the subclavian vein, and crosses in front of the ternal mammary artery from without inwards. Having come into ntact with the inner surface of the cupola of the pleura, it disappears hind the inner end of the clavicle, and enters upon the thoracic part its course (see p. 1015).

The *right* nerve at the root of the neck is superficial to the second rt of the right subclavian artery, with the intervention of the alenus anterior muscle. The *left* nerve at the root of the neck is nterior and parallel to the first part of the left subclavian artery.

The phrenic nerve is sometimes reinforced towards the root of the ck by a branch from the nerve to the subclavius muscle, and when is takes place the root from the fifth cervical nerve is usually absent. efore leaving the neck the phrenic nerve receives a twig from the iddle or inferior cervical ganglion of the sympathetic.

No branches arise from the phrenic nerve in the neck.

Lower Group of Deep Cervical Lymph Glands (Supraclavicular ymph Glands).—These glands lie in the anterior part of the subclavian iangle, and are related *superficially* to the intermediate supraclavicular erve and *deeply* to the upper and middle trunks of the brachial plexus. *uperiorly* they are continuous with the upper deep cervical lymph ands. They receive their *afferent* vessels from the following sources:

1. The back of the neck.
2. The axillary lymph glands.
3. The upper part of the pectoral region.
4. Occasionally the lymphatics along the cephalic vein, which ay ascend over the clavicle.
5. The internal mammary lymph glands.

Their *efferent* vessels form the subclavian trunk, which, with t[…] jugular trunk, opens into the thoracic, or into the right lympha[…] duct.

Subclavian or Supraclavicular Triangle.—The subclavian triangle[…] the lower division of the posterior triangle of the neck, and is separat[…] from the upper division or occipital triangle by the inferior belly[…]

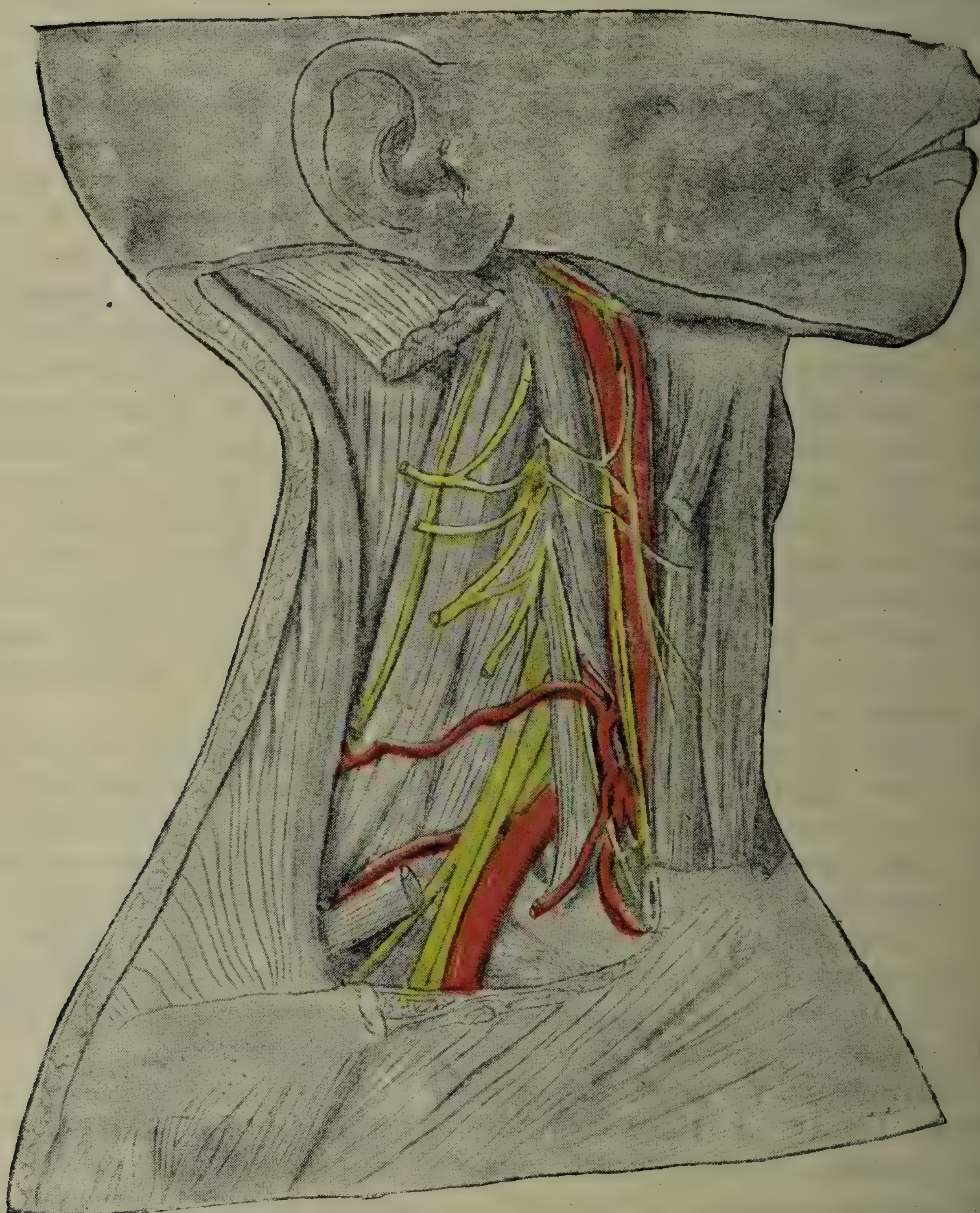


Fig. 715.—Common Carotid and Subclavian Arteries exposed by Remova[…] of Sterno-mastoid, Omo-hyoid, and Internal Jugular Vein.

the omo-hyoid muscle. Situated above the middle third of the clavicl[…] it is of small size until the deep cervical fascia, which ensheathes t[…] inferior belly of the omo-hyoid, has been divided.

Boundaries—*Superior.*—The inferior belly of the omo-hyoid muscl[…] *Inferior.*—The middle third of the clavicle. *Anterior.*—The clavicul[…] part of the sterno-mastoid muscle. *Roof.*—The skin; superficial fasc[…]

platysma muscle; medial, intermediate, and lateral supraclavicular
es; a part of the external jugular vein; and the deep cervical fascia.
r.—The scalenus medius and posterior muscles, and the serratus
rior.

The extent of the triangle is affected by (1) the height to which
inferior belly of the omo-hyoid ascends above the clavicle, and
the extent of the clavicular attachments of the sterno-mastoid
trapezius muscles. The depth of the triangle is influenced by the
tion of the shoulder, being greater when the shoulder is raised
carried forwards, and less when it is depressed and carried
kwards.

Contents.—The contents are: (1) the greater portion of the third
t of the subclavian artery; (2) small portions of the transverse

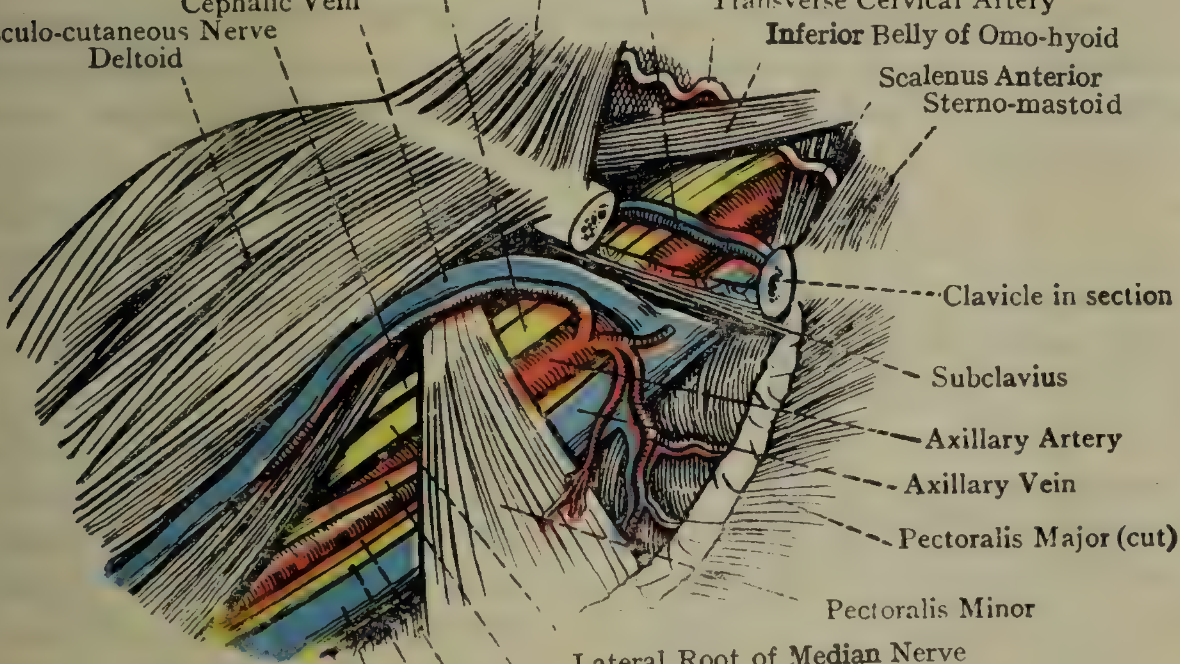


FIG. 716.—SUBCLAVIAN AND AXILLARY REGIONS.

vical artery and vein; (3) the lower portion of the external jugular
in; (4) the nerve-trunks of the brachial plexus; and (5) the nerve
the subclavius muscle, the suprascapular nerve, and the nerve
serratus anterior.

Third Part of the Subclavian Artery.—This part of the vessel extends
m the outer border of the scalenus anterior muscle to the outer
rder of the first rib, where it becomes the axillary artery. Its course
downwards and outwards, and for the greater part of its extent it
s in the subclavian triangle. Its last inch or so, however, passes
hind the clavicle and subclavius muscle.

Relations—*Anterior.*—The skin; superficial fascia and platysma;
edial, intermediate, and lateral supraclavicular nerves; deep cervical
scia; clavicle and subclavius muscle; transverse cervical vessels;
prascapular vessels; nerve to the subclavius muscle; and the termina

portion of the external jugular vein. The last-named vessel cro in front of the artery close to the sterno-mastoid muscle, and in situation is joined by the transverse cervical and suprascapular ve A plexiform arrangement of veins is sometimes met with in fron the artery, which may be rendered more complex by a branch ascend superficial to the clavicle from the cephalic vein. *Posterior.*— scalenus medius, the lower nerve-trunk of the brachial plexus in vening. *Superior.*—The upper and middle nerve-trunks of the brac plexus, the latter being nearest the vessel. *Inferior.*—The upper face of the first rib and the subclavian vein, the vein being on a m anterior plane than the artery, and lying behind the clavicle.

It is most important to understand that, though the first rib is spoken o an inferior relation, its surface is so oblique that it is just as much behind below.

The third part of the subclavian artery does not always give any branch. In very many cases, however, the *deep branch of transverse cervical artery* arises from it, instead of from the latter arte which is a branch of the first p of the subclavian. In these ca the posterior scapular art passes outwards between nerve-trunks of the brac plexus.

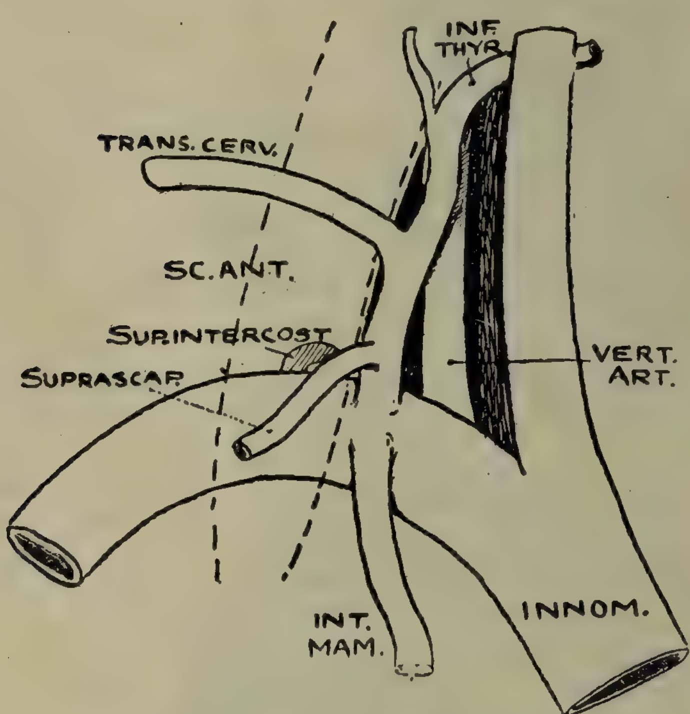


Fig. 717.—Plan of Branches of Subclavian Artery.

The **direction** of the third p of the artery is indicated by line drawn from a point on posterior border of the ster mastoid muscle, about ½ in above the clavicle, to the cen of that bone. The artery may compressed as it passes over first rib, the guide to it at t point being the centre of clavicle. In order to tie the su clavian artery in the dead bo after fully depressing the clavic feel for the outer edge of the scalenus anterior muscle, and follow to its insertion on the first rib. The structure which lies immediat behind the muscle here is the artery; and great care must be taken to mistake it for the lower trunk of the brachial plexus.

For the manner in which the collateral circulation is carried after ligation of the third part of the subclavian artery, see p. 441.

The **subclavian vein,** in the region of the subclavian triangle, situated behind the clavicle, where it lies below and anterior to artery. On the upper surface of the first rib it is anterior to the scaler anterior, and it receives the external jugular vein, and in some ca the anterior jugular vein.

[The **transverse cervical artery** lies in the subclavian triangle for
ıort distance only, close to where the inferior belly of the omo-
id passes deep to the sterno-mastoid. It passes outwards behind
former muscle into the lower part of the occipital triangle, where
ivides into its superficial and deep branches, the former entering
trapezius, and the latter passing in front of the levator scapulæ,
r which it descends along the base of the scapula in front of the
nboid muscles.

[The **transverse cervical vein** opens into the external jugular vein,
e being a valve at or near its ending.

[The **suprascapular artery** is not in the subclavian triangle, but lies
ind the clavicle, close to its upper aspect. It will be described in
nection with the first part of the subclavian artery (see p. 1243).

The **suprascapular vein** also lies behind the clavicle, and it opens
the external jugular vein, there being a valve at or near its ending.

The external jugular vein will be found described on p. 1176.

Brachial Plexus.—The brachial plexus is situated in the lower part
he posterior triangle of the neck, behind the clavicle, and in the
er part of the axilla. Its complex formation is rendered simple
arranging it into four stages—namely (1) nerve-roots, (2) nerve-
nks, (3) divisions of nerve-trunks, and (4) nerve-cords.

First Stage.—The nerves which form the plexus are the anterior
nary rami of the fifth, sixth, seventh, and eighth cervical, and the
ater part of that of the first thoracic. Superiorly the plexus is
nforced by a small descending branch from the fourth cervical,
ich joins the fifth, and inferiorly it is occasionally reinforced by a
nch from the second thoracic, which joins the first. As regards the
t thoracic nerve, the part of it which does not join the plexus, and
ich is of small size, enters the first intercostal space to become the
t intercostal nerve. The nerves, as they emerge at the side of the
k, are placed between the scalenus anterior and scalenus medius,
which they give branches.

Second Stage.—The fifth and sixth cervical nerves join at the
er border of the scalenus anterior to form the **upper trunk**; the
enth cervical remains meanwhile single, and forms the **middle
nk**; and the eighth cervical and greater part of the first thoracic
ite between the scalene muscles to form the **lower trunk.** There
thus three trunks—upper, middle, and lower.

Third Stage.—A little above the clavicle each of the three trunks
aks up into anterior and posterior divisions.

Fourth Stage.—The anterior divisions of the upper and middle
nks unite to form the **lateral cord** of the plexus; the anterior
vision of the lower trunk, which is of large size, forms the **medial
rd**; and all three posterior divisions (that of the lower trunk being
small size) unite to form the **posterior cord.** There are thus three
rds—lateral, medial, and posterior. As a variety, the anterior
vision of the middle trunk may subdivide into two branches, one
tering the lateral cord and the other the medial.

Branches of the Plexus above the Clavicle.—The branches are co veniently divided into two groups—supraclavicular, arising above t clavicle, and coming from nerve-roots and nerve-trunks; and inf clavicular, arising below the clavicle, and coming from nerve-cords.

Supraclavicular Branches.—These are **muscular branches** fr the four cervical nerves to the scalene muscles and longus cervicis.

One root of the phrenic nerve (inconstant) from the front of t fifth cervical.

The Nerve to the Rhomboids.—This branch arises from the ba of the fifth cervical, close to or along with the highest root of t

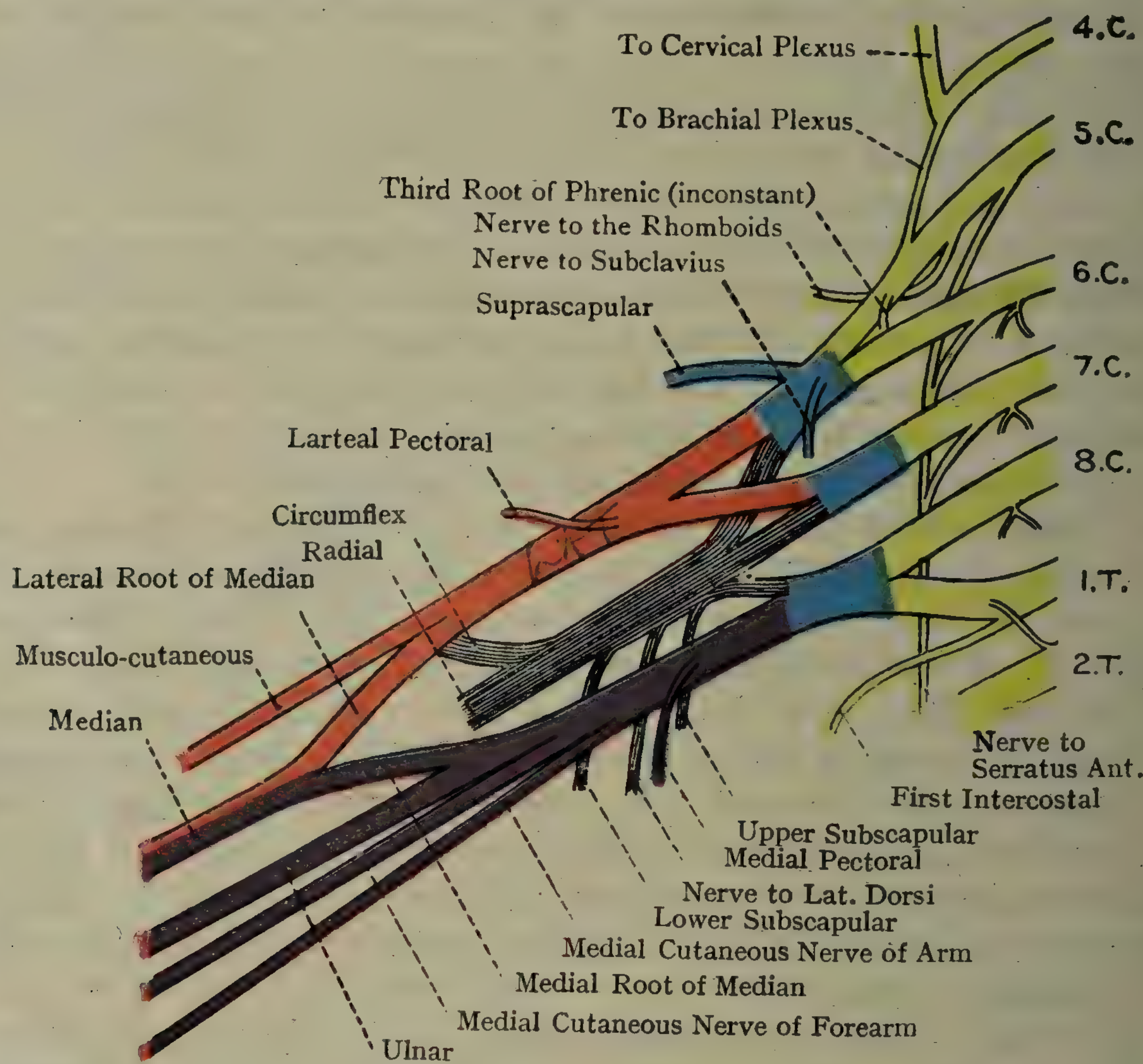


FIG. 718.—THE BRACHIAL PLEXUS.

Yellow=spinal nerves and their branches; blue=trunks; red=lateral cord purple=medial cord; grey=posterior cord.

nerve to serratus anterior, and it takes a backward course throu the scalenus medius.

The Nerve to the Serratus Anterior (Nerve of Bell or Posteri Thoracic Nerve).—This branch arises by three roots from the ba of the fifth, sixth, and seventh cervical nerves. The upper two roo pierce the scalenus medius muscle below the nerve to the rhomboi either conjointly or separately, whilst the lowest root passes in fro of the scalenus medius, and joins the trunk formed by the othe near the first rib. The nerve then courses behind the brachial plex and the first part of the axillary artery to the axillary surface of t serratus anterior, which it supplies.

he Nerve to the Subclavius.—This small branch arises from the of the upper trunk, its fibres being derived from the fifth cer-. It descends in front of the third part of the subclavian artery, passing behind the clavicle, enters the subclavius muscle on leep aspect. This nerve sometimes communicates with the nic nerve.

he Suprascapular Nerve.—This is a large nerve which arises from back of the upper trunk, its fibres being derived from the fifth

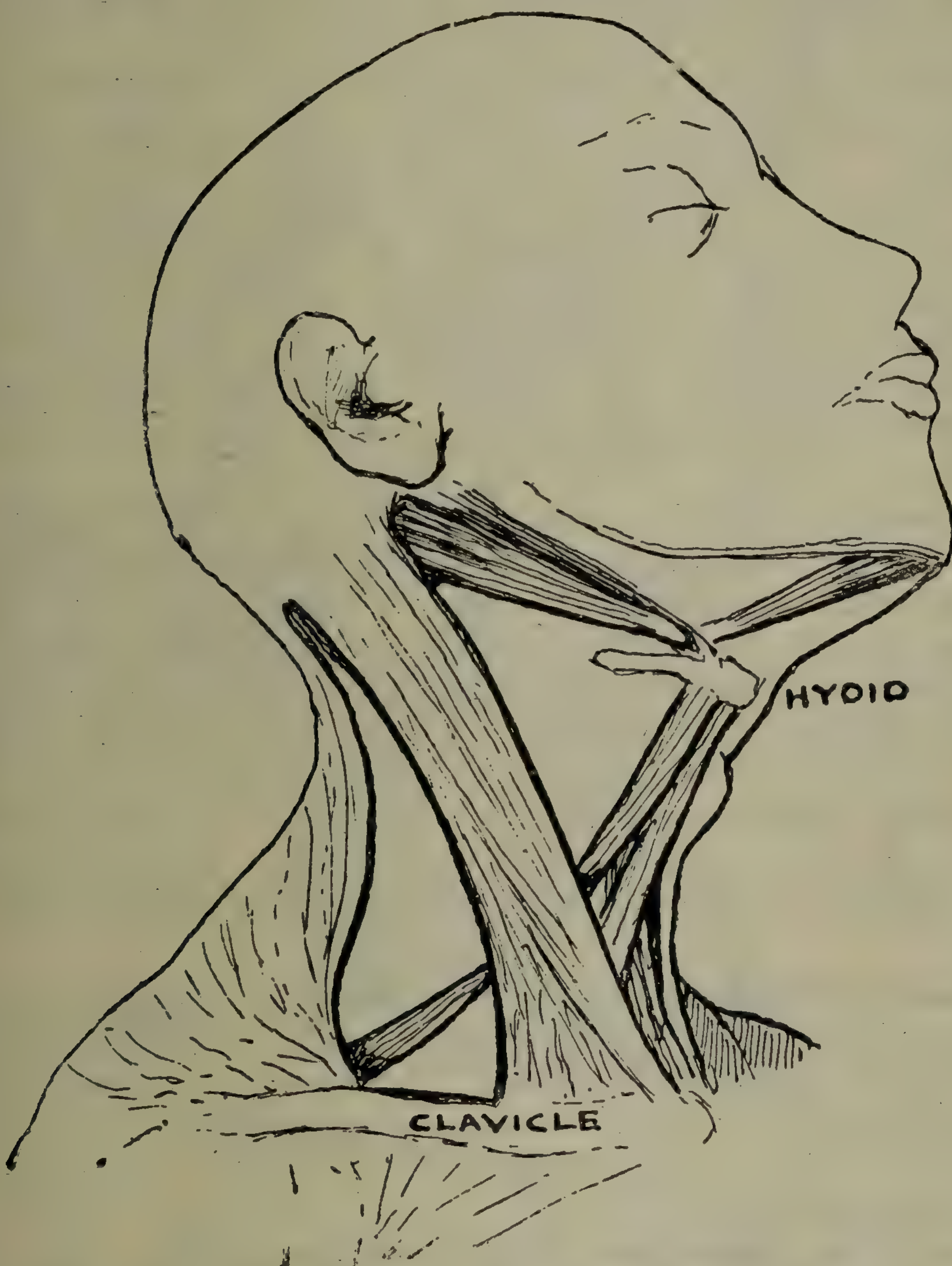


FIG. 719.—PLAN OF TRIANGLES OF NECK.

sixth cervical. It is directed downwards, outwards, and back-ds beneath the trapezius and inferior belly of the omo-hyoid to upper border of the scapula, on approaching which it meets the ascapular artery. It is distributed to the supraspinatus and aspinatus muscles and shoulder-joint.

It will be seen that all the branches of the brachial plexus belong er to the anterior or posterior divisions, even if they come off before se divisions become separate, and that their distribution gives a clue

to the division to which they belong. The nerves to the scale medius and posterior, as well as that to the rhomboids, the sup scapular, and to serratus anterior, are, from their distribution, clea dorsal or posterior in their origin; while the nerves to the scale anterior, longus cervicis, and subclavius are equally clearly anteric

Below the clavicle the lateral and medial cords give off all the anter branches, while the posterior come entirely from the posterior cord.

For the infraclavicular branches of the brachial plexus, see p. 4

Anterior Triangle.—This triangle is situated in front of the ster mastoid muscle, and its base is directed upwards.

Boundaries—*Anterior.*—The middle line of the neck—that is say, a line extending from the chin to the upper border of the ma brium sterni. *Posterior.*—The anterior border of the sterno-mast muscle. *Superior.*—The lower border of the mandible and a l drawn from the angle of that bone to the mastoid process. T triangle is covered by the skin, superficial cervical fascia, platysr and deep cervical fascia. Superficial to the deep fascia there the following structures: the anterior jugular vein, the ramificati of the anterior cutaneous nerve of neck, and the cervical branch of facial nerve.

The anterior triangle is subdivided into three triangles by superior belly of the omo-hyoid muscle inferiorly, and posterior be of the digastric muscle superiorly. The subdivisions from bel upwards are called muscular, carotid, and submandibular.

The **muscular triangle** is bounded *anteriorly* by the middle line the neck; *posteriorly* by the anterior border of the sterno-mastoid; a *superiorly* by the superior belly of the omo-hyoid.

The **carotid triangle** is bounded *inferiorly* by the superior be of the omo-hyoid; *superiorly* by the posterior belly of the digast and stylo-hyoid; and *posteriorly* by the anterior border of the ster mastoid.

The **submandibular triangle** (**submaxillary triangle**) is bound *postero-inferiorly* by the lower part of the posterior belly of the digast the stylo-hyoid, and by the body of the hyoid bone: *antero-inferio* by the mid-line of the neck; and *superiorly* by one half of the ba of the mandible, and a line drawn from the angle of that bone to t sterno-mastoid muscle.

Contents of the Triangles—Muscular Triangle (Fig. 719).—The a of this triangle is occupied by the sterno-hyoid and sterno-thyr muscles; hence the name muscular triangle. Under cover of th muscles there are the carotid sheath with its contents, the late lobe of the thyroid gland, the trachea, and the larynx. The œsophag lies behind the trachea, with a slight inclination towards the l side at the root of the neck, and the recurrent laryngeal nerve l in the groove between the trachea and the œsophagus. The infer thyroid artery has a tortuous course inwards behind the lower p of the carotid sheath, and the trunk of the sympathetic descer behind both.

arotid Triangle.—This triangle contains the upper part of the non carotid, and the beginnings of the external and internal id arteries, all of which are overlapped by the anterior border ie sterno-mastoid, when the connective tissue which ensheathes muscle is undisturbed. The common carotid and internal carotid ies, together with the vagus nerve, are contained within the id sheath, and the descendens hypoglossi lies in front of the th, or within it, being situated in either case in front of the common id artery. The sterno-mastoid artery and the superior thyroid cross the sheath near the bifurcation of the common carotid

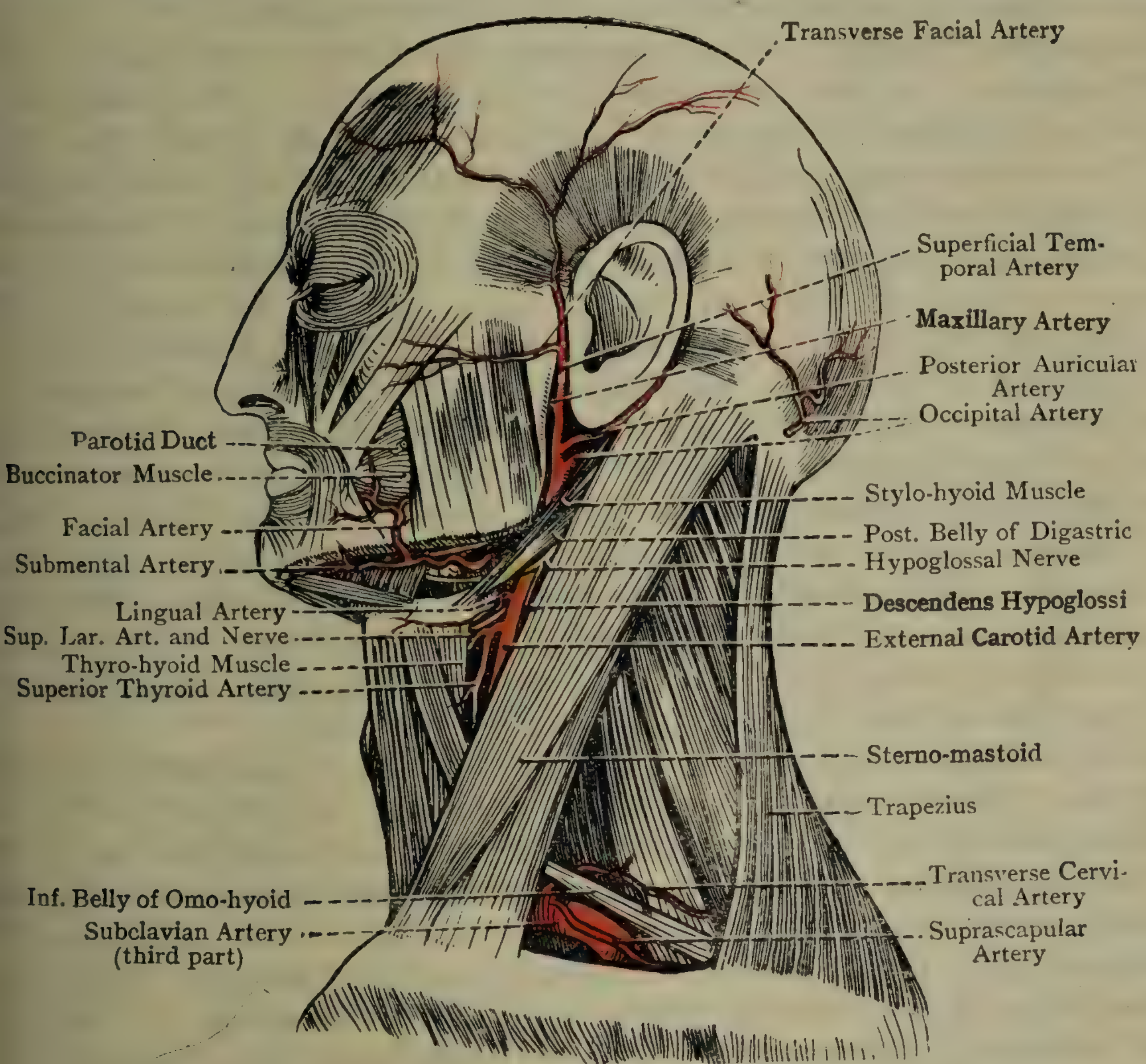


FIG. 720.—THE LEFT SIDE OF THE HEAD AND NECK.
The platysma myoides has been removed.

ery, and the carotid body lies behind the vessel about the same el. The deep cervical lymph glands lie just lateral to the course he internal jugular vein. The origins of the superior thyroid, lingual, ial, and occipital arteries are contained in this triangle, and the ending pharyngeal branch of the external carotid lies deeply between t vessel and the internal carotid. The internal jugular vein in this ingle receives the common facial, lingual, and superior thyroid veins. e hypoglossal nerve lies along the lower border of the posterior ly of the digastric muscle, and it here gives off, from behind wards, the descendens hypoglossi and the nerves to thyro-hyoid

and genio-hyoid, the former passing downwards in front of, or witl the carotid sheath, and the latter passing forwards and downwards an acute angle with the parent trunk. The internal branch of superior laryngeal nerve lies deeply behind the bloodvessels, and external laryngeal branch of that nerve descends parallel and deep the superior thyroid artery, and passes deep to the upper end of posterior border of the sterno-thyroid muscle. The vagus nerve within the carotid sheath, and the sympathetic trunk is behind The accessory nerve lies deeply, its course being downwards and ba wards beneath the sterno-mastoid, the deep portion of which usuall pierces about an inch below the angle of the mandible.

Digastric Triangle.—This triangle is divided into two parts, ante and posterior, by the stylo-mandibular ligament. The anterior p contains the superficial part of the submandibular gland, the ante facial vein being superficial to it, and the facial artery being embed in its upper and back part. In this triangle the facial artery gives its ascending palatine, tonsillar, glandular, and submental branch The muscles in the floor of the anterior part of the triangle are mylo-hyoid and a part of the hyo-glossus. The superficial part of submandibular gland is superficial to the mylo-hyoid muscle, a conceals the mylo-hyoid nerve and submental artery, which are direct contact with the muscle. The hypoglossal nerve lies upon t part of the hyo-glossus muscle which appears in the anterior part the triangle, but it soon disappears beneath the posterior free bor of the mylo-hyoid muscle. It is important to notice that it lies para to and just above the greater horn of the hyoid bone, which forms important structure in the floor of the triangle, and shows a little the insertion of the thyro-hyoid muscle below it.

The anterior jugular vein and the anterior cutaneous nerve of neck have been already described (see pp. 1173 and 1187). T cervical branch of the facial nerve will be found described on p. 12

Submandibular Lymph Glands (Submaxillary Lymphatic Glands) These glands lie upon the superficial surface of the submandibu salivary gland, under cover of the deep cervical fascia. They form chain beneath the corresponding half of the base of the mandib which extends from near the angle of the bone to near the origin of t anterior belly of the digastric muscle. The central gland of the ch is closely related to the facial artery as that vessel is about to asce over the base of the mandible. They receive their *afferent* vess from the following sources:

1. The front of the scalp.
2. The side of the nose.
3. A few from the lower eyelid.
4. The lower part of the cheek.
5. Half of the upper lip.
6. The lateral part of the lower lip.
7. The anterior third of the lateral border of the tongue.
8. The subjacent portion of t floor of the mouth.
9. Half of the upper gum.
10. The lateral part of the low gum.
11. The facial lymph glands.
12. The submandibular and su lingual salivary glands.

Their *efferent* vessels pass to the upper deep cervical lymph glands, ch are on a level with the upper border of the thyroid cartilage of larynx.

The **submental lymph glands** lie beneath the chin, and are two or ee in number. They receive their afferent lymphatics from the tip he tongue, the front of the floor of the mouth, and the inner part the lower lip; and their efferent lymphatics pass to the sub-ndibular lymphatic glands. It must be borne in mind that these phatic vessels, like those elsewhere in the body, frequently com-nicate across the middle line.

The **prelaryngeal lymph glands,** when present, are situated in front the crico-thyroid ligament, and are one or two in number. They eive their afferent lymphatics from the interior of the larynx, ow the rima glottidis, and from the adjacent part of the thyroid nd. Their efferent lymphatics pass to the inferior deep cervical nph glands. The upper part of the larynx drains into the superior p cervical lymph glands along a course accompanying that of the erior laryngeal vessels.

The **para-** and **pretracheal lymph glands** lie in front and at the sides the trachea, from which, as well as from the adjacent part of the roid gland, they receive their afferent lymphatics. Their efferent nphatics pass to the inferior deep cervical lymph glands.

Occasionally a few lymph glands are met with along the course the anterior jugular vein.

Deep Cervical Lymph Glands.—These glands lie deep to the sterno-stoid muscle, and are very numerous. They are arranged in two ups, superior and inferior.

The *superior deep cervical lymph glands* lie along the internal ular vein above the level of the upper border of the thyroid cartilage. ey receive their afferent lymphatics from the cranial cavity, the ernal maxillary glands, some of the parotid and submandibular nph glands, the root of the tongue, the upper part of the thyroid nd, the upper part of the larynx, and the lower part of the pharynx. eir efferent lymphatics pass to the inferior deep cervical lymph nds. One large gland of this group is very constant, and lies close the angle of the mandible. It drains the dorsum and sides of the igue, but not the tip as a rule.

The *inferior deep cervical lymph glands* lie along the lower part of e internal jugular vein, and extend outwards and backwards deep to e sterno-mastoid as far as its posterior border. These lymph glands e continuous inferiorly with the deep cervical lymph glands lying the subclavian triangle, and, through these, with the axillary glands. ey receive their afferent lymphatics from the superior deep cervical nph glands, the upper superficial cervical lymph glands, the lower rt of the thyroid gland and larynx, and the cervical portions of the chea and œsophagus. Their efferent lymphatics unite to form a gle vessel, called the **jugular trunk,** which opens on the left side into e thoracic duct, and on the right side into the right lymphatic duct.

Infrahyoid Muscles.—These are the omo-hyoid, sterno-hyoi sterno-thyroid, and thyro-hyoid.

Omo-hyoid.—This muscle consists of two bellies, superior (anteri and inferior (posterior), and an intermediate tendon. *Origin.*—I means of the **inferior belly** from (1) the upper border of the scapu close to the inner side of the suprascapular notch, and (2) the supr scapular ligament, which bridges over the suprascapular notch.

Insertion.—By means of the **superior belly** into the outer third the lower border of the body of the hyoid bone immediately later to the insertion of the sterno-hyoid muscle.

Nerve-supply.—The superior belly is supplied by the ramus desce dens hypoglossi, and the posterior belly derives its branches from t ansa hypoglossi.

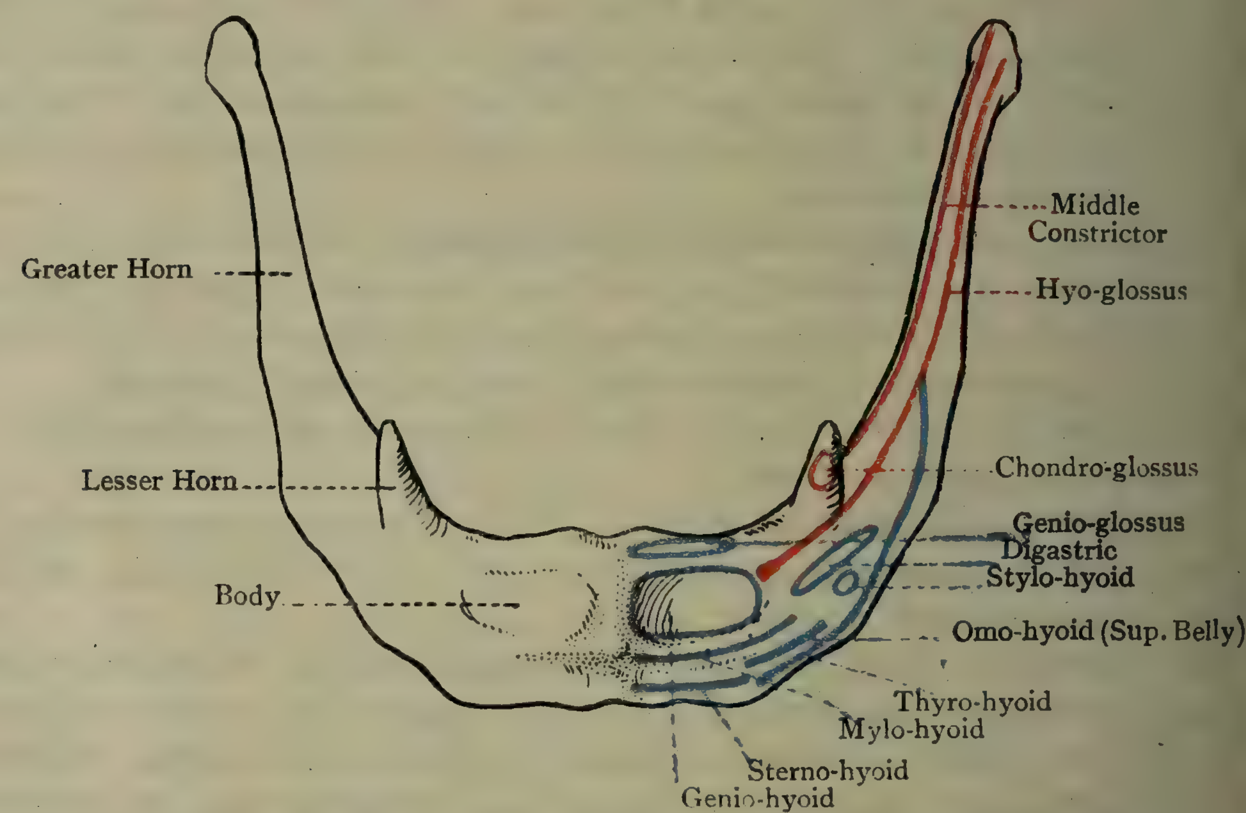


Fig. 721.—The Hyoid Bone, showing its Muscular Attachments.

The inferior belly is contained in the posterior triangle of the nec and separates the occipital from the subclavian triangle. Its course forwards and slightly upwards, and it passes deep to the stern mastoid muscle, where its fibres terminate in the intermediate tendo It is ensheathed by a deep process of the deep cervical fascia as th fascia crosses the posterior triangle, and this process is attached to t back of the inner end of the clavicle and the first rib, which explai the almost horizontal position occupied by the inferior belly.

The superior belly proceeds from the intermediate tendon, a passes upwards and slightly inwards to the body of the hyoid bor As it emerges from beneath the anterior border of the sterno-masto muscle the superior belly crosses the carotid sheath on a level wi the narrow anterior part of the cricoid cartilage, and in the anteri triangle of the neck it forms the separation between the muscular a carotid triangles.

rno-hyoid—*Origin.*—(1) The posterior surface of the manubrium at its upper and outer part; (2) the posterior sterno-clavicular ent; and, sometimes, (3) the posterior surface of the clavicle at er end.

sertion.—The inner two-thirds of the lower border of the body of oid bone, extending from the middle line to the insertion of the or belly of the omo-hyoid.

rve-supply.—The ansa hypoglossi.

e muscle is flat and ribbon-like, and rests upon the sterno-d and thyro-hyoid.

rno-thyroid—*Origin.*—(1) The posterior surface of the manu- sterni at its upper and outer part below the origin of the sterno-; and (2) the posterior surface of the first costal cartilage.

sertion.—The oblique line on the outer surface of the lamina of yroid cartilage.

rve-supply.—The ansa hypoglossi. The nerves enter this and st muscle quite at the lower part of the neck.

e muscle is broader, but shorter, than the sterno-hyoid under- which it lies. Within the thorax the right muscle lies in front innominate artery, and the left in front of the left common d artery and left innominate vein. In the neck each muscle upon the carotid sheath and the corresponding right or left lobe thyroid gland.

e sterno-hyoid muscles as they leave the thorax are separated interval, in which situation the sterno-thyroid muscles lie in contact. As the muscles ascend the sterno-hyoids converge, but erno-thyroids diverge.

yro-hyoid—*Origin.*—The oblique line on the outer surface of mina of the thyroid cartilage.

sertion.—(1) The outer half of the lower border of the body of yoid bone; and (2) the basal half of the greater horn of that

erve-supply.—A special branch of the hypoglossal, though origin- derived from the first and second cervical nerves. The nerve the surface of the muscle close to its posterior border.

e muscle is quadrilateral. Its superficial surface supports the ior belly of the omo-hyoid and the sterno-hyoid muscles, and its surface is related to the lamina of the thyroid cartilage, the -hyoid membrane, the internal branch of the superior laryngeal , and the superior laryngeal artery.

e nerves which supply the infrahyoid group of muscles are derived from st, second, and third cervicals through the hypoglossal and ansa hypo-

ction of the Infrahyoid Muscles—**Omo-hyoid.**—(1) To depress yoid bone; and (2) to render tense the deep cervical fascia in the part of the neck.

erno-hyoid.—To depress the hyoid bone.

erno-thyroid.—To depress the thyroid cartilage.

Thyro-hyoid.—(1) To depress the hyoid bone; and (2) to ele the thyroid cartilage, as in the production of high notes, or in glutition.

Structures in the Median Line of the Neck.—The median line of neck is divisible into two regions, suprahyoid and infrahyoid.

Suprahyoid Region.—The innermost fibres of the two platy muscles decussate at the median line for a short distance below chin. On either side of the median line, under cover of the platys is the anterior belly of the digastric muscle. The anterior bellie

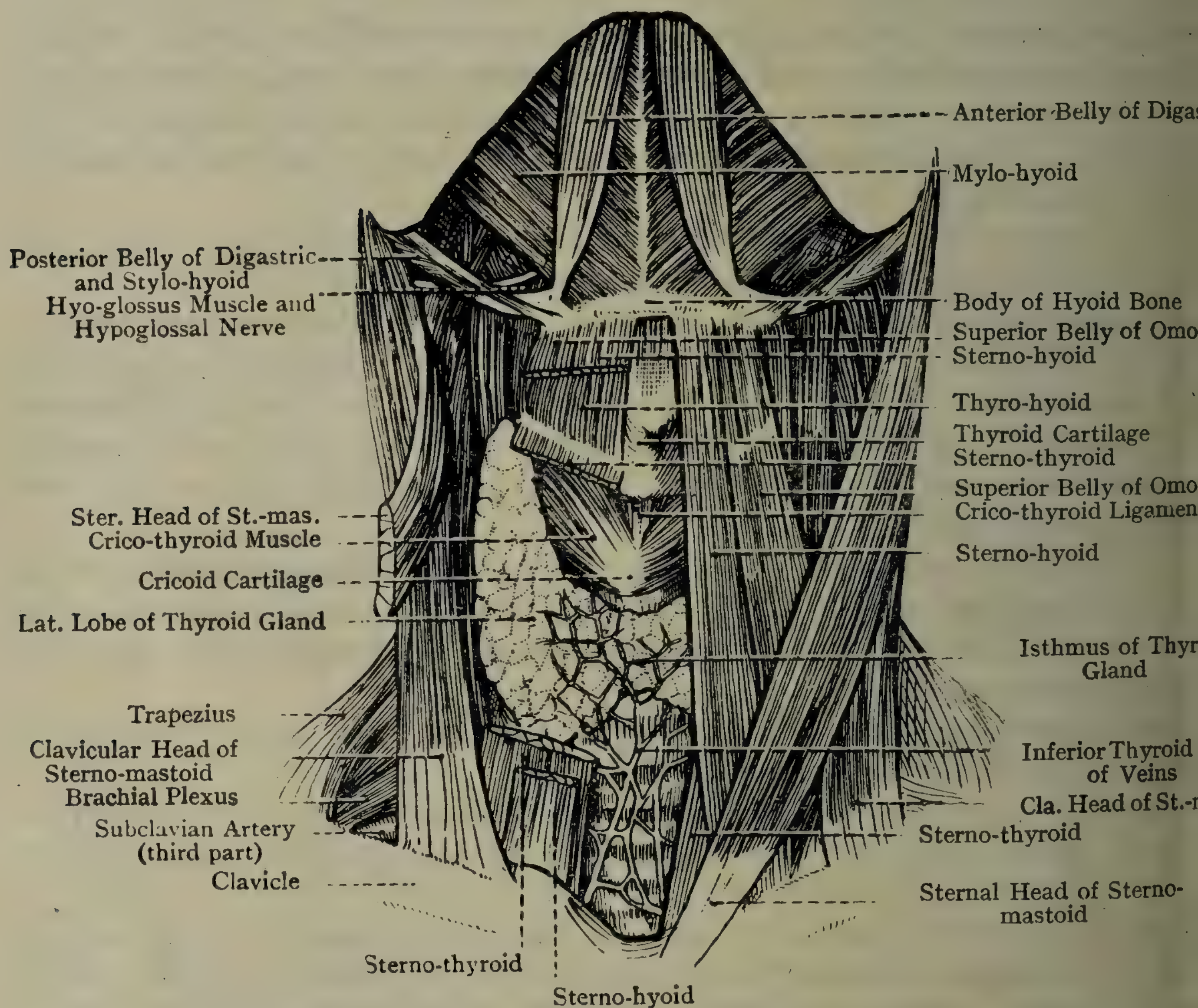


FIG. 722.—DISSECTION OF THE FRONT OF THE NECK.

The area bounded on either side by the anterior belly of the digastric a below by the body of the hyoid bone is the submental triangle.

opposite sides are near each other at the chin, but as they des with an inclination outwards they diverge from each other, and l between them a triangular interval sometimes called the **subm triangle.** The base of this triangle is formed by the body of the h bone, and each lateral boundary is constructed by the anterior l of the digastric, the apex being placed at the chin. The area of triangle is occupied by the anterior portions of the mylo-hyoid mus which meet at the median line in a tendinous raphé, and super to these muscles there are the submental lymph glands.

ubmental Lymph Glands.—These glands, usually two in number, n the submental triangle beneath the chin and above the body of hyoid bone, one being on either side of the median line. Each d receives its *afferent* vessels from (1) the *medial* portions of the r lip and lower gum; (2) the *tip* of the tongue and adjacent portion he floor of the mouth; (3) the skin of the chin; and (4) sometimes upper lip. Their *efferent* vessels pass to (1) the submandibular ph glands, and (2) the lo-omo-hyoid lymph gland, of the superior deep cer-l lymph glands.

nfrahyoid Region.—The re- from the hyoid bone down-ds to the suprasternal notch the upper border of the ubrium sterni is of con-rable importance in con-ion with bronchocele or re, laryngotomy, and tra-otomy.

The **body of the hyoid bone** a well-marked structure, ng with the greater horn on er side of it. Below the id bone there is the **thyro-id membrane,** which passes vards within the lower bor- of the hyoid bone. The t structure is the **thyroid tilage,** the upper border of ch has a well-marked dian notch, whilst its two form by their union the minent **laryngeal prominence mum Adami).**

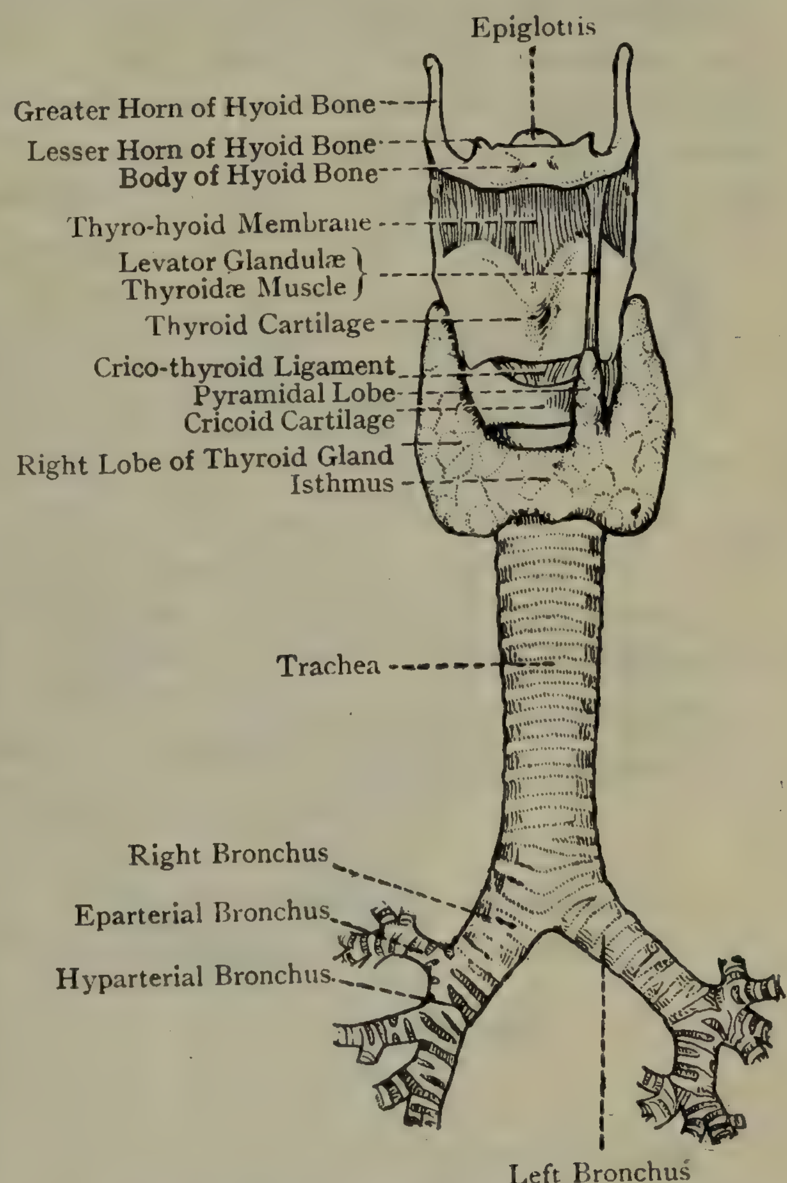


FIG. 723.—THE HYOID BONE, LARYNX TRACHEA, BRONCHI, AND THYROID GLAND (ANTERIOR VIEW).

Succeeding the thyroid carti-e there is a narrow interval, which is occupied by the **crico-thyroid ment,** and immediately below this is the narrow anterior part of **cricoid cartilage.** The crico-thyroid ligament is only exposed close the median line, being elsewhere covered by the two crico-thyroid scles. The exposed part of the ligament is crossed by the *crico-roid arterial arch,* which is situated midway between the thyroid l cricoid cartilages, and lying upon the ligament there may be or two prelaryngeal lymphatic glands. Laryngotomy may be formed in the crico-thyroid region, and the crico-thyroid arterial h has to be borne in mind.

Succeeding the cricoid cartilage is the **trachea,** which, as it cends, inclines backwards, and therefore becomes somewhat

inaccessible; at the suprasternal notch it may be 1½ inches fr the surface. The **thyroid gland** is intimately related to it superio Each *lobe* closely embraces it laterally as low as about the fifth ri and the *isthmus* lies in front of the second and third rings as a r but its position is liable to variation. Crossing the upper border of isthmus there is one of the branches of the superior thyroid arte known as the *artery of the isthmus.*

There is nothing of any importance in front of the trachea ab the isthmus of the thyroid gland. Below the isthmus there is a m or less copious plexus of veins, called the *inferior thyroid plexus,* fr which the right and left inferior thyroid veins descend. Occasi ally a small artery, called the *arteria thyroidea ima,* ascends direc in front of this part of the trachea in the median line to reach

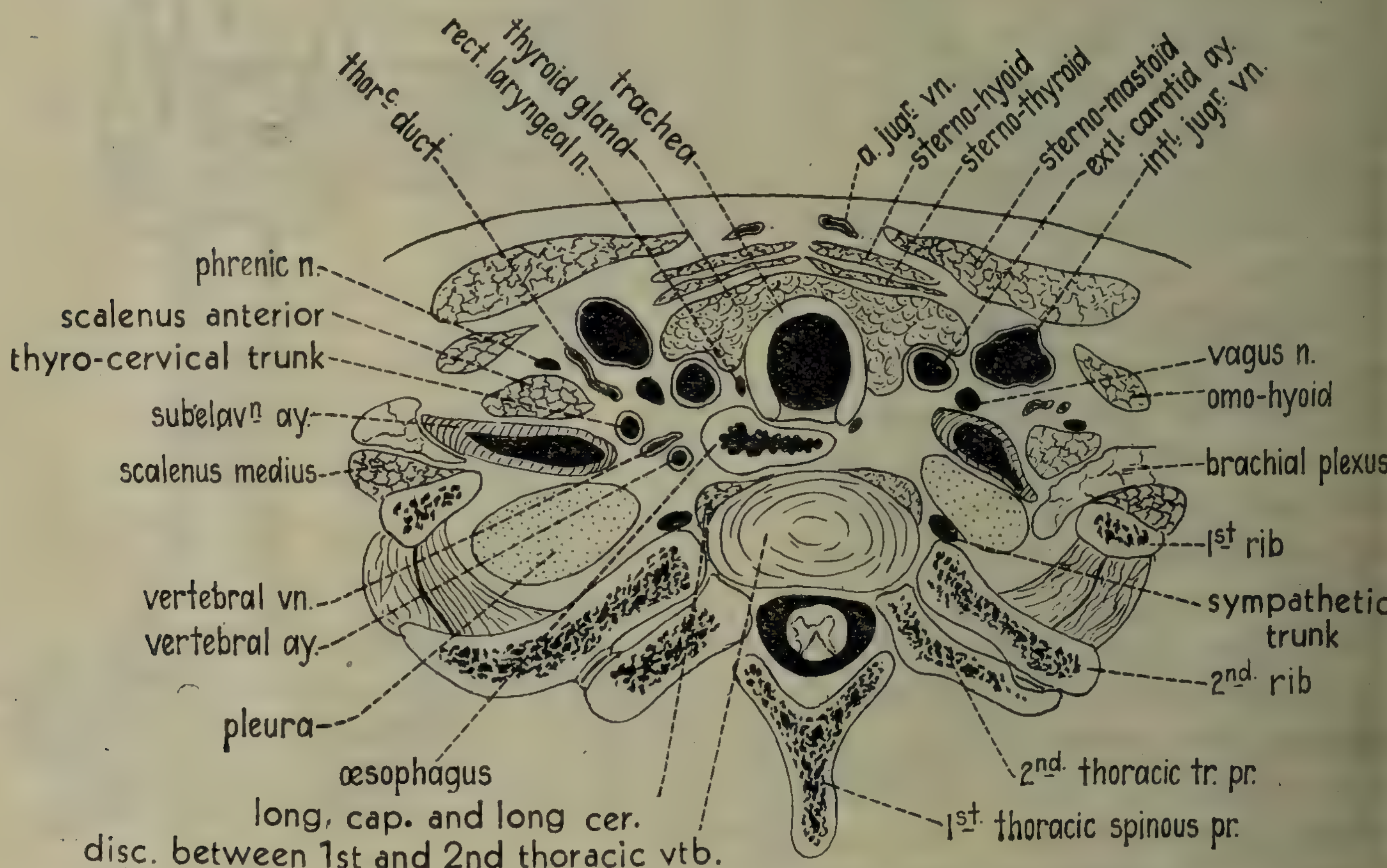
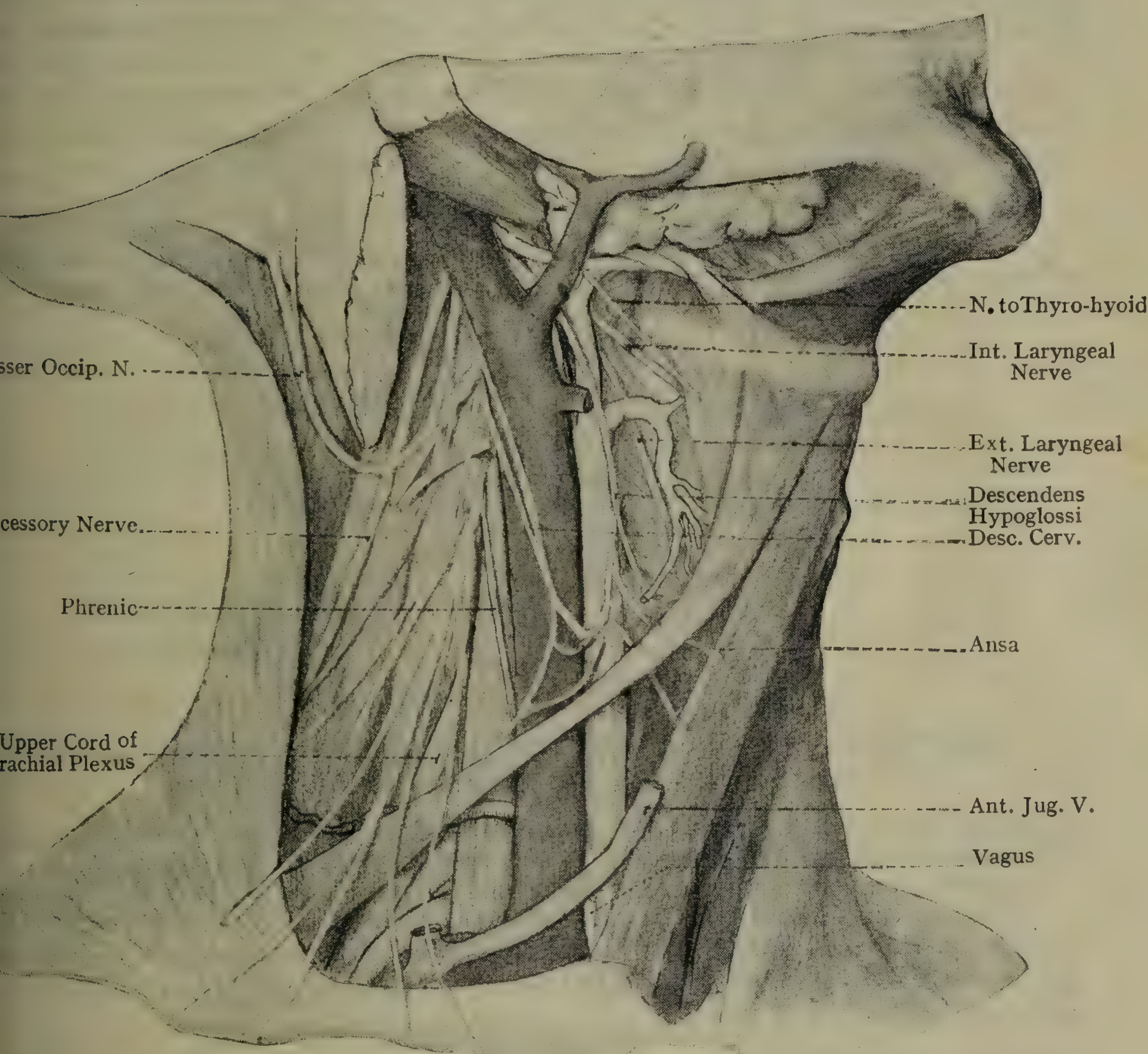


FIG. 724.—SECTION THROUGH LOWER PART OF NECK.

isthmus of the thyroid gland. The innominate, and even the rig common carotid, artery and the left innominate vein sometim encroach upon the front of the trachea towards the root of the ne The latter is a particularly important arrangement to remember, a occurs more frequently in women and children. In early life t upper part of the **thymus** covers the front of the trachea. The fo going structures are covered by the sterno-thyroid and sterno-hyo muscles in the following manner: the two sterno-thyroid muscles a in contact with each other for a short distance above the manubriu sterni, so as to cover the trachea, but the two sterno-hyoid muscl are here separated by an interval; superiorly the two sterno-thyro muscles diverge, and the two sterno-hyoid muscles come very nea together.

he operation performed upon the trachea is tracheotomy. rding as it is performed above or below the isthmus of the thyroid l, it is spoken of as the high or the low operation. In the high ation there is no anatomical obstacle, unless it be a close attach- : of the isthmus of the thyroid gland to the tracheal rings which vers. In the low operation the following obstacles are present: he trachea is here less accessible, because it recedes from the ce; (2) the inferior thyroid plexus of veins might prove trouble-



725.—Deep Nerves in the Neck in Relation with Carotid Sheath.

e; (3) an arteria thyroidea ima may be present; (4) the innominate right common carotid arteries and the left innominate vein may ndangered; and (5) in young children the thymus would be in the .

The Ramus Descendens Hypoglossi (Descendens Cervicis Nerve).— ramus descendens arises from the hypoglossal nerve as the latter ks round the occipital artery, its fibres being derived from the municating branches which the hypoglossal receives from the loop

between the first and second cervical nerves. The nerve, whicl long, passes downwards and slightly forwards, lying upon, or witl the carotid sheath, and in either case directly over the line of common carotid artery. Before reaching the centre of the necl furnishes a branch to the superior belly of the omo-hyoid mus Lower down it is joined by a branch which is formed by the unior the two *rami communicantes cervicales* from the anterior primary ra of the second and third cervical nerves. These two rami, howe sometimes join it separately. In this manner a loop is formed usu about the level of the cricoid cartilage, which is called the **ansa hy**

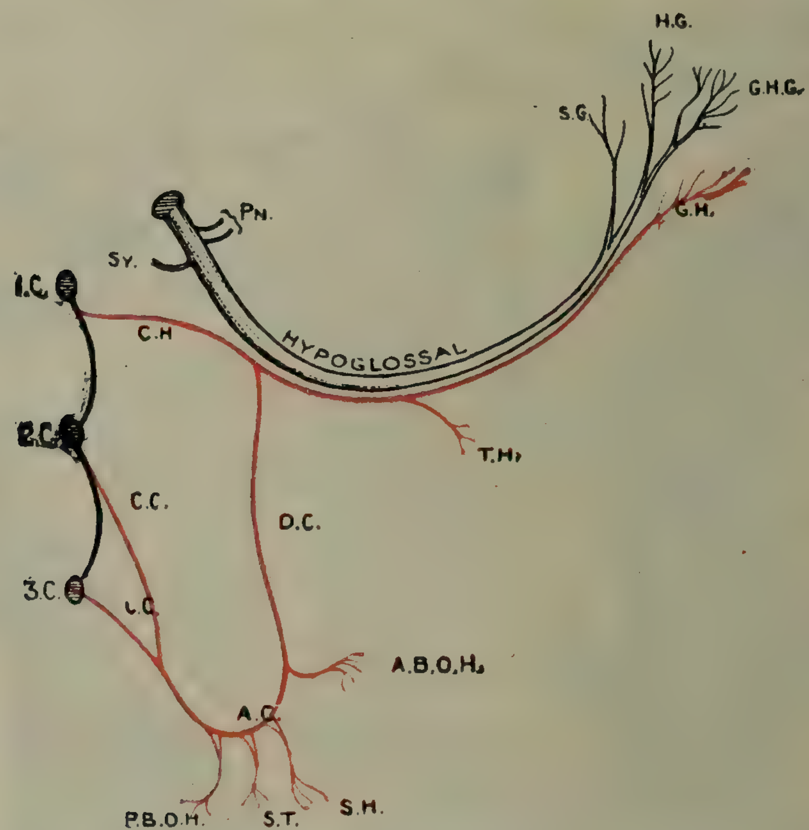


FIG. 726.—SCHEME OF THE HYPOGLOSSAL NERVE, SHOWING ITS CONNECTIONS WITH CERVICAL SPINAL NERVES.

SY., twig from sympathetic; PN., communicating with vagus; 1C, 2C, 3C, fi second, and third cervical; C.H., communicans hypoglossi; C.C., c municantes cervicalis; D.C., descendens hypoglossi; A.B.O.H., to ante belly of omo-hyoid; A.C., ansa hypoglossi; S.H., to sterno-hyoid; S.T. sterno-thyroid; P.B.O.H., to inferior belly of omo-hyoid; T.H., to thy hyoid; G.H., to genio-hyoid; G.H.G., to genio-glossus; H.G., to hyo-gloss S.G., to stylo-glossus.

glossi. The convexity of the loop is directed downwards, and fr it branches are given off to (1) the sterno-hyoid, (2) the sterno-thyrc and (3) the inferior belly of the omo-hyoid muscles.

The fibres of the ramus descendens hyo-glossi are of spinal, not hypoglos origin.

For the rami communicantes cervicales, see Cervical Plexus (p. 118

The Nerve to Thyro-hyoid.—This nerve, which is composed of spi fibres derived from the loop between the first and second cervi nerves, arises from the hypoglossal at the lower border of the poster belly of the digastric. It passes forwards and downwards, formi

cute angle with the parent trunk, and enters the thyro-hyoid le on its superficial surface.

arotid Sheath.—The carotid sheath, already described on p. 1179, rived from the posterior lamina of the sheath of the sterno-mastoid le, and is intimately connected anteriorly with the pretracheal , and posteriorly with the prevertebral layer, of the deep cervical a. The interior of the sheath is divided into three compartments— , inner, and posterior. The outer and inner compartments are rated from each other by a septum, the *inner compartment* contain- he common carotid artery and, it may be, the ramus descendens glossi, and the *outer compartment* the internal jugular vein. The *rior compartment* is situated within the back part of the septum, contains the vagus nerve. The ramus descendens hypoglossi may pon the sheath, or within it, and the trunk of the sympathetic ends behind, and in intimate relation with it.

he foregoing is the usual account of this sheath, but there are some ana- ts who believe that not only it, but many other fascial planes are hardly

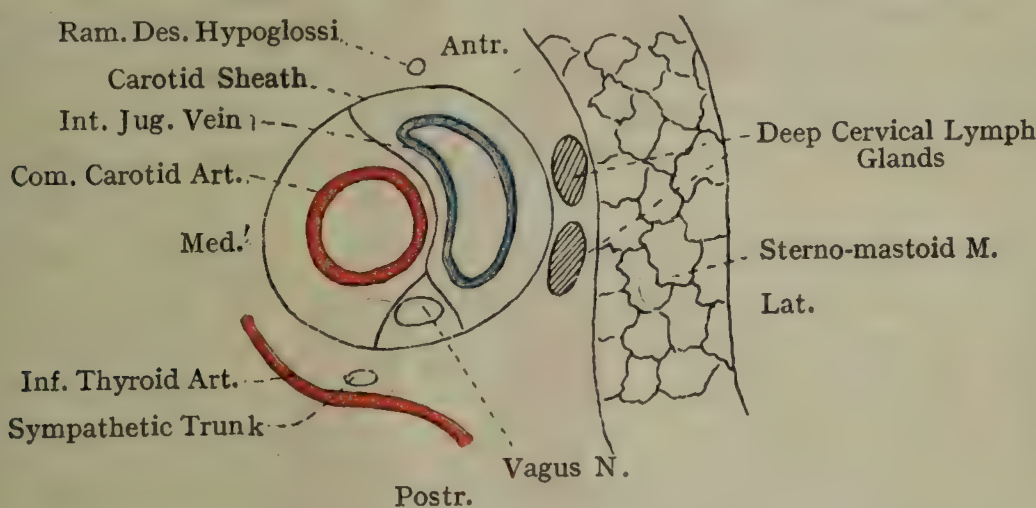


FIG. 727.—SCHEME OF SECTION THROUGH CAROTID SHEATH SHOWING CONTENTS AND CERTAIN RELATIONS.

gnizable in the living or in the undisturbed dead body. In any case, there reason to believe that the carotid has more or less of a sheath than any r artery of its own size elsewhere.

Common Carotid Arteries.—The *right* common carotid artery arises the innominate artery behind the upper border of the right sterno- icular joint, and the *left* common carotid artery arises from the er surface of the arch of the aorta, in close proximity to the origin he innominate artery. The vessel of the right side is therefore rely cervical, whilst that of the left side is partly thoracic and partly ical.

The thoracic part of the left common carotid artery has already n described in connection with the thorax (see p. 1039).

In the neck the common carotid artery of each side extends from back of the corresponding sterno-clavicular joint to the level of upper border of the thyroid cartilage of the larynx, which corre- nds to the disc between the bodies of the third and fourth cervical tebræ. At this level the vessel divides into the external and internal

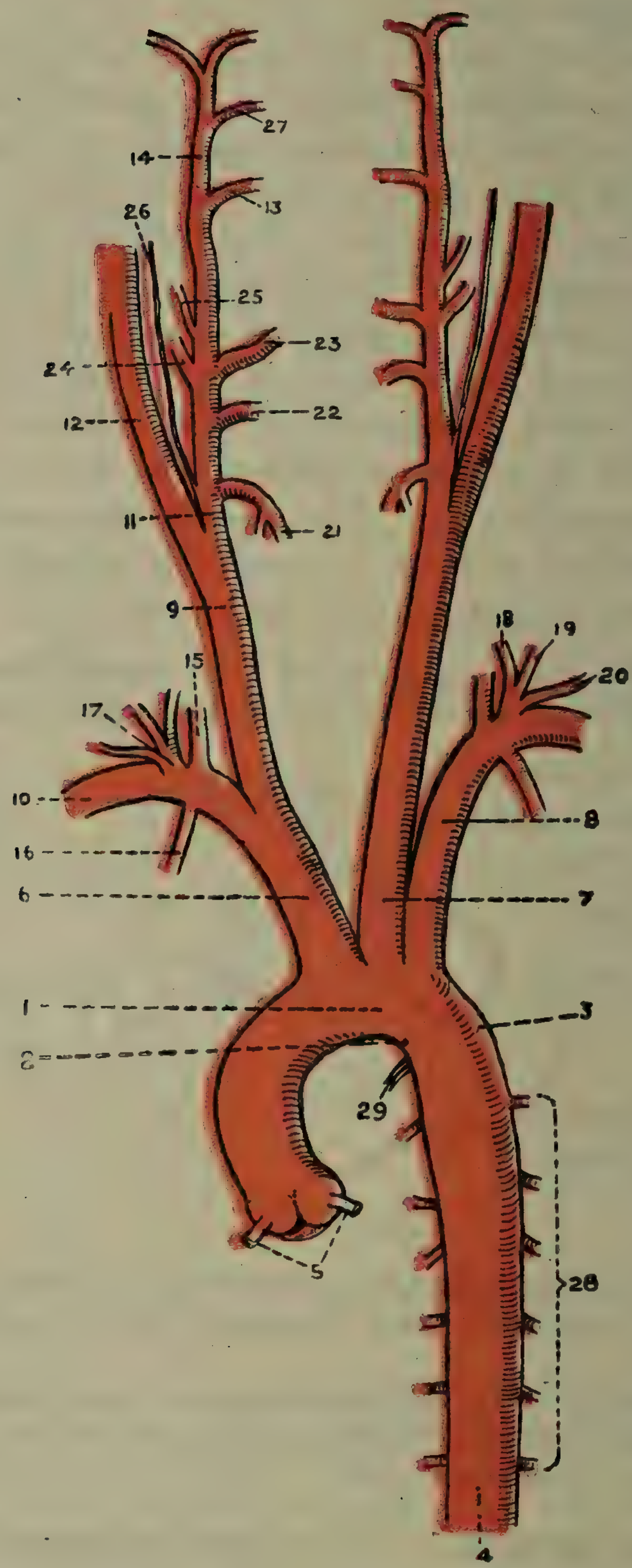


FIG. 728.—THE AORTA IN THE THORAX, AND THE PRINCIPAL ARTERIES OF T HEAD AND NECK.

1. Arch of the Aorta
2. Aortic Isthmus
3. Aortic Spindle
4. Descending Aorta
5. Coronary Arteries (from Ascending Aorta)
6. Innominate Artery
7. Left Common Carotid
8. Left Subclavian
9. Right Common Carotid
10. Right Subclavian
11. External Carotid
12. Internal Carotid
13. Maxillary
14. Superficial Temporal
15. Vertebral
16. Internal Mammary
17. Thyro-cervical Trunk
18. Inferior Thyroid
19. Transverse Cervical
20. Suprascapular
21. Superior Thyroid
22. Lingual
23. Facial
24. Occipital
25. Posterior Auricular
26. Ascending Pharyngea
27. Transverse Facial
28. Posterior Intercostals
29. Ligamentum Arteriosum

rotid arteries. The place of bifurcation is sometimes opposite the dy of the hyoid bone, and, more rarely, on a level with the cricoid rtilage of the larynx. The vessel is about $3\frac{3}{4}$ inches long, and its urse is upwards and outwards in the direction of a line drawn from e sterno-clavicular joint to a point midway between the angle of e mandible and the mastoid process of the temporal bone. This e, as high as the level of the upper border of the thyroid cartilage, presents the course of the common carotid artery. At the root of e neck the two common carotid arteries are not very far apart, and e trachea lies in the intervening space. As the two vessels ascend ey become more divergent, on account of the projection of the right d left lobes of the thyroid gland and the thyroid cartilage.

The artery, along with the internal jugular vein and vagus nerve, d, perhaps, the ramus descendens hypoglossi, is contained within e carotid sheath, already described. Opposite the cricoid cartilage is crossed by the superior belly of the omo-hyoid muscle. Below is level it lies deeply in the region of the muscular triangle, being der cover of the sterno-hyoid and sterno-thyroid muscles, in addition the platysma and the anterior border of the sterno-mastoid. Above is level it is situated in the carotid triangle, where it is more super-ially placed, its only muscular coverings being the platysma and the terior border of the sterno-mastoid.

Relations—*Anterior.*—The skin; superficial fascia and platysma; vesting layer of the deep cervical fascia; anterior border of the erno-mastoid; sterno-hyoid; sterno-thyroid; superior belly of the no-hyoid; and the anterior wall of the carotid sheath. Three veins oss the artery from without inwards: (1) the anterior jugular vein osses it immediately above the clavicle, superficial to the sterno-yoid and sterno-thyroid muscles; (2) the middle thyroid vein just low the level of the cricoid cartilage; and (3) the superior thyroid in near its bifurcation. The sterno-mastoid branch of the superior yroid artery, which is of small size, passes obliquely downwards d outwards in front of the carotid sheath in the carotid triangle. he ramus descendens hypoglossi descends in front of the carotid eath to form the ansa hypoglossi.

Posterior.—The posterior wall of the carotid sheath; the cervical ansverse processes as high as the level of the fourth; the longus rvicis, scalenus anterior, and part of the longus capitis muscles; e sympathetic trunk, which is intimately related to the posterior all of the carotid sheath; the recurrent laryngeal nerve; and the ferior thyroid artery, both of which latter structures pass inwards d upwards behind the lower part of the sheath.

Lateral.—The internal jugular vein and the vagus nerve, the latter ing between the artery and the vein, on a plane posterior to both. t the lower part of the neck, on the right side, the internal jugular ein leaves the common carotid artery, making a slight interval in hich the right vagus nerve appears as it is about to pass in front f the first part of the right subclavian artery. On the left side,

however, the internal jugular vein is very closely related to the commo carotid artery, and even overlaps it.

Medial.—From below upwards (1) the trachea and œsophagu with the recurrent laryngeal nerve and the inferior thyroid arter lying in the intervening groove; (2) the corresponding lobe of th thyroid gland, upon which the vessel impresses a groove, and by whic it is usually overlapped; and (3) the larynx and pharynx.

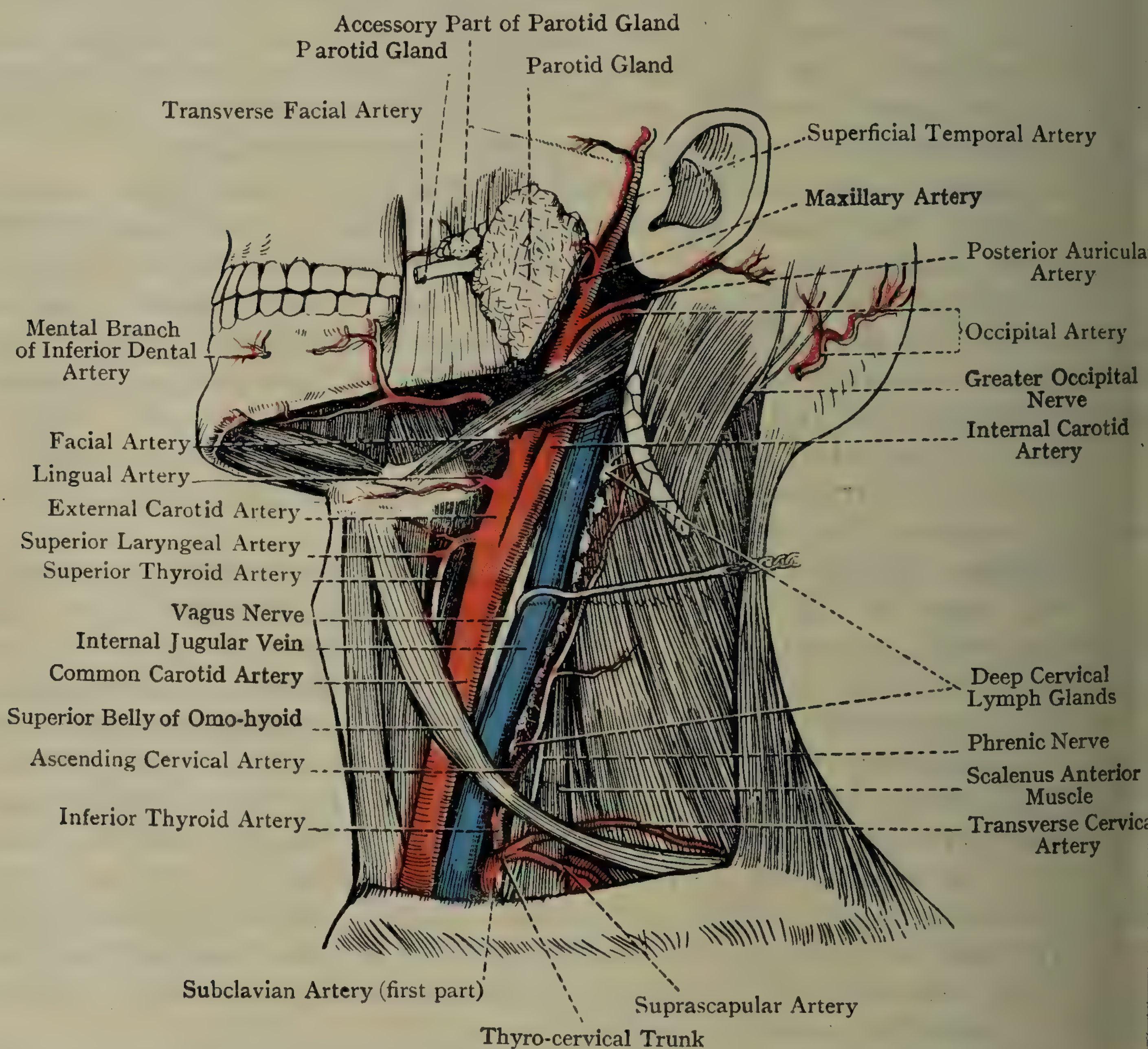


Fig. 729.—Deep Dissection of the Left Side of the Neck (after Spalteholz).

The common carotid artery, as a rule, gives off no branch. Th superior thyroid artery, however, may arise from it superiorly, and i some cases the ascending pharyngeal artery.

Surgery—Compression.—The part of the vessel most favourabl situated for compression lies in front of the tubercle of the transvers process of the sixth cervical vertebra, this tubercle, known as th *carotid tubercle*, being on a level with the cricoid cartilage of the larynx

Ligation.—The part of the vessel most favourably placed fo ligation is situated on a level with the cricoid cartilage just abov the point where it is crossed by the anterior belly of the omo-hyoi

cle. The structures to be avoided in the operation are: (1) the us descendens hypoglossi upon, or it may be within, the sheath; the internal jugular vein and vagus nerve, both of which are in the sheath, and upon the outer side of the artery; and (3) the pathetic trunk, which lies behind and in close contact with the th. The small sterno-mastoid branch of the superior thyroid ry will probably be cut, as it passes obliquely downwards and wards over the sheath in the carotid triangle. Ligation of the ry *below* the level of the cricoid cartilage is attended with diffi-y, the vessel being here covered by the sterno-hyoid and sterno-roid muscles, in addition to the platysma and sterno-mastoid. the left side the internal jugular vein is an additional difficulty.

Collateral Circulation after Ligation.—(1) Cross anastomoses take ce freely between the external and internal carotid arteries of osite sides. (2) The inferior thyroid artery of the side operated n anastomoses freely with the superior thyroid of the same side, ch is a branch of the external carotid. (3) The deep cervical nch of the superior intercostal, which latter is a branch of the ond part of the subclavian artery on the right side, and of the t part on the left side, anastomoses with the descending branch the occipital, which is a branch of the external carotid. (4) The tebral artery undergoes much enlargement.

Carotid Body.—This small body is situated behind the common otid artery close to its bifurcation. It is composed of a few lobules ted by connective tissue, and it receives minute twigs from the acent part of the common carotid artery. The lobules consist groups of polyhedral cells permeated by blood-capillaries and npathetic nerve-filaments. Some of the cellular constituents are *omaffin cells*, similar to those which are met with in the medulla the suprarenal gland and in the sympathetic ganglia. These cells derived from the contiguous ganglia of the sympathetic system. e carotid body of each side is similar to the glomus coccygeum d organs of Zuckerkandl.

The carotid body is developed in part from the sympathetic system, and in t from the lymphatic system.

Development.—The common carotid arteries are developed from the parts of ventral aortæ which are situated between the third and fourth aortic arches.

Internal Jugular Vein.—The internal jugular vein is the continu-on of the intracranial sigmoid sinus. It begins in the postero-eral compartment of the jugular foramen, and ends behind the er end of the clavicle by joining the subclavian to form the inno-nate vein. At its beginning it has a slight dilatation, called the *berior bulb*. The vein descends vertically, lying at first on the outer e of the internal carotid, and then on the outer side of the common otid artery, the vagus nerve being interposed in each case, and being enclosed within the carotid sheath. The relations of the ssel for the most part correspond to those of the arteries which it companies.

Tributaries.—These are as follows:

Inferior petrosal sinus.	Pharyngeal.
Common facial.	Superior thyroid.
Lingual.	Middle thyroid.

A small vein accompanying the occipital artery may occasional open into it.

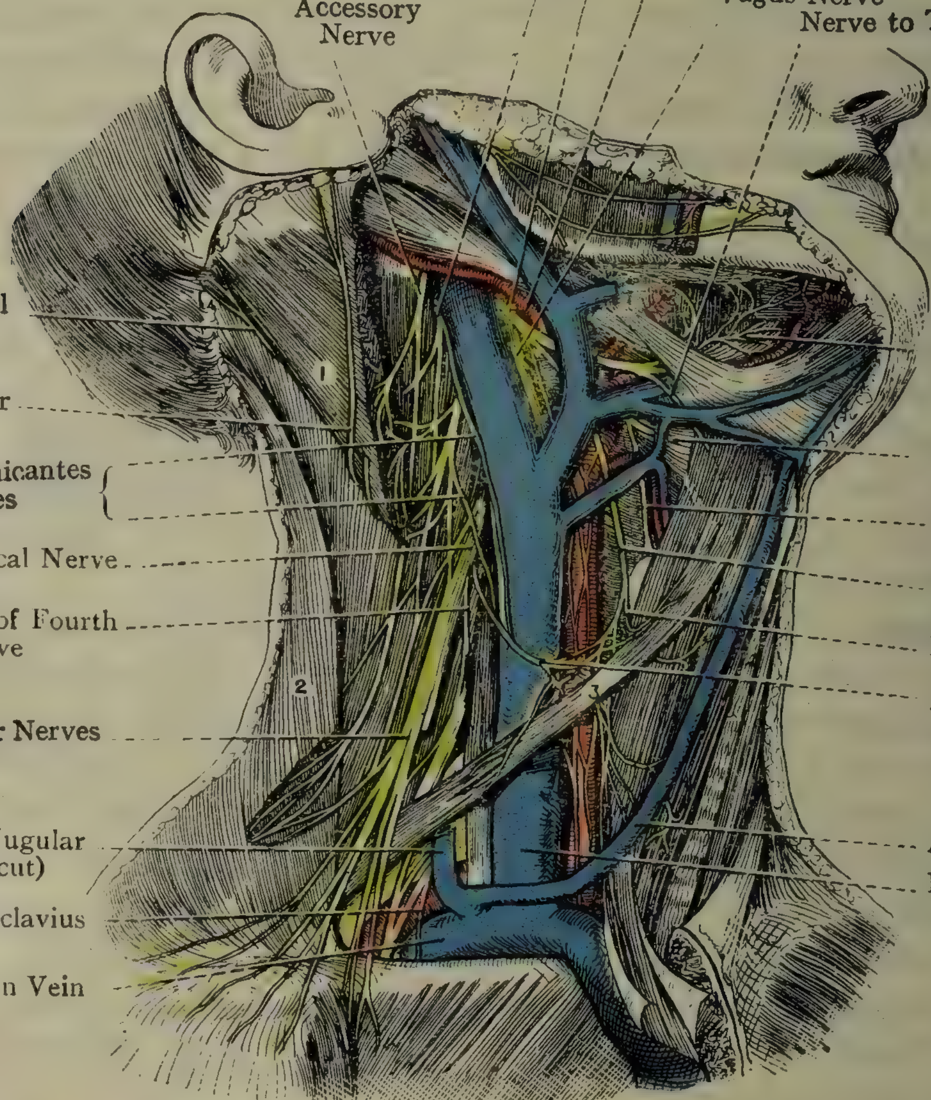


Fig. 730.—Deep Dissection of the Right Side of the Neck (after Hirschfeld and Leveillé).

1, upper part of sterno-mastoid; 2, trapezius; 3, tendon of omo-hyoid.

The inferior petrosal sinus leaves the cranial cavity through th antero-medial compartment of the jugular foramen, and opens int the internal jugular vein close to the base of the skull.

Development.—The internal jugular vein is developed from the anteric cardinal vein.

The vagus nerve in the neck will be found described on p. 1327.

External Carotid Artery.—The external carotid artery is one c the terminal branches of the common carotid, the other being th internal carotid artery. In spite of its name, it is, at its origin, th medial of the two vessels, and it lies anterior to, and nearer the media

than, the internal carotid. It extends from a point on a level
ı the upper border of the thyroid cartilage to one immediately
ind the neck of the mandible, where it divides in the substance of
parotid gland into the superficial temporal and maxillary arteries.
s about $2\frac{1}{2}$ inches in length, and its direction is at first upwards
forwards as far as the angle of the mandible, and then upwards
backwards. At first the artery lies in the carotid triangle, and is
ıparatively superficial. As it leaves this triangle it is more deeply
:ed, being crossed by the posterior belly of the digastric and stylo-
id muscles, and the hypoglossal nerve. Then the vessel is em-
ded in the substance of the parotid gland, where it is crossed from
ind forwards by the facial nerve.

Relations.—*Antero-lateral.*—The skin; superficial fascia; platysma;
p fascia; anterior border of the sterno-mastoid; the lingual and
ımon facial veins; the hypoglossal nerve (all the foregoing being
erior relations, whilst the artery lies in the carotid triangle); the
terior belly of the digastric and stylo-hyoid muscles; the greater
t of the parotid gland; the posterior facial vein; and the facial
ve. *Deep* or *Postero-medial.*—(1) The stylo-pharyngeus muscle,
sso-pharyngeal nerve, and styloid process of the temporal bone,
of which lie between the vessel and the internal carotid (the latter
e lying on a plane behind the external carotid); and (2) a small
tion of the parotid gland. The pharynx and hyoid bone; the
erior laryngeal nerve; a portion of the parotid gland; and the
terior border of the ramus of the mandible.

The external carotid artery has no vein in the sense of a companion
sel, but the posterior facial vein descends superficially to it in the
otid gland to near the angle of the mandible, beyond which point
artery has no vein.

The course of the vessel may be indicated by a line drawn from
side of the cricoid cartilage of the larynx to the tragus of the
icle.

Development.—The external carotid artery is, for a short portion of its
rse, the persistent part of the ventral aorta above the level of the third aortic
ı. In the rest of its extent it is formed from enlarged side-branches of the
inal stem.

Branches.—These are arranged in four sets—anterior, posterior,
ending, and terminal—and are as follows:

Anterior.	Posterior.	Ascending.	Terminal.
erior thyroid.	Occipital.	Ascending pharyngeal.	Superficial temporal.
gual.	Posterior auricular.		Maxillary.
ial.			

Superior Thyroid Artery.—This vessel arises in the carotid triangle
m the front part of the external carotid close to its origin. It
:es an arched course forwards and downwards, passing under cover
the infrahyoid muscles. On reaching the apex of the corresponding
e of the thyroid gland it breaks up into its terminal branches,

which enter the lobe on its superficial aspect, and anastomose free within it with branches of the inferior thyroid artery, and in the isthm with its fellow of the opposite side.

Branches :

Infrahyoid.	Crico-thyroid
Sterno-mastoid.	Glandular.
Superior laryngeal.	Muscular.

The *infrahyoid artery* passes inwards on the thyro-hyoid membran deep to the thyro-hyoid muscle, and close to the lower border of t

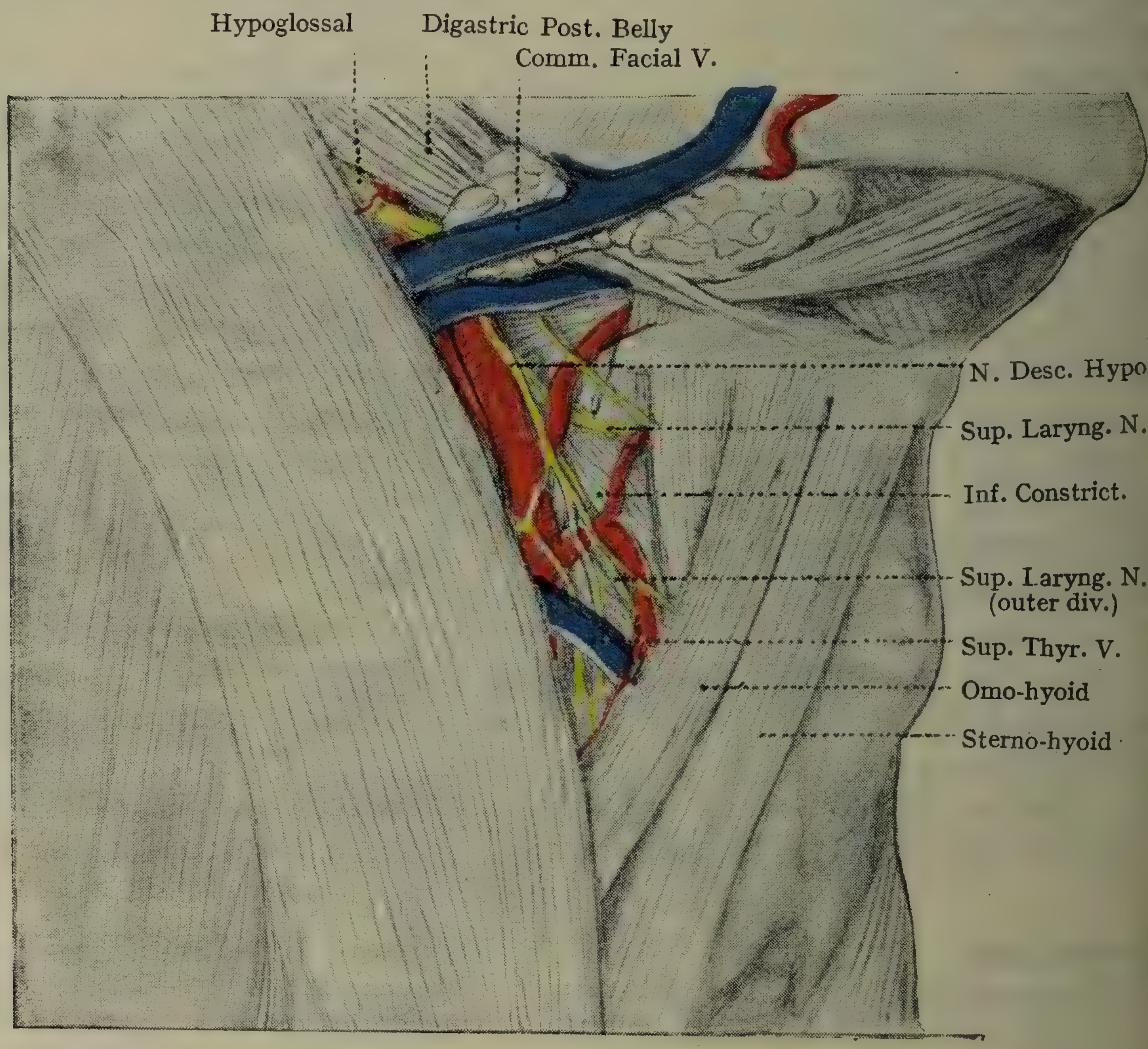


FIG. 731.—DISSECTION OF CAROTID TRIANGLE.

hyoid bone. It anastomoses at the middle line with its fellow of t opposite side, and with the suprahyoid branch of the lingual arte of the same side. The *sterno-mastoid branch* passes obliquely downwar and outwards, lying superficial to the carotid sheath, to enter the de surface of the muscle from which it takes its name. It is liable to cut in tying the common carotid artery. The *superior laryngeal arte* accompanies the internal laryngeal nerve, and, passing deep to t outer border of the thyro-hyoid muscle, pierces the thyro-hyo membrane, to be distributed to the interior of the larynx. The *cri thyroid branch* passes transversely inwards upon the crico-thyro ligament, and anastomoses with its fellow of the opposite side to fo

crico-thyroid arch. The *glandular branches* are distributed to the responding lobe of the thyroid gland. They anastomose freely h branches of the inferior thyroid of the same side, and with branches the fellow of the opposite side to a less extent. One very constant nch, known as the *artery of the isthmus*, courses along the upper der of the isthmus, and anastomoses with its fellow of the opposite e. The *muscular branches* are distributed to the infrahyoid muscles.

The **superior thyroid vein** issues from the upper part of the corre- nding lobe of the thyroid gland, and crosses in front of the common otid artery near its bifurcation to open into the internal jugular n. Its tributaries for the most part correspond to the branches the artery.

Lingual Artery.—The lingual artery arises from the front part of e external carotid a little above the origin of the superior thyroid d opposite the greater horn of the hyoid bone. From its com- cated course it is convenient to divide the artery into three parts.

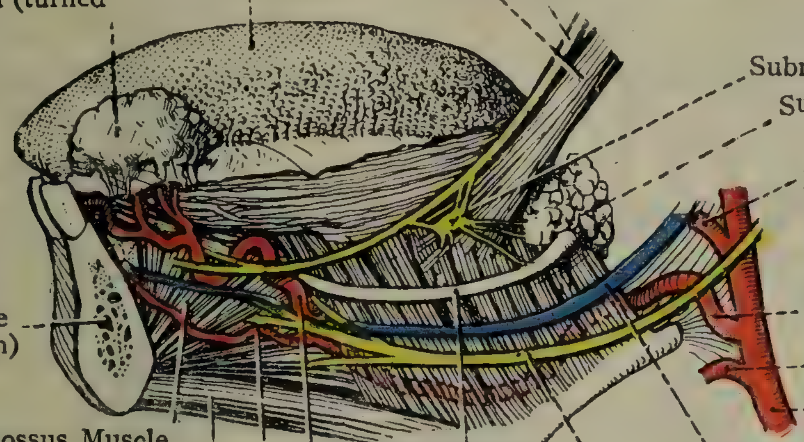


FIG. 732.—DEEP DISSECTION OF THE LEFT SUBMANDIBULAR REGION.

First Part.—The first part of the vessel ascends for a little, and en, bending sharply, descends to the greater horn of the hyoid bone, ssing deep to the posterior belly of the digastric and stylo-hyoid uscles. So far the vessel lies in the carotid triangle, and the bend hich it describes is crossed by the hypoglossal nerve. It is for the ost part comparatively superficial.

Second Part.—The second part passes horizontally forwards along e upper border of the hyoid bone deep to the hyo-glossus, the hypo- ossal nerve and its vena comitans being superficial to that muscle. eep to it is the middle constrictor. At the anterior border of the yo-glossus it enters upon the third part of its course.

Third Part.—Near the anterior border of the hyo-glossus muscle e lingual artery describes another sharp bend in an upward direction, d ascends almost vertically to the under surface of the tongue, sting upon the genio-glossus, and being under cover of the anterior order of the hyo-glossus. Having reached the tongue, the artery

passes forwards on its under surface in a tortuous manner under th name of arteria profunda linguæ.

Branches:

1. Suprahyoid.
2. Rami dorsales linguæ.
3. Sublingual.
4. Arteria profunda linguæ.

The *suprahyoid artery* arises from the lingual at the posterior borde of the hyo-glossus, and passes along the upper border of the hyoi bone.

The *rami dorsalis linguæ* arise under cover of the hyo-glossu muscle, which they pierce, and so reach the posterior third of th

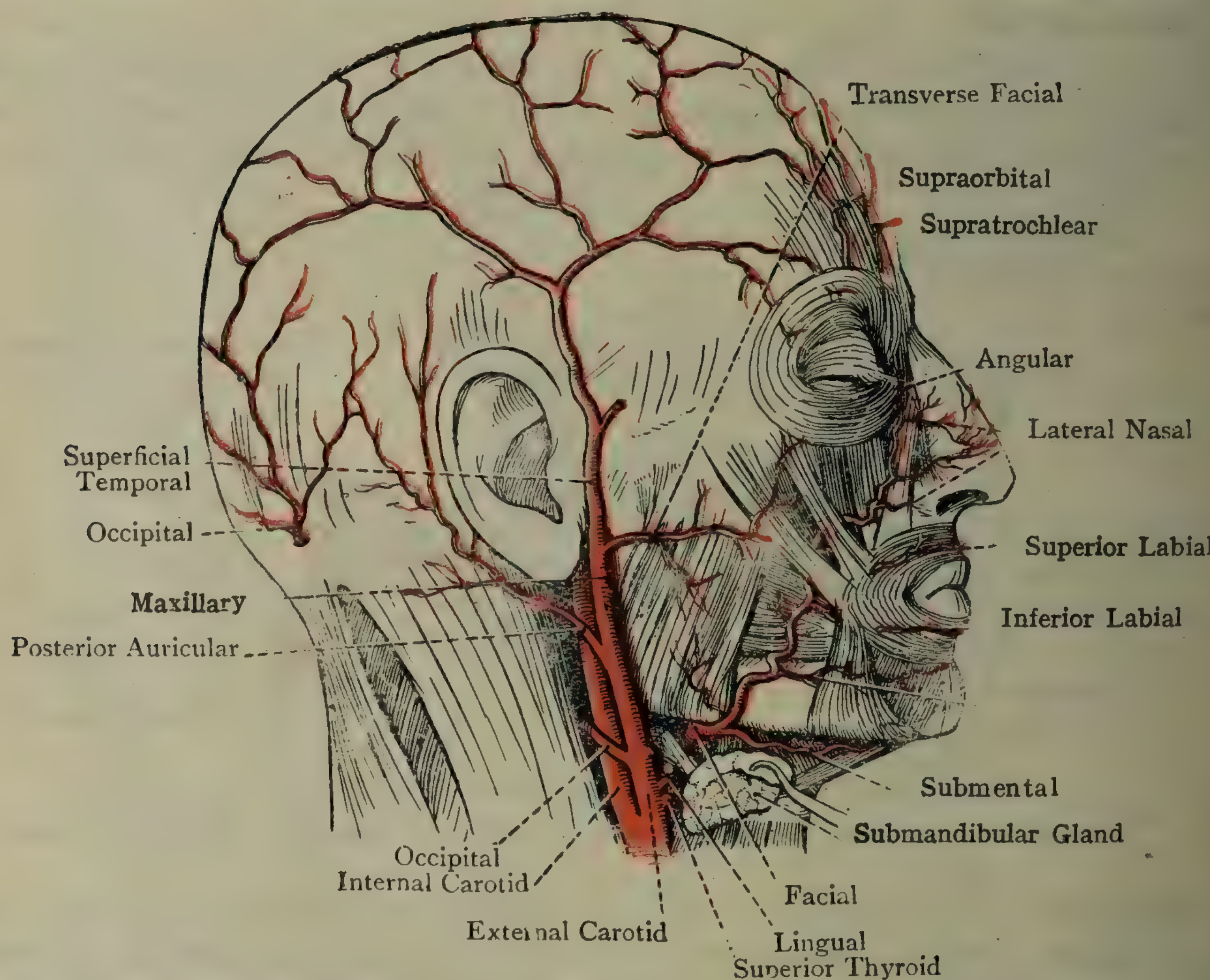


FIG. 733.—THE ARTERIES OF THE RIGHT SIDE OF THE HEAD (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

dorsum of the tongue. They are distributed to the mucous membran and substance of the tongue, the tonsil, and the soft palate.

The *sublingual artery* arises close to the anterior border of th hyo-glossus muscle. It supplies the sublingual gland, the adjacen muscles, and the mucous membrane of the floor of the mouth. On of the lateral branches anastomoses at the median line with a corre sponding branch of the opposite artery, and another of them is know as the *artery of the frenulum linguæ*.

The *arteria profunda linguæ* (*ranine artery*) is the terminal pa of the lingual. It passes forwards on the under surface of the tongu lying immediately lateral to the insertion of the genio-glossus, betwee

ıd the longitudinalis linguæ inferior. It is more or less embedded ıe substance of the tongue, and its course is tortuous in adaptation he mobility of the organ to which it is so intimately related. To-ls the tip of the tongue the vessel is very superficially placed, g close by the side of the frenulum linguæ, and it anastomoses ı its fellow of the opposite side near the tip. Elsewhere the cross stomoses are remarkable for their absence, and if one lingual artery led with fine injection hardly any crosses the mid-line of the tongue pt at the tip. The arteria profunda linguæ furnishes branches y to the substance of the tongue. Its close relation to the frenulum ıæ is to be carefully noted in connection with the operation for f of tongue-tied children.

The **lingual veins** are as follows: (1) the *vena comitans hypoglossi ine vein*), which is of large size, commences under the tip of the gue, and passes backwards, in company with the hypoglossal nerve, rficial to the hyo-glossus muscle, receiving tributaries from the ounding structures; (2) two *venæ comitantes* accompanying the ual artery; and (3) the *dorsal lingual veins*, which originate in a us beneath the mucous membrane over the posterior third of the n. These three sets of veins may join into a common trunk, called **lingual vein,** which opens into the internal jugular vein, or they terminate independently in that vein.

Lingual Lymph Glands.—These glands, which are of small size, pon the outer surfaces of the genio-glossus and hyo-glossus muscles, g the vena comitans hypoglossi. They are really small gland-ions lying in the course of the lymphatic vessels of the tongue hese pass to join the deep cervical lymph glands.

Facial Artery.—The facial artery arises from the front part of external carotid in the carotid triangle immediately above the ual artery, or sometimes in common with that vessel. It passes ards and forwards deep to the hypoglossal nerve, the posterior y of the digastric and the stylo-hyoid muscles, into the subman-ılar triangle. It then becomes embedded in a groove on the upper back part of the submandibular gland, its general course being vards with many curves. From this groove it describes a sharp l upwards over the base of the mandible in front of the masseter cle. The vessel then enters upon the facial part of its course, for scription of which see p. 1278.

Branches.—Four branches arise from the cervical part of the facial ry:

1. Ascending palatine.
2. Tonsillar.
3. Glandular.
4. Submental.

The *ascending palatine artery* passes upwards between the stylo-sus and stylo-pharyngeus muscles, and then over the upper ler of the superior constrictor of the pharynx along with the levator ti muscle. It is distributed to the soft palate, tonsil, and auditory e. The *tonsillar artery* passes upwards between the stylo-glossus

and medial pterygoid muscles, and, after piercing the superior c strictor muscle, it is distributed to the tonsil and the posterior p of the side of the tongue. The *glandular branches* are distributed the submandibular gland. The *submental artery* arises from facial just below the mandible, and passes forwards superficial the mylo-hyoid muscle. It gives branches to the submandibular gla and mylo-hyoid muscle, some of the branches piercing that mus to reach the sublingual gland and anastomose with the subling artery.

The cervical part of the **anterior facial vein** passes downwa and backwards superficial to the submandibular gland. Hav received tributaries corresponding to the branches of the cervical p of the artery, it unites with the anterior division of the posterior fac vein to form the **common facial vein,** which opens into the inter jugular opposite the body of the hyoid bone.

Occipital Artery.—The occipital artery arises from the poster aspect of the external carotid opposite the facial artery. It pas at first upwards and sligh backwards beneath the poster belly of the digastric and sty hyoid muscles, and the hy glossal nerve, having hook round it, passes forwards sup ficial to it. Having reached level of the interval between transverse process of the at and the mastoid process, artery changes its course, a passes backwards to occupy occipital groove on the in aspect of the mastoid proc where it is in touch with rectus capitis lateralis. In t backward course it crosses

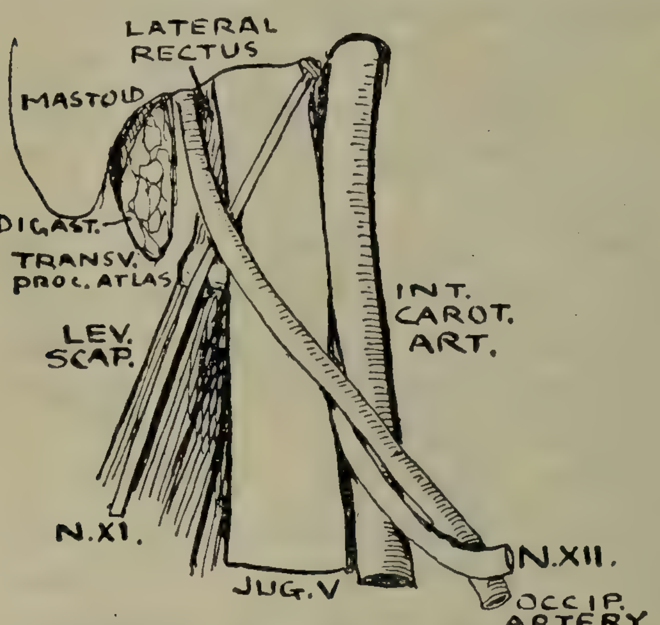


FIG. 734.—PLAN OF COURSE OF OCCIPITAL ARTERY IN NECK.

internal carotid artery, internal jugular vein, and vagus, accesso and hypoglossal nerves. As it lies in the occipital groove the ve is very deeply placed, being covered by the following structu (1) the origin of the posterior belly of the digastric; (2) the lon simus capitis; (3) the splenius capitis; and (4) the sterno-mast After escaping from beneath the splenius capitis, the vessel takes upward course superficial to the semispinalis capitis to the occip region, where it ramifies in a tortuous manner along with the branc of the greater occipital nerve.

Branches. — Muscular; meningeal; mastoid; descending; a Occipital.

The *muscular branches* are distributed to the adjacent musc one of them, the *sterno-mastoid branch,* crosses the hypoglossal ne and enters the deep surface of the sterno-mastoid muscle in comp

the accessory nerve. The *meningeal branch* accompanies the internal
lar vein, and enters the cranial cavity through the jugular foramen
ıpply the dura mater of the posterior fossa. The *mastoid branch*
es through the mastoid foramen when present, and supplies the
cent dura mater. The *descending* and the *occipital* (*terminal*)
ıches have been already described (see p. 1146).

'he description of the occipital veins will be found on p. 1147.

'osterior Auricular Artery.—This vessel arises from the posterior
ct of the external carotid a little above the origin of the occipital
ry, and above the posterior belly of the digastric. It passes
ards and slightly backwards under cover of the lower part of the
tid gland, and behind the styloid process of the temporal bone,
g crossed by the facial nerve. Having reached the groove between
back of the auricle and the mastoid process, where it meets the
erior auricular nerve, it divides into two branches, auricular and
ɔital.

ɜranches.—These are as follows: muscular; glandular; stylo-
toid; auricular; and occipital.

'he *muscular branches* supply the adjacent muscles. The *glandular*
ches are distributed to the lower part of the parotid gland. The
-mastoid artery enters the facial canal through the stylo-mastoid
men. It is distributed to the tympanic cavity and the mastoid
ells, and anastomoses with the tympanic branch of the first part
ıe maxillary artery. With this latter branch it forms a ring at the
ımference of the tympanic membrane on its inner aspect. Within
facial canal the stylo-mastoid artery anastomoses with the super-
l petrosal branch of the middle meningeal artery, which branch
rs the canal through the hiatus for greater superficial petrosal
e. The *auricular branch* passes upwards deep to the auricularis
erior muscle, and furnishes branches to the inner aspect of the
cle, some of which reach the outer surface by piercing the cartilage
by turning round its margin. The auricular branch anastomoses
ı the posterior branch of the superficial temporal artery. The
ɔital branch passes backwards over the mastoid process to the
pital region, and anastomoses with the occipital artery.

'he **posterior auricular vein,** of fairly large size, often unites with
posterior division of the posterior facial vein near the angle of
inferior maxilla, and by this union the external jugular vein is
ıed. The arrangement, however, is very variable.

ıscending Pharyngeal Artery.—This long, slender vessel arises from
beginning of the deep surface of the external carotid. It runs
ically upwards towards the base of the skull, lying very deeply
ı the longus capitis muscle, and between the internal carotid
ry, in front of which it has passed, and the pharynx.

ɜranches :

1. Pharyngeal.
2. Palatine.
3. Prevertebral.
4. Inferior tympanic.
5. Meningeal.

The *pharyngeal branches* are distributed to the pharynx. Th *palatine branch* passes over the superior constrictor muscle of th pharynx, and is distributed to the soft palate, auditory tube, and tons The *prevertebral branches* supply the prevertebral muscles. Th *inferior tympanic artery* passes with the tympanic branch of the gloss pharyngeal nerve through the tympanic canaliculus in the petro part of the temporal bone, and so reaches the tympanic cavity, to th inner wall of which it is distributed. The *meningeal branches* are th terminal branches of the ascending pharyngeal, and are three in numbe One passes through the foramen lacerum, a second through the jugul foramen, and a third through the anterior condylar canal, to be di tributed to the dura mater in the vicinity of these foramina.

The *descending pharyngeal vein* accompanies the ascending phary geal artery.

For the superficial temporal and maxillary branches of the extern carotid artery, see pp. 1158 and 1304.

The internal carotid artery will be found described on p. 1323.

Thyroid Gland.—The thyroid gland is situated on either side the upper part of the trachea and larynx, and a small portion of it li in front of the upper part of the trachea. Its size is subject to mu variation; its weight is rather more than 1 ounce; and it is larger the female than in the male. It consists of right and left lobes and isthmus.

Each **lobe** is conical and about 2 inches long, the rounded ba being directed downwards. It extends from the middle of the lami of the thyroid cartilage to about the level of the fifth ring of the trache Its *superficial surface*, which looks forwards and outwards, is somewh convex, and is covered by the sterno-thyroid, sterno-hyoid, and superi belly of the omo-hyoid muscles. It is also overlapped by the anteri border of the sterno-mastoid. Its *deep surface* is concave in adaptati to the trachea and larynx. The *anterior border* is thin, and towar its lower part is connected with that of the opposite lateral lobe means of the isthmus. The *posterior border* is thick, and is in conta with the pharynx and œsophagus, and has the parathyroid glan embedded in it. Each lobe overlaps the corresponding common carot artery, enclosed in the carotid sheath, and is frequently grooved by th vessel. Inferiorly it overlaps the recurrent laryngeal nerve and inferi thyroid artery. The apex of each lobe rests upon the inferior constrict muscle of the pharynx, and the superior thyroid artery enters it supe ficially and deeply.

The **isthmus** is inconstant as regards size and position. Its dep ranges from $\frac{1}{4}$ to 1 inch, and its breadth is about $\frac{1}{2}$ inch. It conne the lower parts of the anterior borders of the lateral lobes, but do not reach quite so low as their bases. It lies in front of the trach usually upon the second and third rings, and fits closely to the rin upon which it rests. Along its upper border there is a branch of t superior thyroid artery, known as the *artery of the isthmus*, which an tomoses with its fellow of the opposite side. From its lower bord

eral veins issue, which take part in the inferior thyroid plexus of ns in front of the trachea.

In some cases an additional lobe is present, called the **pyramidal** . It forms a long pyramid, which is attached by its base to the er border of the isthmus, usually at its junction with the left lobe. apex is attached to the body of the hyoid bone by a fibrous band, ch sometimes contains muscular fibres, known as the *levator glandulæ oidæ muscle.* It is seldom quite median in position.

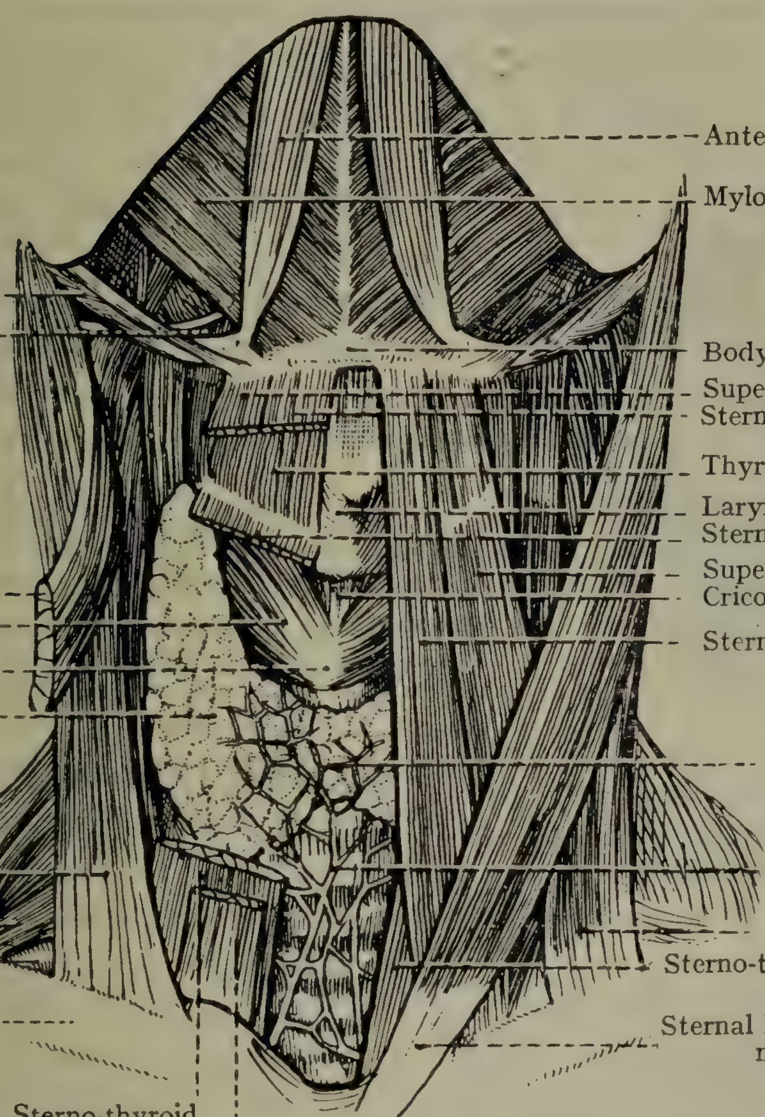


FIG. 735.—DISSECTION OF THE FRONT OF THE NECK.

he area bounded on either side by the anterior belly of the digastric and below by the body of the hyoid bone is the submental triangle.

The thyroid gland is invested by a fibrous sheath which is derived n the pretracheal layer of the deep cervical fascia.

When a portion or portions of the pyramidal lobe, or of the right or lobes, become detached, the isolated masses are known as **accessory roids.**

Blood-supply—Arteries.—The thyroid gland is very vascular. The eries on either side are (1) the superior thyroid, which is a branch of external carotid; and (2) the inferior thyroid, which is a branch of thyro-cervical trunk of the first part of the subclavian. Occasion- there is a third thyroid artery, called the *arteria thyroidea ima,* ich is derived from the innominate artery, or from the arch of the

aorta, and is distributed to the isthmus, its position being in fro of the trachea at the median line, or close to it.

The **veins** are superior, middle, and inferior. The **superior a middle thyroid veins** open into the internal jugular. The **inferi thyroid veins,** right and left, issue from a plexus of veins in front the trachea below the isthmus. The *left* vein opens into the le innominate vein, whilst the right may open into the left innomina vein, into the angle of junction of the right and left innominate vei or into the lower part of the right innominate vein.

Nerves.—These are derived from the sympathetic plexuses whi accompany the superior and inferior thyroid arteries.

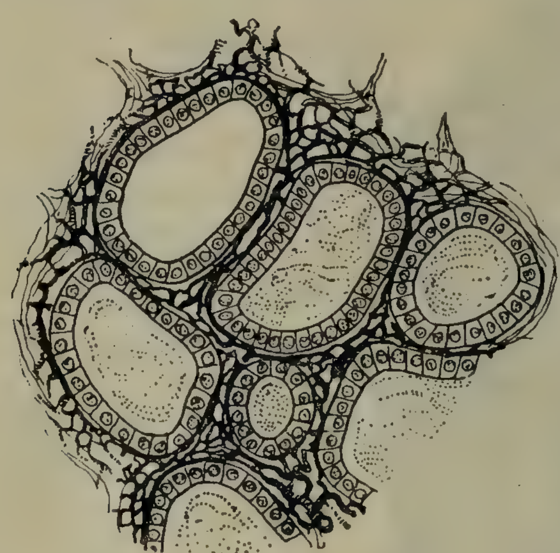


FIG. 736.—SECTION OF THE THYROID GLAND, SHOWING THE VESICLES AND THEIR EPITHELIAL LINING.

The colloid is indicated.

Lymphatics.—The lymphatic vessels the thyroid body are disposed in *t groups*—ascending and descending. T **ascending lymphatics** form *three sets* median and two lateral, right and le The *median ascending lymphatics* retu lymph from the *upper part* of the isthm and pass to the prelaryngeal lym glands. The *lateral ascending lymphat* on either side accompany the super thyroid artery, and pass to the infer deep cervical lymph glands on a level w the cricoid cartilage of the larynx. T **descending lymphatics** also form *three se* The *median descending lymphatics* retu lymph from the *lower part* of the isthm and pass to the pretracheal lymph glan The *lateral descending lymphatics* on eit side accompany the inferior thyroid artery, and pass to the pa tracheal lymph glands, which lie in the groove between the trach and œsophagus, the efferents of which terminate in the inferior de cervical lymph glands.

Structure.—The thyroid gland has an external capsule of dense connect tissue which sends trabeculæ into the interior, thereby dividing it into irregu lobules. These **lobules** are composed of groups of **closed vesicles,** which connected together by areolar tissue. The vesicles are oval or spherical, a each is lined with a single layer of columnar or cubical epithelium. They cont a yellowish viscid, albuminous fluid called *colloid* and are surrounded by n works of capillary bloodvessels.

Development.—The thyroid body is developed from the *entoderm* of ventral wall of the **pharyngeal portion of the primitive gut.**

The first indication of the **median thyroid** is an evagination of the **vent pharyngeal entoderm** immediately behind the tuberculum impar. This evagi tion is called the *median thyroid diverticulum.* It forms a thick-walled epithe vesicle embedded in *mesoderm,* which soon becomes solid. As the vesicle gro its distal end becomes bilobed. Superiorly it retains for a little time its co munication with the ventral wall of the pharynx behind the tuberculum im by a hollow pedicle, which constitutes the **thyro-glossal duct (canal of H** This duct usually disappears, its superior orifice being represented on the dors of the adult tongue by the blind recess, called the *foramen cæcum.* In very r

the lingual portion of the duct may persist for a short distance, in which the foramen cæcum leads to the lumen of a short tube, known as the *ductus alis.*

he median thyroid, as stated, gives rise to the isthmus and lobes of the thyroid gland.

he median bud almost from its beginning is in contact with the pericardial and the two ventral aortæ arising from the truncus arteriosus; it extends these vessels. It lies in loose mesoderm ventral to the condensations e second and third visceral arches. As the head grows forward and the ardium assumes in consequence a more caudal position, the thyroid bud h has separated from its lingual attachment) remains in contact with the ardium and the vessels; thus it moves caudally with reference to the pharyn- loor above it, and as a result of its lateral extension at the same time along vessels, comes into relation with the ventral angle of the fourth lateral n (p. 77). Becoming attached to this, its farther caudal dislocation is ed, save perhaps in the middle line, where some of its cells may still follow ericardium in its retrogression. The main part of the bud, however, ins in its fixed position, and forms the lobes and isthmus.

he ventral bud from the fourth pouch is sometimes termed the **lateral id bud,** being supposed to contribute to the formation of each lobe. It is ally believed, however, that it does not do so, but remains as a small elial mass in the lobe; under some circumstances it appears to show a ncy to thyroid vacuolization.

onnective tissue derived from this mesodermic investment now invades the mass, and it is broken up into numerous solid epithelial cords, which omose freely, and so give rise to an intricate reticulum, the meshes of which ccupied by connective tissue and bloodvessels of mesodermic origin. The epithelial cords of the reticulum become hollow, and the lumina so produced roken up at intervals by constrictions into *closed vesicles,* which contain **olloid material.**

he **pyramidal lobe** of the thyroid gland sometimes met with in connection the isthmus of the adult thyroid is developed from the median bud.

he epithelial cells of the vesicles of the adult thyroid are derived from the lerm of the pharyngeal part of the fore-gut.

'arathyroid Glands.—The **parathyroids** are four in number, and are nged in pairs. The upper pair are related to the dorsal borders ie lobes of the thyroid gland, and the lower pair are placed behind ower ends of the lobes. They are difficult to distinguish with the d eye, but the best way to find them is to follow the anastomosis een the superior and inferior thyroid arteries. They are developed aginations of the *entoderm* of the **third** and **fourth visceral pouches** ther side. The parathyroids present no traces of closed vesicles he colloid material.

ccessory Thyroid Glands.—These glands are sometimes met with in the neigh- hood of the hyoid bone, and are known as the **suprahyoid** and **prehyoid s.** They are developed as buds or evaginations of the thyroglossal duct, they consist of thyroid tissue.

The Trachea and Œsophagus.

Trachea.—The trachea extends from the cricoid cartilage of the nx to about the level of the disc between the bodies of the fourth fifth thoracic vertebræ, where it divides into the two bronchi, t and left. Its average length is about $4\frac{1}{2}$ inches, and its width

about 1 inch. Anteriorly and laterally it is cylindrical and fi but posteriorly it is flattened and membranous, so that it does press upon the œsophagus, in front of which it lies. It occupie medial position, and its direction is downwards with an inclinat backwards. It is divisible into two parts, cervical and thoracic.

For the trachea in the thorax, see p. 1085.

The **cervical part of the trachea** extends from the cricoid cartil to the level of the upper border of the manubrium sterni, and it measu about $2\frac{1}{2}$ inches in length. It is freely movable, and is surroun by areolar tissue, which c tains many elastic fibres, is somewhat loosely arrange

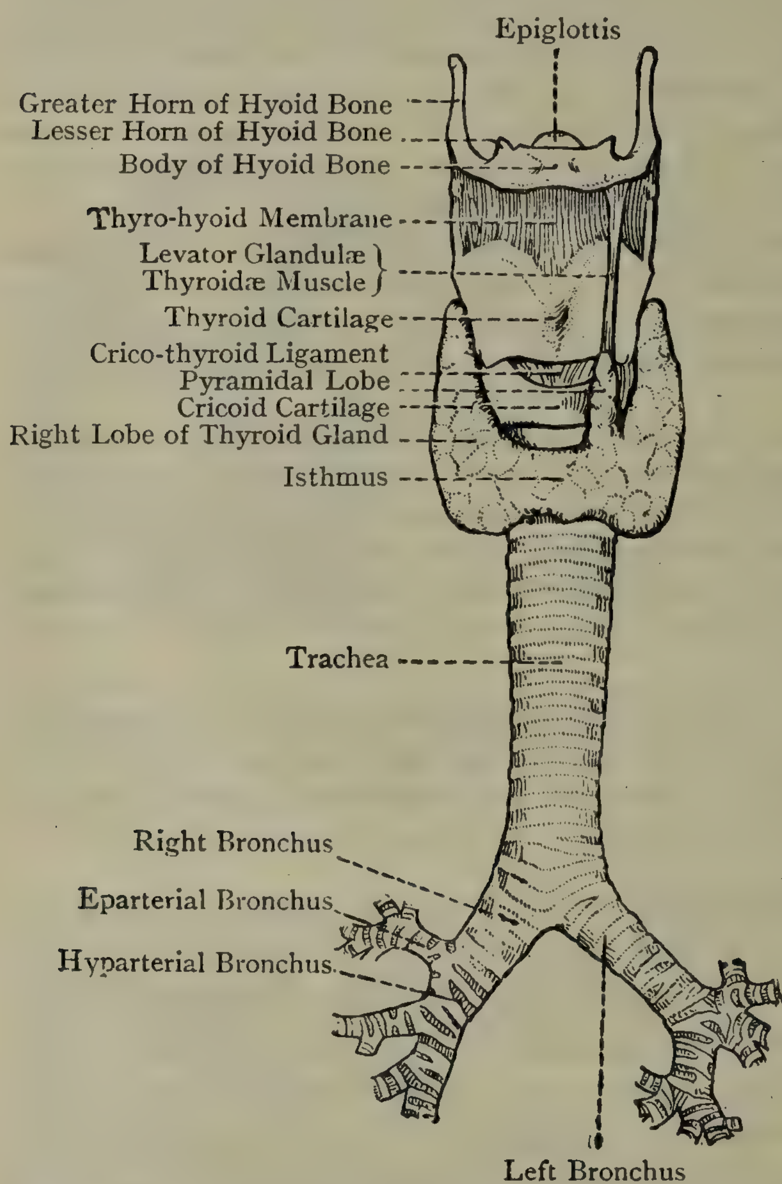


Fig. 737.—The Hyoid Bone, Larynx, Trachea, Bronchi, and Thyroid Gland (Anterior View).

Relations—*Anterior.*— isthmus of the thyroid gl lies directly upon the sec and third rings as a rule, first ring usually lying expo between its upper border the cricoid cartilage. Su ficial to the first ring, on left of the median line, th may be the lower part of pyramidal lobe of the thy gland. Below the isthmus the inferior thyroid plexus veins, from which the ri and left inferior thyroid v pass downwards one on eit side of the median line. arteria thyroidea ima may cend to the isthmus of thyroid gland, lying in fr of the trachea at the med line, or slightly to the right it. The anterior jugular ve right and left, are anterio it, and just above the ma brium sterni it is crossed by communicating branch wh passes between these two veins. In children under two years age the cervical portion of the thymus forms an important ante relation. Close to the upper border of the manubrium sterni innominate artery may encroach slightly upon it. The pretrac layer of the deep cervical fascia forms an anterior relation, as as the superficial layer of that fascia, which is here usually descri as dividing to form the suprasternal space above the supraste notch. Another, and perhaps more common-sense, description is say that in front of the trachea is a layer of cellular tissue c

ous with that in which the thyroid gland is embedded, and that tissue increases in thickness from before backward as the hea recedes from the surface on approaching the thorax. Other rior relations are the anterior jugular veins, along with one or two ph glands, and in some cases the left innominate vein. The sterno-d and sterno-thyroid muscles cover it in the following manner: sterno-hyoid muscles are separated by an interval below, but they e nearly into contact above; and the sterno-thyroid muscles are ntact below, but diverge above. Between the muscles of opposite s there is a very nar- interval, along which trachea is free from cular covering.

Lateral.—The trachea closely embraced on er side by the lobes he thyroid gland as as about the level of fifth ring, and lateral this is the carotid th with its contents, common carotid artery g nearest the lobe.

Posterior.—The trachea n front of the œso-gus, which projects a e to its left side to-ds the root of the neck. ween the two there is groove, in which the urrent laryngeal nerve inferior laryngeal ery ascend. For a ref-nce to the high and operations of trache-my, see p. 1174.

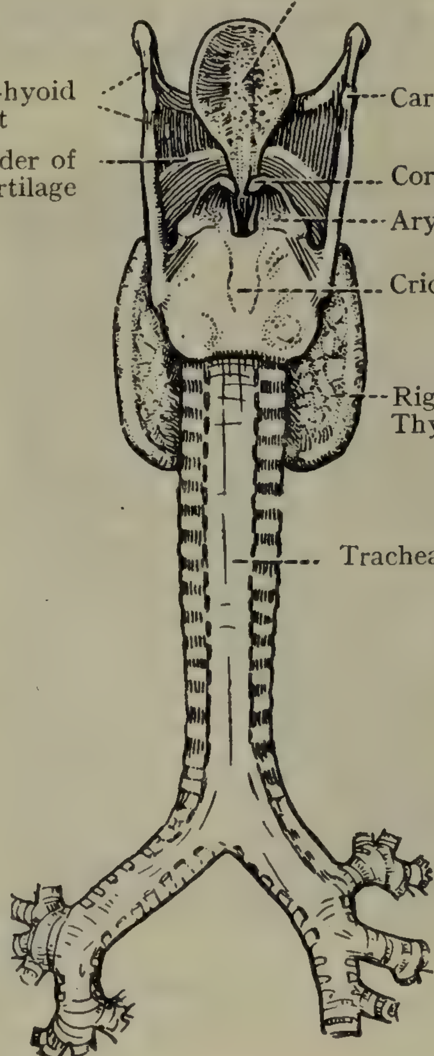


Fig. 738.—The Epiglottis, Larynx, Trachea, Bronchi, and Thyroid Gland (Posterior View).

Blood-supply.—The **ar-es** of the cervical part of the trachea are derived from the in-or thyroid of each side, which is a branch of the thyro-cervical nk.

The **veins** terminate in the inferior thyroid plexus and inferior roid veins.

The **lymphatics** pass to the inferior deep cervical lymph glands.

Pretracheal Lymph Glands.—These glands lie upon the front of the vical part of the trachea, below the isthmus of the thyroid gland. eir *afferent* vessels are derived from the front of the trachea, and *lower part* of the isthmus of the thyroid gland. Their *efferent* sels pass to the inferior deep cervical lymph glands. The **lymphatic**

vessels of the cervical part of the trachea pass to the pretrache inferior thyroid, and inferior deep cervical lymph glands.

Nerve-supply.—The nerves are derived from the vagus, recurre laryngeal, and sympathetic.

Structure.—The trachea is composed of about twenty so-called rings hyaline cartilage, which are incomplete posteriorly. They serve to keep t tube permanently open for the transmission of air, and are embedded in fibro tissue, which also connects together their contiguous borders. They are hors shoe shaped, and each forms rather more than two-thirds of a circle, being fl externally and convex internally. The deficient portions of the rings are plac posteriorly, and here each ring ends in two round extremities. The interva between these extremities are bridged over by fibrous tissue continuous wi that which connects the borders of the rings and in which they are embedde In some cases a ring m end in a bifurcated e tremity, or it may jo one of the adjacent ring The lowest ring is dee and its lower border pr jects backwards so as form a ridge betwe the openings of the tw bronchi.

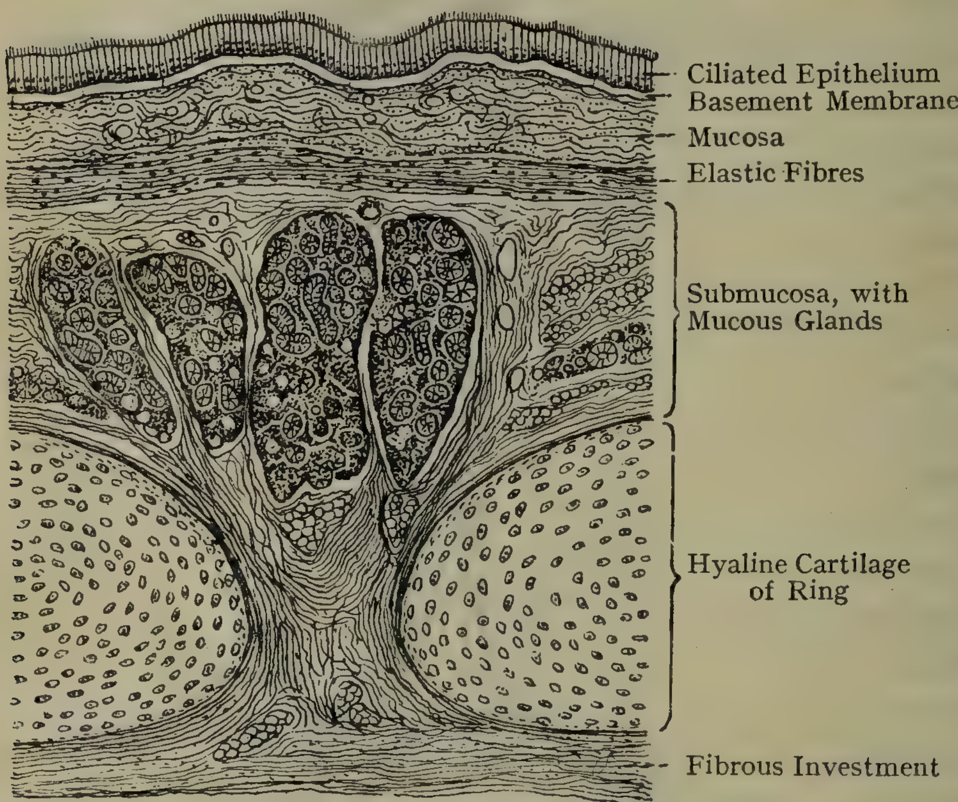


Fig. 739.—Longitudinal Section of the Trachea.

In the posterior wa of the trachea within t **fibrous layer** there is continuous layer of **u striped muscular tissu** the fibres of which e tend transversely betwe the ends of the rings which they are attache In the intervals betwe the extremities of t rings they are attach to the fibrous coat. The fibres serve to approx mate the ends of t rings, and so diminish t calibre of the tube.

The **submucous coat** consists of loosely-arranged areolar tissue, and contai the larger bloodvessels and nerves, together with the mucous glands.

The **mucous coat** consists of areolar and elastic tissues, and a large amou of lymphoid or adenoid tissue. It contains the ramifications of the arteri and nerves, as well as the lymphatics. Superficial to the mucosa there is well-marked basement membrane which supports the epithelium. The dee portion of the mucosa consists principally of elastic fibres. On the posteri wall these elastic fibres are very numerous, and are arranged in longitudin bundles which give rise to elevations of the mucosa.

The **epithelium** is of the stratified columnar ciliated variety.

The wall of the trachea contains many **mucous glands.** Some of these a situated in the submucous coat. Others, which are of large size, lie on t posterior wall, where they are very superficial, many of them appearing li small grains superficial to the fibrous layer. Others are contained within t fibrous layer. The ducts of these glands have to pass through the muscula elastic, and mucous walls of the tube.

Development.—The trachea is developed from the lower part of the *laryng*

al tube from the ventral aspect of the fore-gut superiorly, the upper part is diverticulum giving rise to the larynx.

Esophagus.—The œsophagus is that part of the alimentary canal h extends from the pharynx to the stomach. In the neck it ns on a level with the lower border of the cricoid cartilage, and on a level with the upper border of the manubrium sterni. It ompressed from before backwards and between the trachea and the vertebral mn covered by the longus cervicis cles. At first it occupies the median but as it descends it inclines slightly ne left side, so as to be partly visible on left side of the trachea.

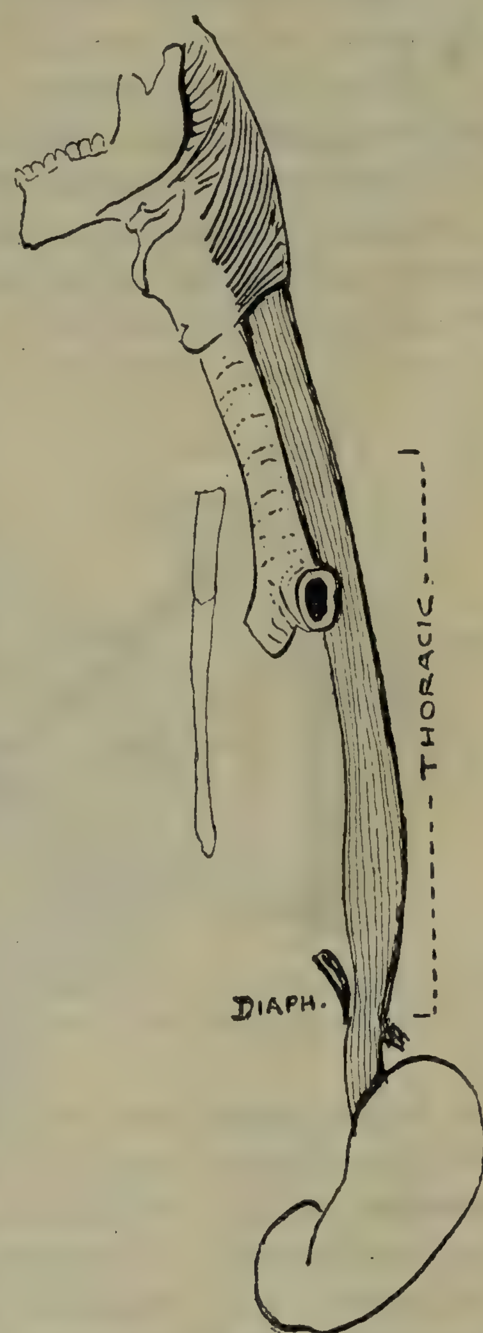


Fig. 740.—Schematic View of Œsophagus.

Relations—*Anterior.*—The trachea; the erior parts of the lobes of the thyroid y; the recurrent laryngeal nerves; and inferior thyroid arteries. *Posterior.*—The ebral column and the longus cervicis cles covered by the prevertebral cellular ie. *Lateral.*—On either side there is the otid sheath with its contents. The right left recurrent laryngeal nerves are in-ately related to the œsophagus, and end on each side in the groove between nd the trachea.

The cervical part of the œsophagus re-ves its blood-supply from the inferior roid arteries, which accompany the cor-ponding recurrent laryngeal nerves.

Paratracheal Lymph Glands (Inferior roid Lymph Glands).—These glands lie the groove between the cervical parts of trachea and œsophagus, along the course the inferior thyroid artery and recurrent yngeal nerve. Their *afferent* vessels are ived from (1) the *lower part* of the lobe the thyroid body, and (2) the adja-t parts of the trachea and œsophagus. eir *efferent* vessels pass to the inferior deep cervical lymph glands.

For a description of the œsophagus in the thorax, including its ucture and development, see p. 1087.

Suprahyoid Region—Muscles—Digastric.—The digastric muscle nsists of two bellies, posterior and anterior. *Origin.*—The **posterior ly** arises from the mastoid notch on the inner aspect of the mastoid rt of the temporal bone; and the **anterior belly** arises from the di-stric fossa on the inner surface of the base of the mandible close to e symphysis.

Insertion.—The two bellies end upon an intermediate tendon,

about 2 inches long, which is inserted by means of a broad fibr band into the anterior surface of the body of the hyoid bone at outer part, and the adjacent portion of the greater horn.

Nerve-supply.—The posterior belly is supplied by the facial ner and the anterior belly by the mylo-hyoid branch of the inferior den a branch of the mandibular nerve.

The posterior belly is directed downwards and forwards, and anterior belly downwards and slightly outwards.

Action.—To elevate the hyoid bone, as in the act of deglutiti and to depress the mandible.

Relations.—The **posterior belly** is at first deeply placed, be overhung by the mastoid process, and lying under cover of the lon simus capitis, splenius capitis, and sterno-mastoid muscles. It is overlapped by the lower part of the parotid gland. It crosses external and internal carotid arteries, internal jugular vein, hypoglossal nerve. stylo-hyoid muscle above it, and the hy glossal nerve below it a short distance. intermediate tendon embraced by the fibres the stylo-hyoid mus This tendon crosses hypoglossal nerve, forms two sides of a angle, known as the **angle of Lesser,** the b of which is directed wards, and is formed the hypoglossal nerve. In the area of this triangle is a portion the hyo-glossus muscle, and deep to this is the lingual artery. **anterior belly,** which is shorter than the posterior, is covered the integument, platysma, and deep cervical fascia. It rests u the mylo-hyoid muscle, and forms part of the floor of the digas triangle. Its inner border is connected with that of its fellow b fascial expansion.

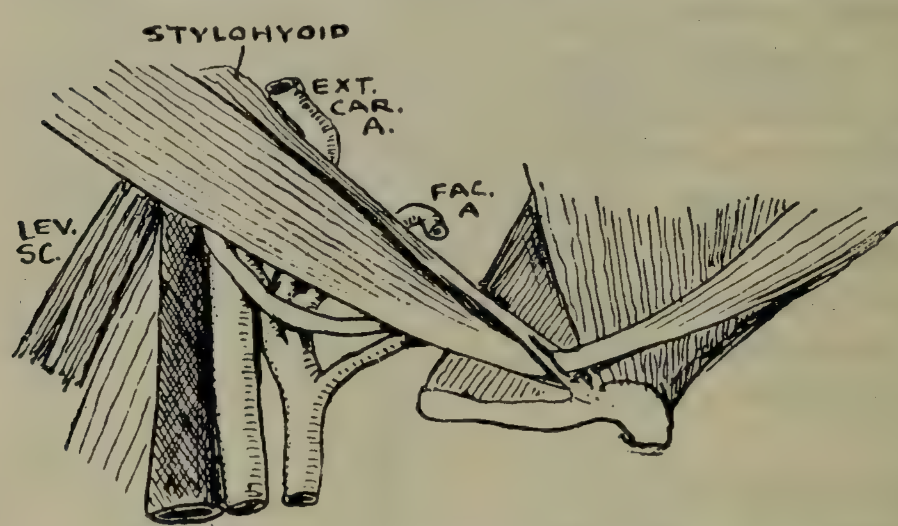


FIG. 741.—PLAN OF MAIN DEEP RELATIONS OF DIGASTRIC IN ANTERIOR TRIANGLE.

The **posterior belly** of the digastric, along with the stylo-hyoid muscle, the stapedius muscle, is associated with the posterior end of the *second visc* or *hyoid arch.* The nerve of this arch is the **facial nerve,** and this explains nerve-supply of the posterior belly.

The **anterior belly** is associated with the anterior or medial end of the *visceral* or *mandibular arch.* The nerve of this arch is the *mandibular* from **trigeminal nerve,** thus accounting for the nerve-supply of the anterior belly.

Stylo-hyoid—*Origin.*—The posterior and outer aspect of the styl process of the temporal bone near its base.

Insertion.—The anterior surface of the hyoid bone at the junct of the body and greater horn.

erve-supply.—The facial nerve.
he muscle is directed downwards and forwards.
ction.—To draw the hyoid bone upwards and backwards.
he muscle lies close above the posterior belly of the digastric, before taking insertion, it usually splits into two bundles, which ace the intermediate tendon of the digastric. It is morphologic- a delamination of the same sheet as the posterior belly of the di- ic, which explains its nerve-supply.
[ylo-hyoid—*Origin.*—The mylo-hyoid line of the mandible.
nsertion.—The **posterior fibres** are inserted into the anterior surface e body of the hyoid bone; and the **principal part** of the muscle is ted into a central fibrous raphé, which extends from the symphysis ti on its deep and lower aspect to the body of the hyoid bone.

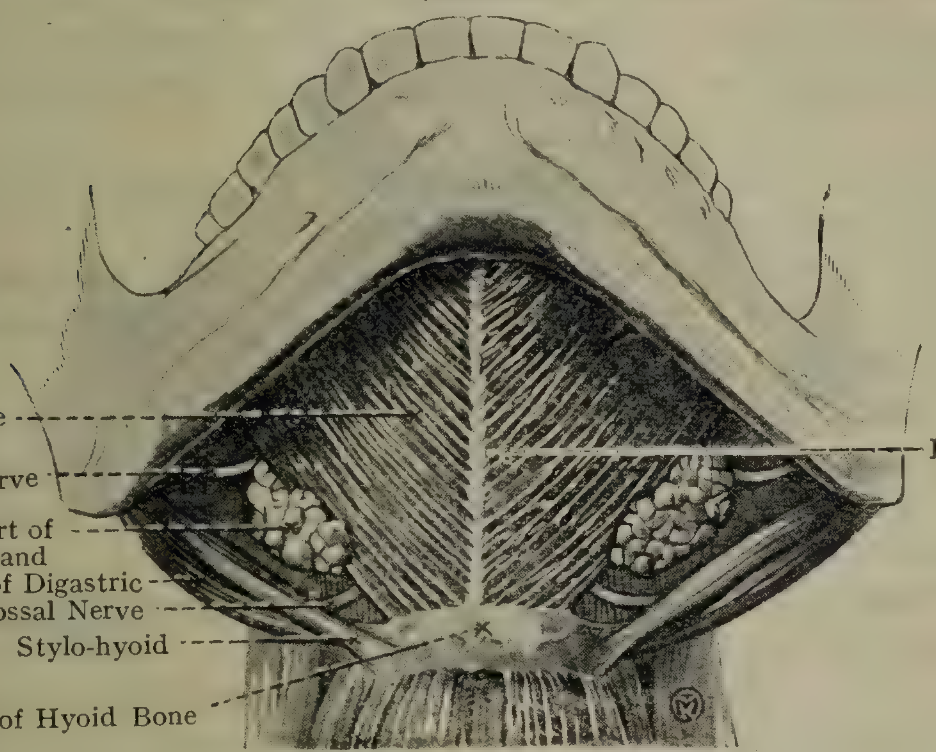


FIG. 742.—THE MYLO-HYOID REGION.
Anterior belly of digastric removed.

Nerve-supply.—The mylo-hyoid branch of the inferior dental nerve, ch is a branch of the mandibular nerve.
The muscle is directed downwards and forwards.
Action.—To raise the floor of the mouth, and, in doing so, to ss the tongue against the hard palate, as in the first stage of the of deglutition; to elevate the hyoid bone, and draw it forwards; l to depress the mandible.
The two mylo-hyoid muscles form a muscular floor for the buccal ity, which is known as the *diaphragma oris*.
Relations—*Superficial or Inferior.*—The anterior belly of the di- tric; the superficial part of the submandibular gland, lodging a tion of the facial artery; and the mylo-hyoid nerve and submental nch of the facial artery.

Posterior Border.—Passing deep to the posterior free border of
muscle there are the following structures, in order from above do
wards: (1) the lingual nerve; (2) a portion of the submandibular gla
and (3) the hypoglossal nerve and its vena comitans.

Deep or Superior.—The hyo-glossus muscle, external to which
the lingual nerve, the submandibular ganglion, the deep part of the s
mandibular gland and the submandibular duct, the hypoglossal ne
and its vena comitans. In front of the hyo-glossus is the genio-hy
muscle, and between it and the hyo-glossus is a portion of the ge
glossus, with the sublingual gland resting upon it.

Genio-hyoid—*Origin.*—The inferior genial tubercle of the mand
close to the symphysis on its deep aspect.

Insertion.—The inner two-thirds of the anterior surface of
body of the hyoid bone over its upper part. At its insertion the mu
is divided externally into two laminæ, anterior and posterior,
former of which extends farthest out upon the hyoid bone. The inn
most fibres of origin of the hyo-glossus pass inwards between th
two laminæ.

Nerve-supply.—The hypoglossal nerve, the branch of which is
garded as being composed of spinal fibres.

The muscle is directed downwards and slightly backwards.

Action.—To elevate the hyoid bone and draw it forwards, and
depress the mandible.

The muscle is in intimate contact with its fellow of the oppo
side at the median line. Its inferior or superficial surface is cove
by the mylo-hyoid, and its superior or deep surface is related to
lower or posterior border of the genio-glossus.

Genio-glossus—*Origin.*—The upper genial tubercle of the mand
close to the symphysis on its deep aspect.

Insertion.—The under surface of the tongue close to the med
line, and extending from near the tip to the root; very slightly i
the inner part of the anterior surface of the body of the hyoid b
close to its upper margin; and slightly into the side of the phary
where the fibres blend with those of the middle constrictor muscle.

Nerve-supply.—The hypoglossal nerve, the branches of which en
the outer surface of the muscle.

The upper or anterior fibres arch upwards and forwards, and
lower downwards and backwards, whilst the intervening fibres spr
out in a fan-like manner.

Action.—The entire glossal fibres depress the tongue at the med
line, and, along with those of the opposite side, they give rise to
antero-posterior groove on the dorsum of the organ; the poster
glossal fibres draw forwards the tongue, causing its tip to be protru
from the mouth; the anterior glossal fibres retract the tip of the ton
when it has been protruded from the mouth; and the lower or poster
(hyal) fibres elevate the hyoid bone, and draw it forwards.

The muscle is fan-shaped. The medial surface is closely appl
to that of its fellow of the opposite side. The lateral surface is rela

ne longitudinalis inferior muscle, the arteria profundæ linguæ, the glossus and stylo-glossus muscles, and the sublingual gland. The rior border is covered by the buccal mucous membrane, and the r or posterior border by the genio-hyoid muscle.

Iyo-glossus—*Origin.*—The greater horn of the hyoid bone over its re length; the anterior surface of the body of the bone over about uter half; and the lesser horn (inconstant). The innermost fibres rigin from the hyoid bone lie between the two laminæ of the genio-d muscle.

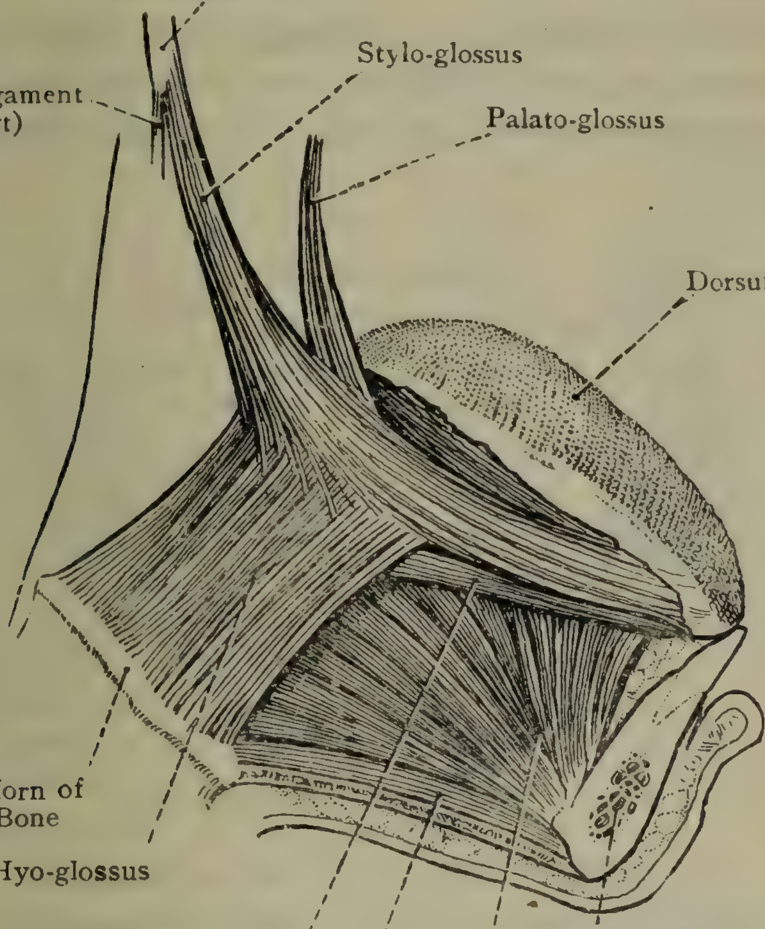


FIG. 743.—THE EXTRINSIC MUSCLES OF THE TONGUE.
The longitudinalis inferior is an intrinsic muscle.

Insertion.—The posterior half of the under surface of the tongue se to its lateral border, the fibres being situated medial to those of stylo-glossus, and both sets of fibres being intimately intermixed h each other and with the intrinsic lingual muscles.

Nerve-supply.—The hypoglossal nerve, the branches of which enter superficial surface.

The muscle is for the most part directed upwards, but its anterior res have a slight inclination forwards.

Action.—To depress the side of the tongue, and, along with its low, to render the dorsum of the organ convex; and to assist in racting the protruded tongue.

The hyo-glossus is a flat, four-sided muscle.

Relations—*Superficial.*—The mylo-hyoid muscle; the intermedi tendon of the digastric, and stylo-hyoid muscle; the lingual nerve, w the submandibular ganglion lying a little below it; the deep part of submandibular gland, and the submandibular duct; the hypoglos nerve; and the vena comitans hypoglossi. *Posterior Border.*—The lowing structures pass deep to this border in order from above dov wards: the glosso-pharyngeal nerve; the stylo-hyoid ligament; and lingual artery. *Deep.*—The posterior part of the genio-glossus; a port of the middle constrictor muscle of the pharynx; the lingual arte the lower end of the stylo-hyoid ligament; and the glosso-pharyng nerve.

The fibres of the hyo-glossus which arise from the lesser horn the hyoid bone are separated from the rest of the muscle by th fibres of the genio-glossus which take insertion into the side of

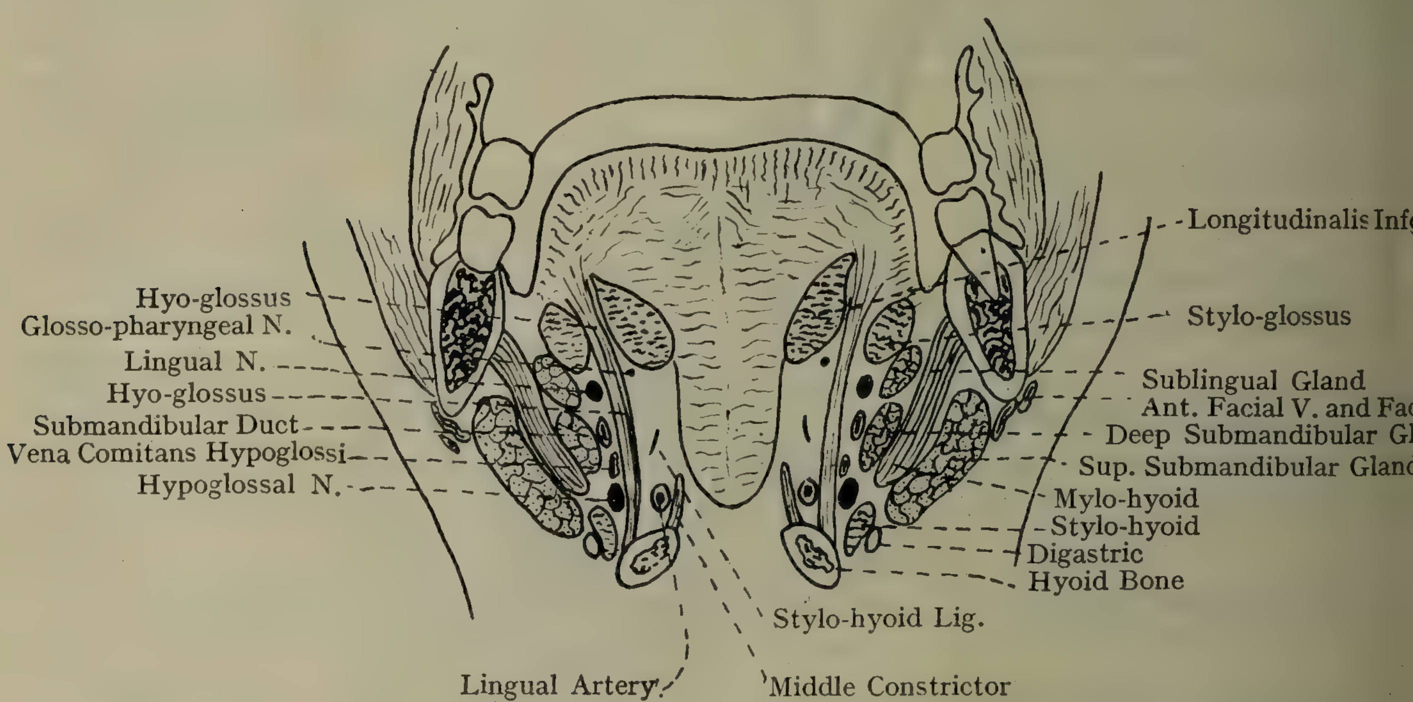


FIG. 744.—CORONAL SECTION THROUGH SUBMANDIBULAR REGION.

pharynx, and they are vestigial remains of the chondro-glossus monkeys. These fibres, however, are inconstant.

Stylo-glossus—*Origin.*—The front of the styloid process of t temporal bone near its tip; and the upper extremity of the sty mandibular ligament.

Insertion.—The under surface of the tongue close to its late border. The fibres extend as far forwards as the tip, and are situat lateral to the fibres of the hyo-glossus, both sets of fibres being in mately intermixed with each other, and with longitudinalis infer muscle.

Nerve-supply.—The hypoglossal nerve.

The muscle is directed downwards, forwards, and inwards.

Action.—(1) To draw the tongue backwards; and (2) to elevate t root of the tongue.

Stylo-hyoid Ligament.—This is a narrow fibrous cord which attached superiorly to the tip of the styloid process, and inferiorly

lesser horn of the hyoid bone. Its direction is downwards and ards, superficial to the glosso-pharyngeal nerve and deep to the rnal carotid artery, and its lower extremity is covered by the glossus muscle. It is liable to become ossified more or less pletely.

The ligament represents the usually unossified skeletal part of the nd visceral arch, and ossification in it, when it occurs, corresponds ie epihyal bone of lower mammals, so well seen in the ruminants.

ubmandibular Gland (Submaxillary Gland).—This gland is situated he anterior part of the digastric triangle. It consists of a large rficial part and a small deep part. The *superficial part* superiorly ipies the submandibular fossa on the inner surface of the body of mandible, and inferiorly it is covered by skin, superficial fascia, platysma, and fascia. The anterior facial vein de- ds superficial to it. Its deep surface s anteriorly upon the mylo-hyoid muscle, the intervention of the mylo-hyoid e and submental branch of the facial ry; and posteriorly upon the hyo-glossus, slightly upon the posterior belly of the stric and stylo-hyoid muscles. The rficial part is grooved at its upper and part by the facial artery, which lies edded in the gland. Posteriorly the rficial part is related to the cervical ion of the parotid gland, from which s separated by the stylo-mandibular ment. The *deep part* of the gland is of ll size, and is continuous with the superficial part at the posterior der of the mylo-hyoid muscle. It lies under cover of that muscle n the hyo-glossus, and is related to the sublingual gland.

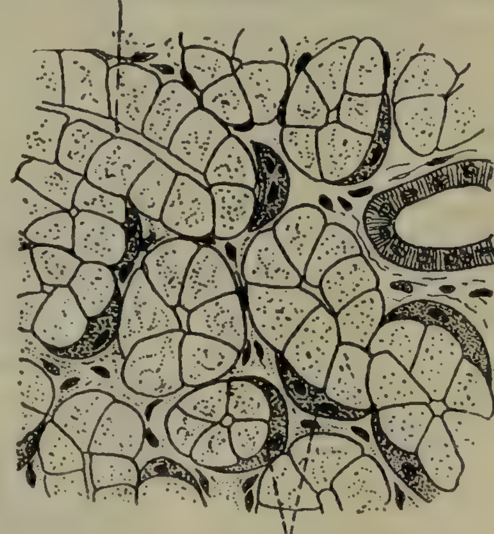


FIG. 745.—SECTION OF THE SUBMANDIBULAR GLAND OF A DOG.

The **submandibular duct** (**Wharton's duct**) emerges from the deep ect of the superficial part of the gland close to the posterior border he mylo-hyoid muscle. It is about 2 inches in length, and passes ards upon the hyo-glossus muscle, lying beneath the deep part of gland. In this situation it has the submandibular ganglion and ual nerve above it, and the hypoglossal nerve below it. After ing the hyo-glossus muscle, the duct lies superficial to the genio- ssus, and, passing slightly upwards, it is crossed from above down- ds by the lingual nerve. Having passed just below the mucous nbrane of the floor of the mouth on the inner side of the sublingual id, the duct opens upon the floor of the mouth by a minute orifice, ch is situated on the summit of a papilla lying close to the side of frenulum linguæ.

The submandibular gland corresponds to the posterior half of the ly of the mandible, and sometimes reaches down below the level of hyoid bone.

Blood-supply.—The gland derives its blood chiefly from the cerv
part of the facial artery.

Nerve-supply.—The nerves are derived from the submandibu
ganglion, and through this from the chorda tympani, the lingual, a
the sympathetic plexus on the facial artery.

Lymphatics.—These pass to the submandibular lymph glands, a
thence to the superficial and deep cervical lymph glands.

Structure.—The submandibular gland is a **muco-serous gland,** and its gen
structure is similar to that of the parotid gland. The essential difference
tween the two has reference to the alveoli or acini, and the nature of t
secretion. The cells of the parotid alveoli are *serous* or *albuminous*. The s
mandibular alveoli contain around the lumen *mucous cells* filled with gran
mucigen, which is discharged as mucus. They, however, also contain s
albuminous cells, known as the *marginal cells,* which are situated externa

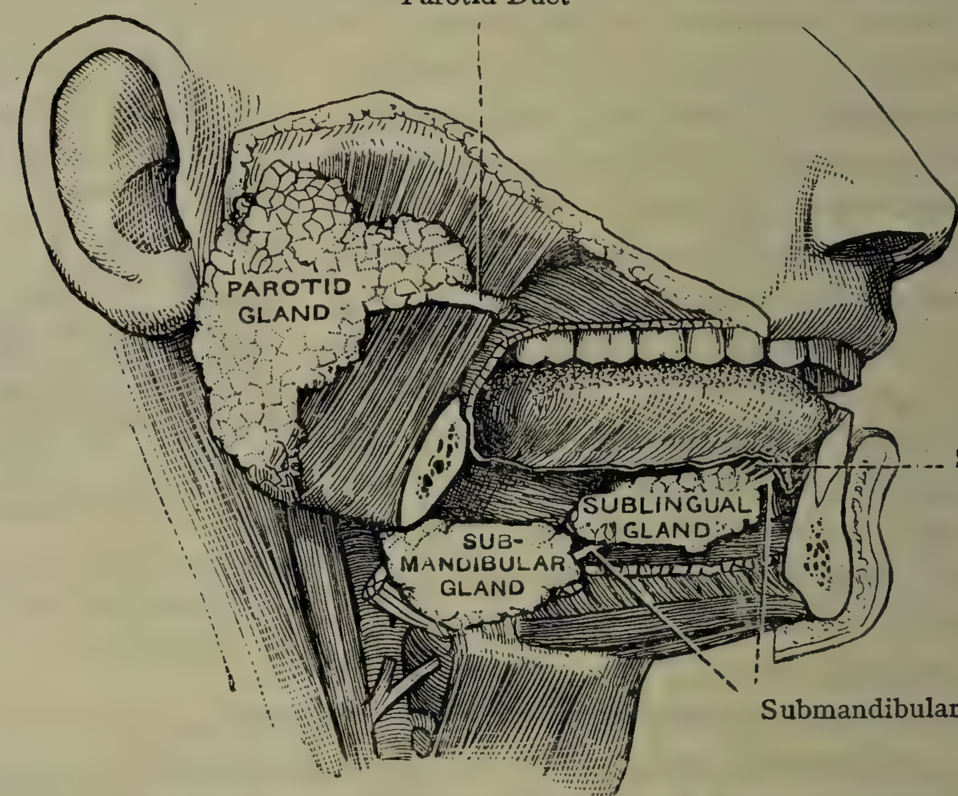


FIG. 746.—THE SALIVARY GLANDS OF THE RIGHT SIDE.

the mucous cells, but within the membrana propria of the alveolus. Th
cells usually form groups which, from their crescentic arrangement, are kno
as the *crescents of Gianuzzi*.

Development.—The submandibular gland is developed as a solid outgro
of the buccal epithelium. This outgrowth undergoes ramifications, and t
subsequently become hollow. The outgrowth takes place from the floor of
sulcus between the tongue and the mandibular arch, far back in its lateral p
at the beginning of the second month. The lingual nerve passes to the ton
below the floor of the sulcus in front of the outgrowth. The submandibular d
is gradually produced from before backwards by the closing off of the low
part of the sulcus, so that it really corresponds with the original floor of
groove. Thus it possesses a lumen from its earliest stages, while the glan
still solid, and the lingual nerve has to pass below it.

Sublingual Gland.—This is the smallest of the salivary glands, a
resembles an almond in shape. It measures about $1\frac{1}{2}$ inches in leng
and is situated beneath the mucous membrane of the floor of
mouth, where it gives rise to a mucous fold, called the *plica sublingua*

eriorly it rests upon the mylo-hyoid muscle, and is here related to deep part of the submandibular gland, the submandibular duct, the lingual nerve. Laterally it occupies the sublingual fossa on inner surface of the body of the mandible above the mylo-hyoid ; and medially it is in contact with the genio-glossus muscle. Its dial extremity comes into contact with its fellow of the opposite e over the anterior border of the genio-glossus muscle.

The **sublingual ducts (ducts of Rivini)** vary in number from ten to enty. A few of them open into the submandibular duct, but the jority open in a linear manner upon the summit of the plica sub-gualis.

Blood-supply.—The gland receives its blood from the sublingual nch of the lingual artery.

Nerve-supply.—The nerves are derived from the chorda tympani l lingual nerves, and the sympathetic plexus on the facial artery, means of a branch of the submandibular ganglion, which is con-cted to the sublingual gland by the lingual nerve.

Structure.—The sublingual gland is a **mucous gland,** and its general structure imilar to that of the parotid and submandibular glands, but the lobules are re loosely arranged. The cells of the sublingual alveoli are for the most part *cous cells,* but there are also serous or albuminous cells.

Development.—The sublingual gland is developed as a number of outgrowths m the buccal epithelium. These undergo ramifications, and subsequently come hollow.

Scalene Muscles and Subclavian Artery.

Scalene Muscles.—The scalene muscles e three.

Scalenus Anterior (Scalenus Anticus)—*igin.*—By four short tapering tendons om the anterior tubercles of the trans-rse processes of the third, fourth, fifth, d sixth cervical vertebræ.

Insertion.—The scalene tubercle of the st rib.

Nerve-supply.—The anterior primary mi of the fifth and sixth cervical nerves.

The muscle is directed downwards, itwards, and forwards.

Action.—To fix the first rib in ordinary spiration, and to elevate it in forced spiration; and to bend the neck to one le.

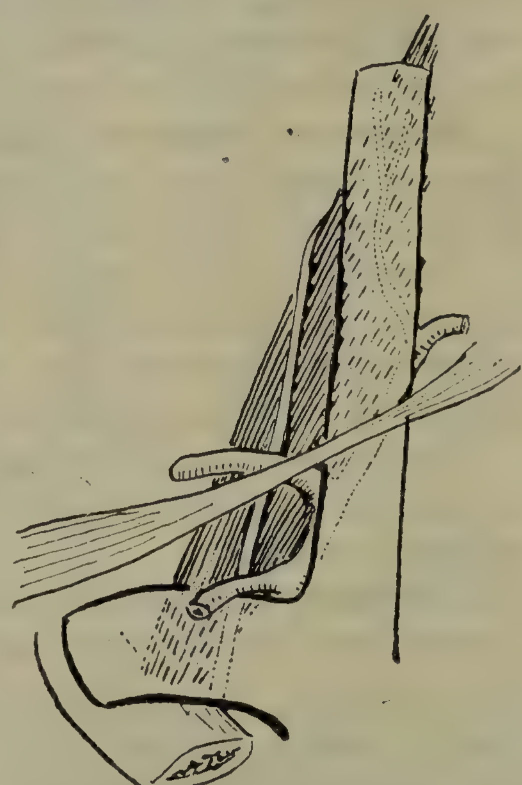


Fig. 747.—Plan of Front Relations of Scalenus Anterior.

Chief Relations—*Anterior.*—The renic nerve, which crosses the muscle liquely downwards and inwards; the ternal jugular vein, which lies in front of its origin; the subclavian ein close to its insertion; the thoracic or the right lymphatic duct;

the transverse cervical and suprascapular arteries; and the omo-hy muscle. *Posterior.*—The scalenus medius, with the intervention of second part of the subclavian artery, the nerve-roots of the brac plexus, and the cupola of the pleura. *Medial.*—The ascending cervi artery and the origin of the longus capitis.

Scalenus Medius—*Origin.*—By six short tapering tendons from posterior tubercles of the transverse processes of the lower six cervi vertebræ.

Insertion.—The upper surface of the first rib from the groove the subclavian artery backwards to the tubercle. Sometimes a fibres are inserted into the suprapleural membrane (Sibson's fasc over the cupola of the pleura. When distinct they are called scalenus pleuralis.

Nerve-supply.—The anterior primary rami of cervical nerves fr the third to the eighth inclusive.

The muscle is directed downwards and outwards.

Action.—(1) To fix the first rib in ordinary inspiration, and (2) bend the neck to one side.

Relations—*Anterior.*—The cervical plexus, the nerve-roots of brachial plexus, except the first thoracic, and the second and th parts of the subclavian artery. *Posterior.*—The levator scapulæ a scalenus posterior muscles.

The scalenus medius is pierced by the following nerves: the ne to the rhomboids, which passes in a backward direction; and the up and middle roots of the nerve to serratus anterior. These two ro usually emerge from the muscle as a single cord, and the lower or th root of the nerve descends in front of the scalenus medius, and jo the foregoing cord about the level of the first rib.

Scalenus Posterior (Scalenus Posticus)—*Origin.*—By two or th short tendons from the posterior tubercles of the transverse proces of the lower two or three cervical vertebræ.

Insertion.—The upper part of the outer surface of the second in front of the insertion of the highest slip of the serratus poster superior, and behind the origin of a portion of the first and the seco digitations of the serratus anterior.

Nerve-supply.—The anterior primary rami of the sixth, seven and eighth cervical nerves, the branches of which pass through scalenus medius.

The muscle is directed downwards and outwards.

Action.—To elevate the second rib, and to extend the neck.

The scalenus posterior is the vestige of an important extensor muscle of neck in pronograde mammals, in which it is attached to several ribs. In orthograde position, however, with its balanced head, the need for it has appeared.

Relations—*Anterior.*—The scalenus medius. *Posterior.*—The lov two tendons of origin of the levator scapulæ. The scalenus poster is intimately connected with the scalenus medius, of which it is pr tically a part.

Subclavian Artery.—The right subclavian vessel arises from the
ominate artery behind the right sterno-clavicular joint on a level
n its upper part, and the left subclavian vessel arises from the
er aspect of the arch of the aorta towards its back part. On each
the artery ends at the outer border of the first rib by becoming
axillary artery. In its course the vessel is crossed superficially
the scalenus anterior muscle, which divides it into three parts.

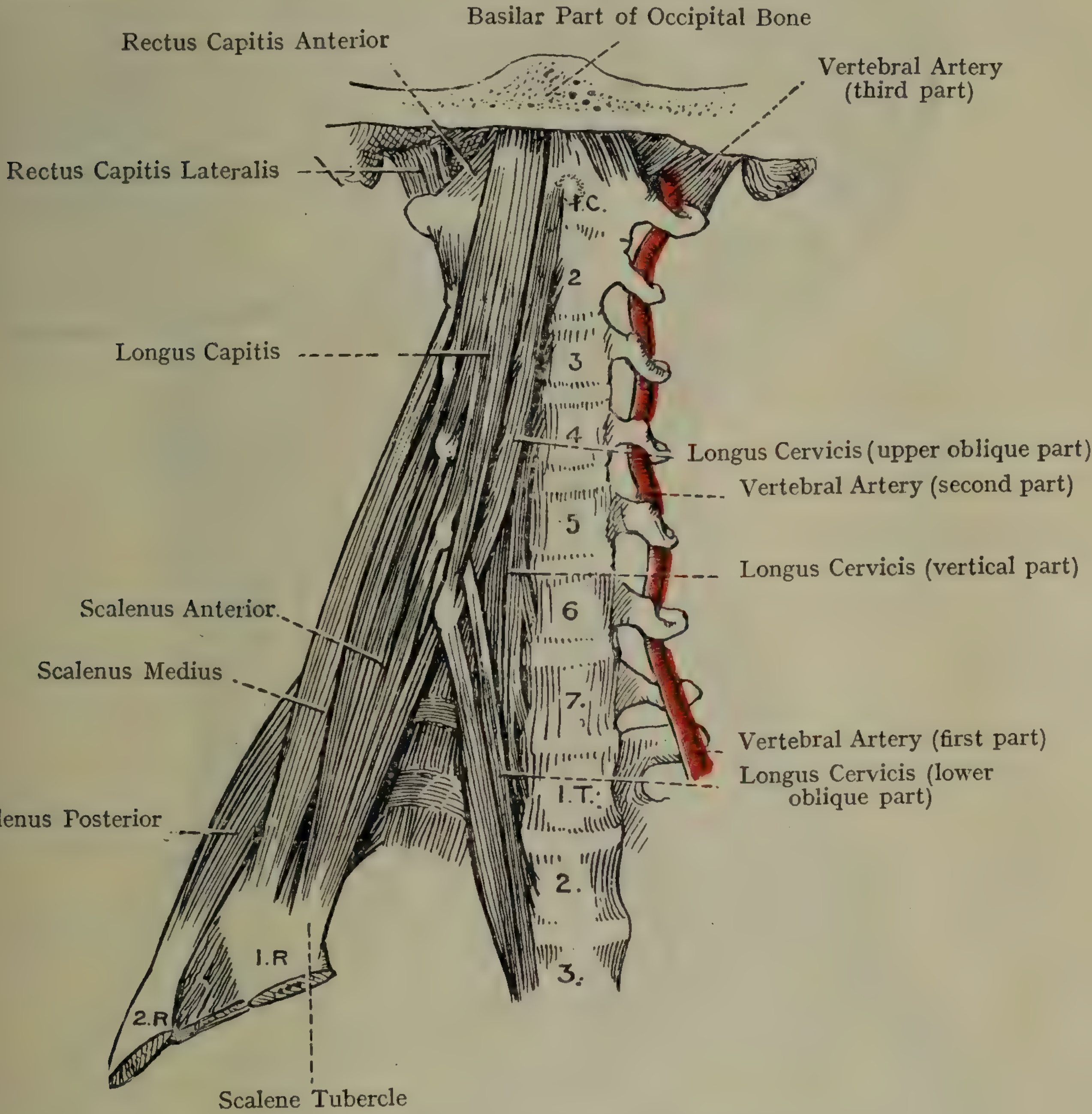


FIG. 748.—THE RIGHT PREVERTEBRAL MUSCLES.
The vertebral artery is also shown.

The **first part** extends from the origin of the vessel to the inner
rder of the scalenus anterior; the **second part** lies behind that muscle;
d the **third part** extends from the outer border of the muscle to the
ter border of the first rib. The total length of the vessel on the
ht side is about 3 inches, and on the left about 4½ inches. The
ery describes an arch in front of the apex of the corresponding
g and pleura, and the height to which it rises above the clavicle
about ½ inch.

First Part of the Right Subclavian Artery.—This part extends from
bifurcation of the innominate artery behind the right sterno-

clavicular joint, on a level with its upper part, to the inner border the scalenus anterior muscle. Its direction is upwards and outwar and it lies very deeply.

Relations—*Anterior.*—The skin, superficial fascia and platysr deep cervical fascia, clavicular origin of the sterno-mastoid, and ster hyoid and sterno-thyroid muscles. Three veins are related to it sup

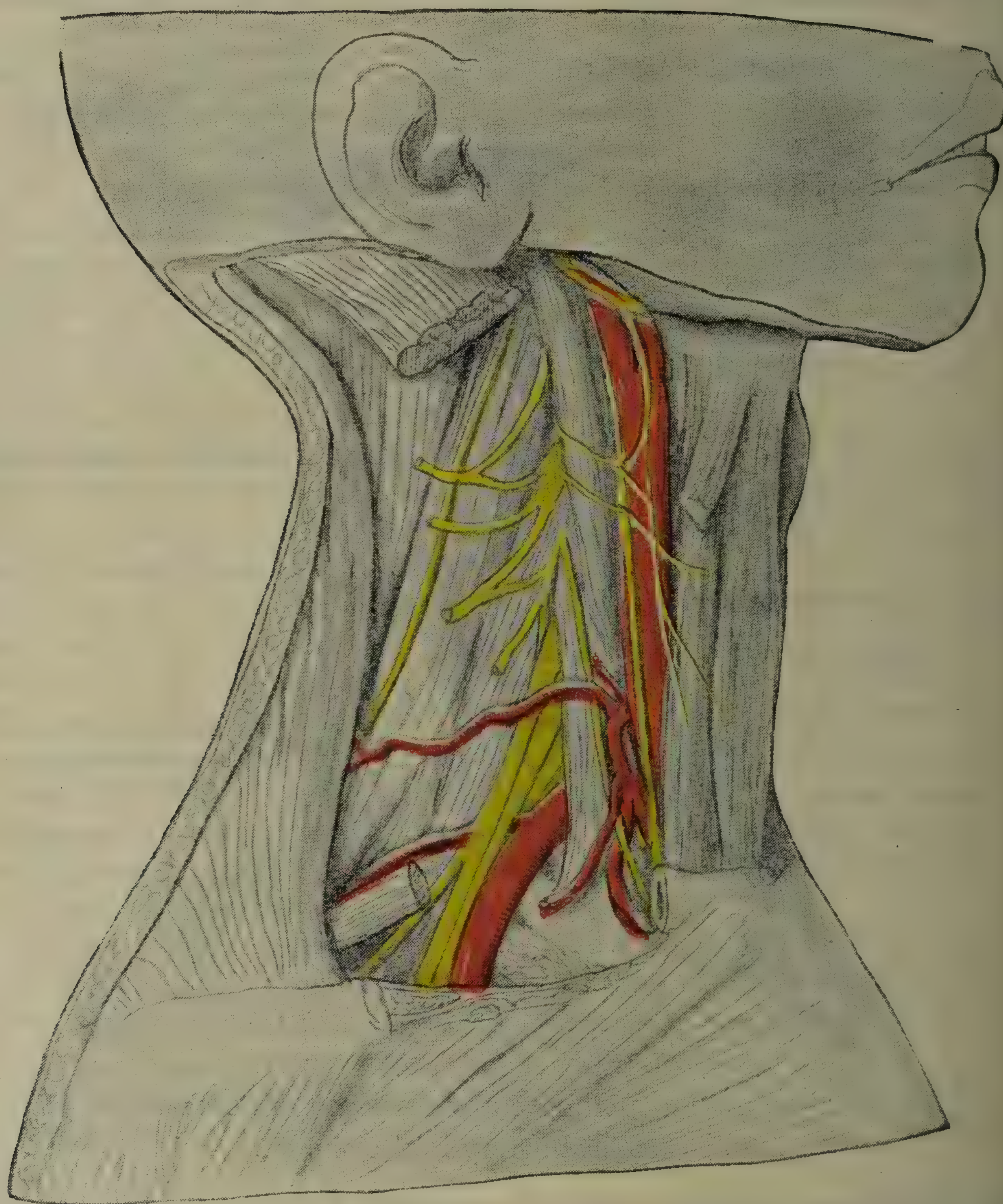
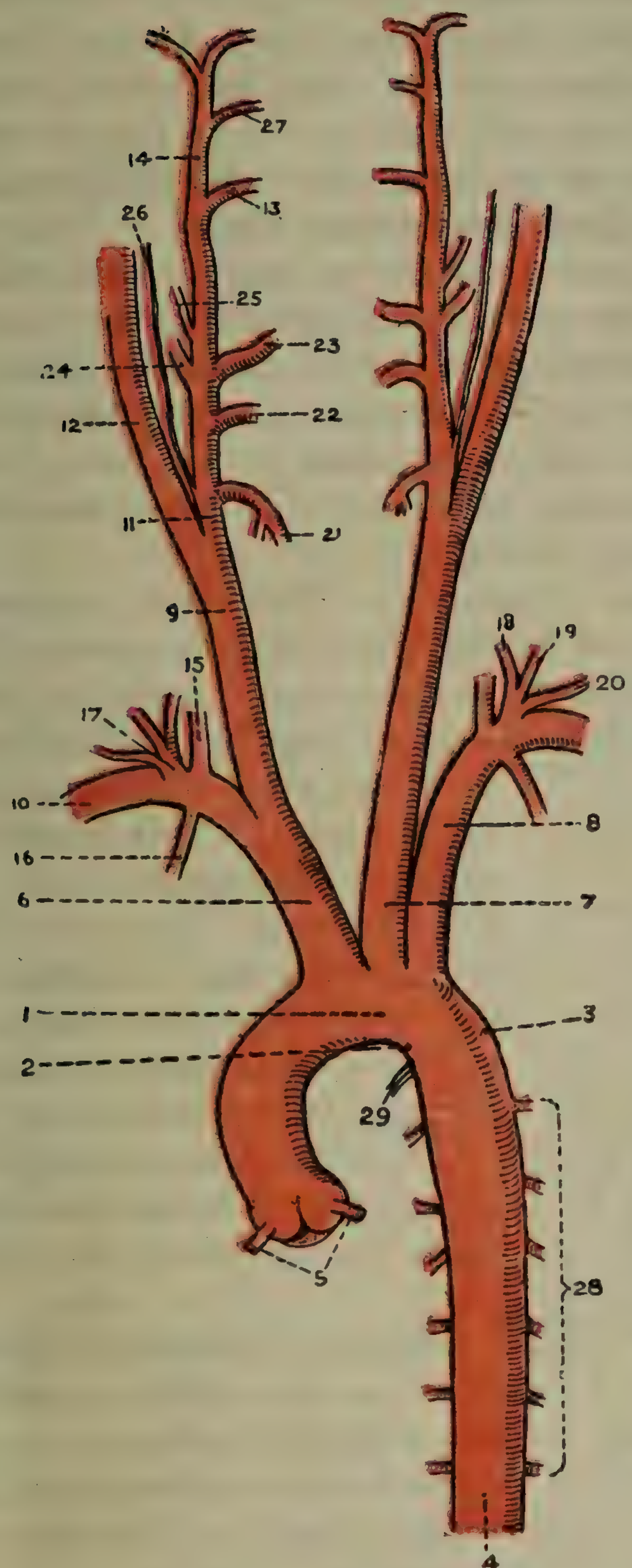


FIG. 749.—RIGHT SUBCLAVIAN ARTERY IN SITU: JUGULAR AND SUBCLAVIA VEINS REMOVED.

ficially. The internal jugular and vertebral veins cross it from ab downwards close to the scalenus anterior, the latter vessel being beh the former, and the anterior jugular vein crosses it from within o wards, but superficial to the sterno-hyoid and sterno-thyroid musc The vagus and its cervical cardiac branches, the cervical card branches of the sympathetic, and the nerve-loop known as the a



. 750.—THE AORTA IN THE THORAX, AND THE PRINCIPAL ARTERIES OF THE HEAD AND NECK.

1. Arch of the Aorta
2. Aortic Isthmus
3. Aortic Spindle
4. Descending Aorta
5. Coronary Arteries (from Ascending Aorta)
6. Innominate Artery
7. Left Common Carotid
8. Left Subclavian
9. Right Common Carotid
10. Right Subclavian
11. External Carotid
12. Internal Carotid
13. Maxillary
14. Superficial Temporal
15. Vertebral
16. Internal Mammary
17. Thyro-cervical Trunk
18. Inferior Thyroid
19. Transverse Cervical
20. Suprascapular
21. Superior Thyroid
22. Lingual
23. Facial
24. Occipital
25. Posterior Auricular
26. Ascending Pharyngeal
27. Transverse Facial
28. Posterior Intercostals
29. Ligamentum Arteriosum

subclavia also cross it superficially. *Posterior.*—The recurrent lar geal nerve, sympathetic trunk, fat, longus cervicis muscle, first thora vertebra, cupola of the pleura, and apex of the lung. *Inferior.*—T recurrent laryngeal nerve, part of the ansa subclavia, and the pleura

The right subclavian and right internal jugular veins unite in fr of this part of the vessel to form the right innominate vein.

First Part of the Left Subclavian Artery.—This part extends fr the upper aspect of the arch of the aorta, towards its back part, the inner border of the scalenus anterior muscle. It is therefore plac at first in the thoracic cavity. Its course is almost vertical until reaches the root of the neck, where it curves sharply outwards upon cupola of the pleura, and so reaches the scalenus anterior. The re tions of the intrathoracic portion have been described in connecti with the thorax (see p. 1040).

Cervical Relations—*Anterior.*—The skin, superficial fascia a platysma, deep cervical fascia, clavicular origin of the sterno-masto sterno-hyoid, and sterno-thyroid muscles, and the thoracic duct whi arches over it. The left internal jugular and subclavian veins un in front of it to form the left innomin vein, and the left vertebral vein descen in front of it under cover of the left inter jugular vein. *Posterior.*—The sympathe trunk with the inferior cervical ganglio fat, and the left longus cervicis musc *Right.*—The trachea, œsophagus, left current laryngeal nerve, and thoracic du

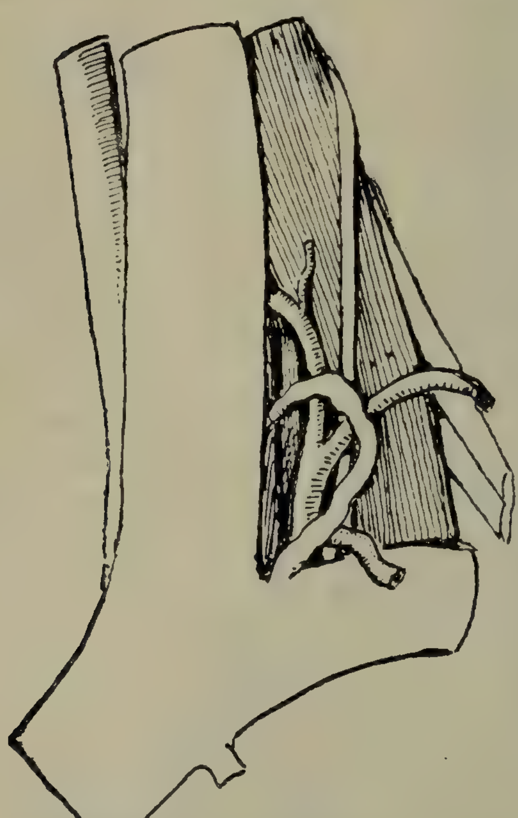


Fig. 751.—Left Subclavian Vessels and Terminal Piece of Thoracic Duct.

The varieties in origin of the subclavi artery have been described in connecti with the arch of the aorta (see p. 1040 *seq.*).

Second Part of the Subclavian Artery. This portion of the vessel is situated behi the scalenus anterior muscle. It lies abo $\frac{1}{2}$ inch above the clavicle, and forms t highest part of the arch described by t vessel.

Relations—*Anterior.*—Its only dire anterior relation is the scalenus anteri *Posterior.*—The pleura. *Superior.*—T nerve-roots of the brachial plexus. *I ferior.*—The pleura.

In some cases the second part of the vessel passes through the scalenus anter and in rare cases it passes in front of the muscle.

For the third part of the subclavian artery see p. 1191.

Development.—The *right* subclavian artery as far as the origin of the inter mammary artery is developed from the fourth right aortic arch.

The *left* subclavian artery is developed from the seventh left segmen artery.

Branches of the subclavian artery are the vertebral, internal nmary, thyro-cervical trunk, and superior intercostal. The first e arise from the *first part* of the artery towards its termination, and last arises from the *second part* on the **right** side, and from the *part* on the **left** side.

Vertebral Artery.—This, the first branch on the right side, arises n the upper and back part of the artery about an inch from its in, and on the left side from the vessel just after it enters the root he neck. It passes for a short distance upwards, backwards, and htly outwards, and disappears from view by entering the foramen sversarium in the sixth cervical vertebra as a rule. It then ascends tically through the successive foramina transversaria above that of sixth vertebra, passing outwards between the axis and atlas. ving traversed the foramen transversarium of the atlas, it passes kwards and inwards, lying in vertebrarterial groove on the er surface of the posterior arch the atlas behind the superior icular process, pierces the dura ter and arachnoid, and having ched the side of the spinal d, it turns upwards and for- rds in the subarachnoid space, l enters the cranial cavity ough the foramen magnum. gradually inclines from the eral to the ventral aspect of medulla, and at the lower rder of the pons it joins its low to form the basilar artery.

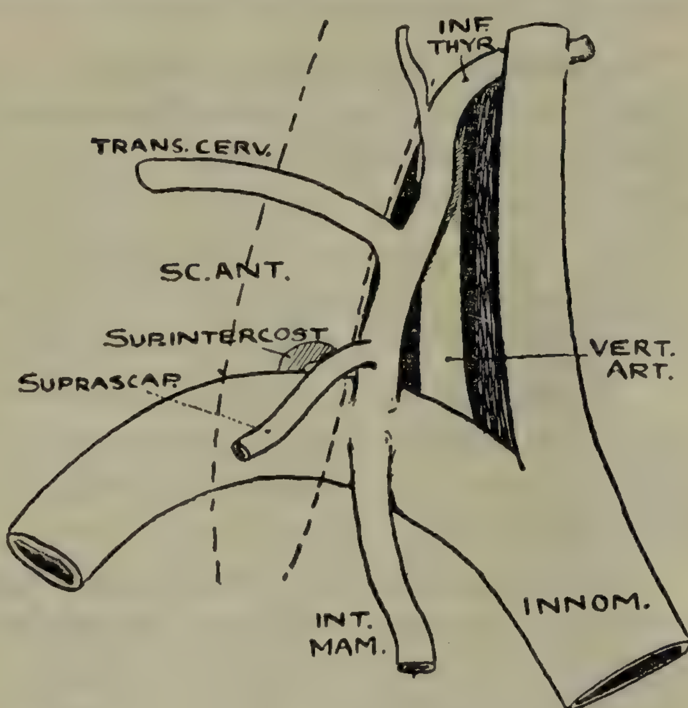


FIG. 752.—PLAN OF BRANCHES OF SUBCLAVIAN ARTERY.

On account of its complicated irse, the vertebral artery is vided into four parts—namely, first or cervical, second or costo- nsverse, third or suboccipital, and fourth or intercranial.

The **first part** extends from the origin of the vessel to the foramen nsversarium in the transverse process of the sixth cervical vertebra. lies between the scalenus anterior and longus cervicis muscles, ving the internal jugular and vertebral veins in front of it, being ossed by the inferior thyroid artery, and having the sympathetic ink and the transverse process of the seventh cervical vertebra hind it. The vessel of the left side has the thoracic duct as an ditional anterior relation.

The first part gives off no branches.

The **second part** traverses the foramina transversaria of the cervical rtebræ from, as a rule, the sixth upwards. It is surrounded by the rtebral venous plexus, and by the vertebral plexus of the sympa- etic, and it lies in front of the cervical spinal nerves as these emerge om the intervertebral foramina.

Branches.—These are as follows: spinal and muscular. T *spinal branches* enter the vertebral canal through the interverteb foramina. The *muscular branches* supply the deep muscles of t neck, and anastomose with the deep cervical, ascending cervical, a occipital arteries.

For the third or suboccipital, and the fourth or intracranial, pa of the vertebral artery, see p. 1151.

Varieties.—(1) The left vertebral artery not uncommonly arises from the a of the aorta between the origins of the left common carotid and left subclav arteries. (2) The vessel may pass the foramen transversarium of the si cervical vertebra, and may enter that of the fifth, or even that of the four (3) The vessel has been found in rare cases to enter the foramen transversari of the seventh cervical vertebra.

Development.—The vertebral artery is developed from (1) the seventh cervi somatic artery, and (2) the longitudinal anastomotic chain which connects t seven cervical somatic arteries.

Internal Mammary Artery.—This vessel, so named in contr distinction to the *external mammary*, or *lateral thoracic*, a branch of t second part of the axillary artery, arises from the lower aspect of t first part of the subclavian very nearly opposite the thyro-cervic trunk. Its course is downwards, forwards, and slightly inwards, a it disappears behind the sternal end of the clavicle and first cost cartilage. For its subsequent course and relations, see p. 999.

Relations of Cervical Part—*Anterior.*—The clavicular part of t sterno-mastoid, and the internal jugular and subclavian veins. T phrenic nerve crosses the vessel superficially from without inward *Posterior.*—The pleura.

No branches arise from this part of the vessel.

Thyro-cervical Trunk (Thyroid Axis).—This is a short trunk whi springs from the front of the first part of the subclavian artery clo to the inner border of the scalenus anterior muscle. It almost imm diately divides into three diverging branches—inferior thyroi transverse cervical, and suprascapular.

The **inferior thyroid artery** passes upwards and inwards in a to tuous manner in front of the vertebral artery, and behind the carot sheath and sympathetic trunk, the middle cervical ganglion of whi often rests upon it. Having reached the lower part of the lobe of t thyroid body, the artery breaks up into its terminal branches, whi enter the lobe on its deep aspect, and ramify in it, anastomosing wi the superior thyroid and with its fellow of the opposite side of t isthmus. As the vessel ascends it is intimately related to the recurre laryngeal nerve, which usually lies behind it.

Branches.—These are as follows: muscular, ascending cervic inferior laryngeal, tracheal, and œsophageal.

The *muscular branches* supply the scalenus anterior, longus cervic the infrahyoid muscles, and inferior constrictor of the pharynx. T *ascending cervical artery* arises from the inferior thyroid as it pass inwards behind the carotid sheath. It ascends in front of the tran verse processes of the cervical vertebræ, lying between the scalen

rior and longus capitis, and having the phrenic nerve on its outer and the sympathetic trunk just medial to it. It anastomoses branches of the vertebral, occipital, and ascending pharyngeal ries. It may furnish some spinal branches which enter the vertebral l through the intervertebral foramina to be distributed in a manner lar to the other spinal arteries. The *inferior laryngeal artery* mpanies the recurrent laryngeal nerve to the larynx. The *tracheal œsophageal* branches are distributed as their names suggest.

The **transverse cervical artery** passes transversely outwards in t of the scalenus anterior and phrenic nerve, and behind the icular part of the sterno-mastoid, lying a little above the clavicle, also above the suprascapular artery. It then enters the sub-ian triangle, which it soon leaves by passing deep to the inferior y of the omo-hyoid. It then passes in front of, or between, the ve-trunks of the brachial plexus to the deep surface of the trapezius scle. Having reached the anterior border of the levator scapulæ, ivides into its two terminal branches—superficial and deep.

The *superficial branch* (*superficial cervical artery*) passes superficial the levator scapulæ, and is distributed to the trapezius, levator pulæ, splenius, and the adjacent lymph glands. The *deep branch sterior scapular artery*) passes backwards in front of the levator pulæ to the superior angle of the scapula. It then descends along base of the bone, under cover of the rhomboid muscles, as far as inferior angle, where it anastomoses with the circumflex scapular l subscapular arteries. The artery gives branches to the adjacent scles, and anterior and posterior branches to the scapula, which e part in the scapular anastomoses proper (see p. 438).

The deep branch of the transverse cervical is frequently a branch the third part of the subclavian, in which cases there is no transverse vical artery, the superficial branch of the latter artery taking its ce and arising from the thyro-cervical trunk (see p. 1192).

The **suprascapular artery** passes downwards and outwards in front the scalenus anterior and phrenic nerve, and behind the clavicular rt of the sterno-mastoid. Having reached the back of the clavicle, courses outwards behind that bone, passing in front of the third rt of the subclavian artery and the trunks of the brachial plexus. then passes to the upper border of the scapula in company with the prascapular nerve. For the further course of the vessel and for the apular anastomoses of arteries see p. 441.

Branches in the neck are muscular, suprasternal, and nutrient. e *muscular branches* supply the sterno-mastoid and subclavius. e *suprasternal branch* descends over the inner end of the clavicle to pply the integument over the manubrium sterni. The *nutrient tery* of the clavicle is directed *outwards*, and enters the nutrient ramen of that bone. It is often double.

Superior Intercostal Artery.—This vessel arises from the second rt of the subclavian on the right side, and from the first part on e left side, in each case from the posterior aspect of the parent

trunk. On the right side it is therefore behind the scalenus anter and on the left side close to the inner border of that muscle. vessel at first passes backwards and upwards for a short distance, then descends in front of the neck of the first rib. At the poste extremity of the first intercostal space it furnishes the first poste intercostal artery to that space, and then descends in front of neck of the second rib to become the second posterior intercos artery. The superior intercostal artery therefore furnishes the f and second posterior intercostal arteries for the first and second int costal spaces, their distribution being similar to that of the succeed posterior (aortic) intercostal arteries. Besides these two branch the vessel gives off the *deep cervical artery*. This branch, which homologous with the posterior branch of a posterior intercostal arte arises from the superior intercostal before it descends in front of neck of the first rib.

The superior intercostal artery and the deep cervical art are often described as terminal branches of a common trunk origin. This trunk is called the costo-cervical trunk; in description adopted here this trunk is looked on as part of superior intercostal itself.

It passes backwards between the transverse process of the sever cervical vertebra and the neck of the first rib, and then ascends betw the semispinalis capitis and semispinalis cervicis muscles to about level of the axis. In this situation it anastomoses with the de division of the descending branch of the occipital artery. The de cervical in its course gives off muscular branches which anastomo with branches of the vertebral and ascending cervical arteries. also furnishes a spinal branch which enters the vertebral canal throu the intervertebral foramen between the seventh cervical and fi thoracic vertebræ.

The superior intercostal artery on each side is developed from the anast motic loop between the upper two or three *thoracic somatic arteries*.

Subclavian Vein.—This vessel, which is the direct continuation the axillary vein, extends from the outer border of the first rib to t back of the inner end of the clavicle, where it unites with the intern jugular to form the innominate vein. It lies in front of, and on lower plane than, the subclavian artery, and it passes in front of t scalenus anterior muscle and phrenic nerve. In rare cases the ve has been met with passing behind the scalenus anterior. Its princip tributary is the external jugular vein (sometimes also the anteri jugular). The external jugular vein joins it close to the outer bord of the sterno-mastoid.

The thoracic duct opens at the angle of junction of the left su clavian and left internal jugular veins, and the right lymphatic du opens into the angle of junction of the corresponding veins on t right side. The duct often opens in two or more parts.

Vertebral Vein.—This vein begins in the suboccipital veno

xus within the suboccipital triangle. It passes through the foramen nsversarium in the atlas, and accompanies the vertebral artery ough the succeeding foramina transversaria as low as the sixth, ning a plexus around the vessel. This plexus is ultimately replaced a single vein, which emerges through the foramen transversarium he sixth cervical vertebra (sometimes the seventh). It then descends ront of the first part of the subclavian artery under cover of the ernal jugular vein, and opens into the back part of the innominate 1, the opening being provided with a single or double valve.

The **chief tributaries** of the vertebral vein are as follows: muscular, ial, anterior vertebral, and deep cervical. It also, as a rule, eives the first intercostal vein.

No vein accompanies the cer- al part of the internal mam- ry artery. The **inferior thyroid n,** which does not accompany corresponding artery, is found cribed in connection with the roid gland on p. 1222.

The **transverse cervical** and **rascapular veins** return the od from the parts supplied by corresponding arteries, and tributaries of the lower part the external jugular vein.

The **deep cervical vein** starts the suboccipital venous plexus hin the suboccipital triangle. descends in company with the p cervical artery, and passes wards between the transverse ocess of the seventh cervical tebra and the neck of the first to terminate in the vertebral in.

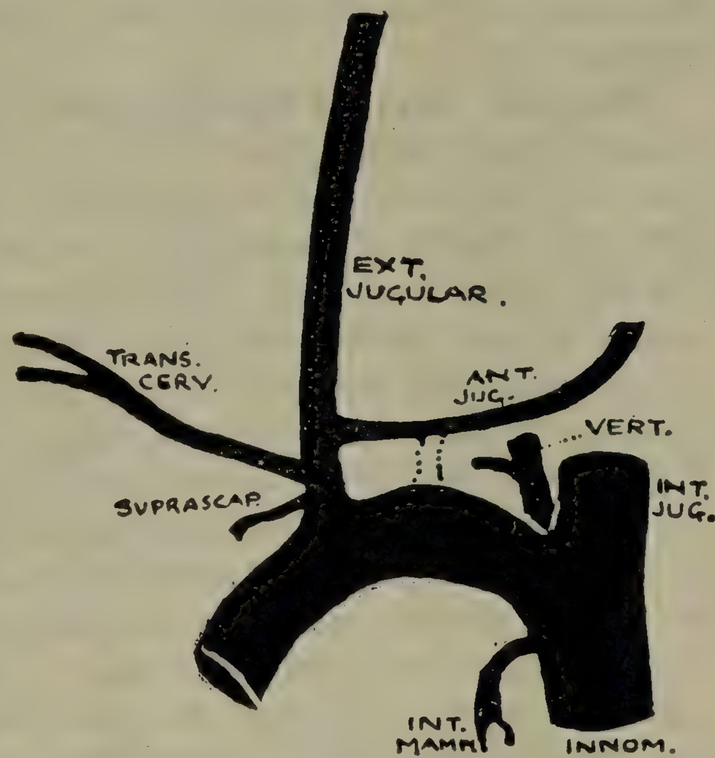


Fig. 753.—Plan of Subclavian Vein and Tributaries.

Anterior jugular frequently opens directly into subclavian vein. Vertebral vein, which receives superior intercostal, opens into beginning of innominate.

The **anterior vertebral vein** begins in a plexus in front of the upper vical transverse processes. It descends in company with the cending cervical branch of the inferior thyroid artery, receiving iscular tributaries in its descent, and it opens into the lower part the vertebral vein.

Collateral Circulation after Ligature of the Third Part of the Sub- vian Artery.—(1) The suprascapular and the deep branch of the nsverse cervical, both branches of the thyro-cervical trunk from the st part of the subclavian, take part in the scapular anastomoses, and astomose freely with branches of the first and third parts of the illary artery. (2) The internal mammary from the first part of subclavian anastomoses with the lateral thoracic from the second rt of the axillary.

Collateral Circulation after Occlusion of the First Part of Subclavian Artery.—(1) The vertebral artery of one side anastomo with that of the opposite side. (2) The internal mammary anas moses with the inferior epigastric from the external iliac, and w the posterior intercostal arteries. (3) The inferior thyroid anas moses with the superior thyroid from the external carotid. (4) superior intercostal anastomoses with the third posterior intercos (5) The deep cervical of the superior intercostal anastomoses with deep division of the descending branch of the occipital from the exter carotid. (6) The scapular branches of the thyro-cervical tru anastomose with branches of the axillary artery. (7) The thora branches of the axillary artery anastomose with the posterior int costals.

Cervical Part of the Thoracic Duct (Fig. 751).—This part of thoracic duct occupies the root of the neck on the *left side*, and upon the side of the œsophagus, between it and the left subclav arteries. In this position it ascends to about the level of the seve cervical vertebra, and then it describes a curve and passes outwar forwards, and downwards in contact with the cupola of the left pleu It then inclines inwards, and, after receiving the left jugular and su clavian trunks, ends in the angle of junction of the internal jugu and subclavian veins of the left side. The terminal orifice of the d is guarded by a valve composed of two segments, which are so direc as to effectually prevent the reflux of chyle and the flow of blood i it. The duct crosses the left vertebral artery, passing either in fr of or behind the vertebral vein. In half the cases the duct is dou for some distance before it enters the internal jugular, and one bra may open into the subclavian vein. Occasionally three or m openings have been found, and this multiple opening is of surgi importance, for if one branch is cut in an operation on the root of neck, it is an even chance that there may be another to carry chyle to the blood-stream. It is important to notice that the d passes behind the vagus and in front of the phrenic nerves.

Right Lymphatic Duct.—The position of this duct corresponds that of the thoracic duct on the left side. It is about ½ inch in leng and is formed by the union of the right subclavian trunk and rig jugular trunk. Besides returning lymph from the right side of head and neck and the right upper limb, it receives the lympha vessels from the right side of the heart, the right lung, the up part of the right half of the thoracic wall, and some of those from antero-superior surface of the liver. It ends in the angle of juncti of the internal jugular and subclavian veins of the corresponding si its orifice being guarded by a double valve.

Cervical Portion of the Lung.—The apex of the lung projects in the root of the neck as high as the neck of the first rib. It is cover by the cupola of the pleura, on the inner and anterior aspects of whi the subclavian artery arches outwards. The cupola of the pleura covered by the **suprapleural membrane (Sibson's fascia)**, which exten

m the medial border of the first rib to the front of the transverse ocess of the seventh cervical vertebra. This membrane is probably rived from the adjacent scalene muscles, and it may contain some iscular fibres.

The Contents of the Orbit.

The following structures are found in the orbit:

Orbital Fascia.—The periosteum of the orbit is continuous posteriorly th the dura mater through the superior orbital fissure, and constitutes e orbital fascia. Anteriorly it becomes continuous with the peri- anium of the frontal bone, and the periosteum of the maxilla and gomatic bones. Along the supra-orbital and infra-orbital margins e superior and inferior palpebral fasciæ blend with it. The orbital scia is loosely attached to the bony walls of the orbit, and forms a eath for the contents of the cavity, which is incomplete in front.

Lacrimal Gland.—This gland lies at the anterior and outer part the orbit superiorly, where it occupies the lacrimal fossa on the ier side of the zygomatic process of the frontal bone. It is disc- aped. Its upper surface is convex, and its under surface is con- ve in adaptation to the eyeball. The anterior part of the gland is rtly cut off by the outer edge of the levator palpebræ superioris, d is known as the *palpebral portion*, the chief part being known the *orbital portion*. The **ducts,** which issue from both portions, e about twelve in number, and they open in a row into the outer part the superior conjunctival fornix.

Blood-supply.—The lacrimal artery.

Nerve-supply.—The lacrimal nerve and sympathetic filaments.

The **structure** of the gland is something like to that of the parotid.

Development.—The **lacrimal gland,** like the tarsal and ciliary glands, is veloped as solid epithelial cords from the conjunctiva. These epithelial rds spring from the upper and outer part of the conjunctiva, where it is re- cted from the inner surface of the upper eyelid on to the front of the eyeball. e solid cords grow into the neighbouring mesoderm, and give off lateral pro- sses. Cords and processes, at first solid, soon become hollow, and so give e to the alveoli, or acini, and ducts of the lacrimal gland.

In reptiles the ducts open all round the fornix of the conjunctiva, but in ammals only the upper and outer ones persist.

Muscles.—These are the levator palpebræ superioris, rectus superior, ctus inferior, rectus medialis, rectus lateralis, obliquus superior, and liquus inferior.

Levator Palpebræ Superioris—*Origin.*—The under surface of the of of the orbit above, in front of, and medial to the optic foramen.

Insertion.—By a broad membranous expansion, which divides into ree tendinous laminæ. The *middle lamina*, which is the chief sertion, and consists largely of involuntary muscular fibres, is attached the upper margin of the superior tarsus. The *upper* or *superficial yer*, which is fibrous, passes in front of the superior tarsus, lying tween it and the palpebral fibres of the orbicularis oculi. Its fibres

pierce the superior palpebral fascia, and, having passed between bundles of the palpebral portion of the orbicularis oculi, they attached to the skin of the upper eyelid. The *lower* or *deep layer*, wh is also fibrous, is attached to the conjunctiva along the superior for

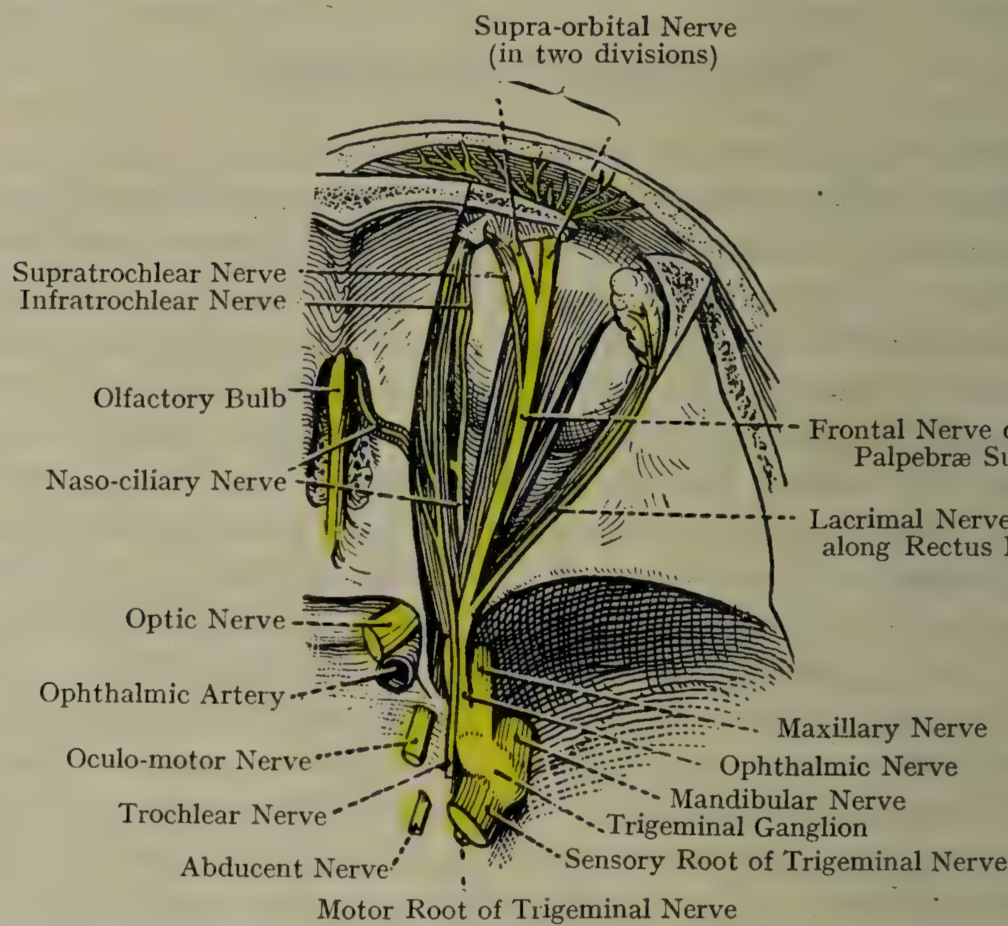


FIG. 754.—DISSECTION OF THE ORBIT FROM ABOVE (HIRSCHFELD AND LEVEIL

The outer and inner margins of the broad membranous expans are attached to the outer and inner margins of the orbit close to lateral and medial palpebral ligaments, and at the inner angle a is attached to the pulley of the obliquus superior.

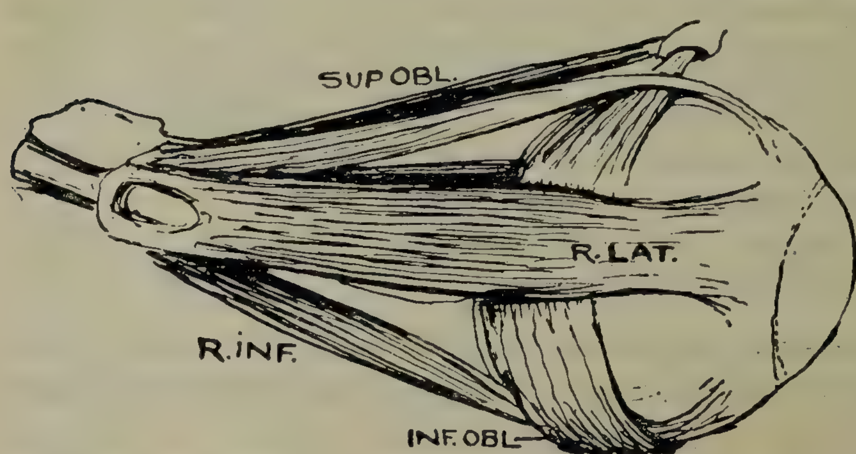


FIG. 755.—LATERAL VIEW OF THE MUSCLES WHICH MOVE THE EYEBALL.

Nerve-supply.—The per division of the th cranial nerve, the bra from which enters the d or ocular surface of muscle near its orig having pierced the rec superior.

Action.—To raise upper eyelid. The mus is the antagonist of superior palpebral fibres the orbicularis oculi.

The levator palpebræ is a delamination of the rectus superior, to whic is so closely attached that, even when it is paralyzed, the upper lid may raised a little by looking upwards.

Relations.—*Superiorly*, the frontal nerve and the supra-orbi artery. *Inferiorly*, the rectus superior and the conjunctiva.

Recti Muscles—Rectus Superior—*Origin.*—The upper part of the *mmon tendinous ring* in relation to the optic foramen.

Insertion.—By a thin expanded tendon into the upper surface of e sclera about three or four lines from the margin of the cornea.

Nerve-supply.—The upper division of the oculo-motor nerve, the anch from which enters the deep or ocular surface of the muscle ar its origin.

The muscle is flattened from above downwards, and its direction forwards and slightly outwards.

The actions of the muscles of the eyeball are considered together ı p. 1251.

Relations.—*Superiorly,* the levator palpebræ superioris, which is e narrower of the two muscles. *Inferiorly,* the tendon of the obliquus perior, the eyeball, and the soft fat of the orbit.

Rectus Medialis (Internal Rectus)—*Origin.*—The inner part of the mmon tendinous ring in relation to the optic foramen, the origin ing wide.

Insertion.—By a thin expanded tendon into the inner surface of e sclera about three or four lines from the margin of the cornea.

Nerve-supply.—The lower division of the oculo-motor nerve, the anch from which enters the deep or ocular surface of the muscle.

The muscle is flattened from within outwards, and its borders are perior and inferior. Its direction is almost straight forwards.

Relations.—Above the upper border of the muscle is the obliquus perior, and between the two the naso-ciliary nerve and the anterior d posterior ethmoidal vessels pass.

Rectus Inferior—*Origin.*—The lower part of the common tendinous ng in relation to the optic foramen.

Insertion.—By a thin expanded tendon into the lower surface the sclera about three or four lines from the margin of the rnea.

Nerve-supply.—The lower division of the oculo-motor nerve, the anch from which enters the deep or ocular surface of the muscle.

The muscle is flattened from above downwards, and its direction forwards and slightly outwards.

Relations—*Inferior.*—A part of the obliquus inferior.

Rectus Lateralis (External Rectus)—*Origin.*—This muscle arises by o heads.

Inferior Head.—(1) The lower part of the common tendinous ring relation to the optic foramen, where it is near the rectus inferior; d (2) the prominent spine on the lower margin of the superior orbital sure near its inner end.

Superior Head.—The outer portion of the upper part of the common ndinous ring in relation to the optic foramen, where it is above e superior orbital fissure, external to the optic foramen, and near e rectus superior. The two heads are connected by a tendinous nd which arches over the superior orbital fissure, and gives origin some of the fibres of the inferior head of the muscle.

Insertion.—The outer surface of the sclera from three to four li
from the margin of the cornea.

Nerve-supply.—The abducent nerve, the branches of which en
the deep or ocular surface of the muscle.

The muscle is flattened from without inwards, and its directio
forwards and outwards.

Action.—To abduct the eyeball, so as to direct the cornea outwa

Relations.—The following structures pass between the two he
of the muscle in order from above downwards: (1) the upper divis
of the oculo-motor nerve; (2) the naso-ciliary nerve; (3) the lo
division of the oculo-motor nerve; (4) the abducent nerve; and (5)
superior ophthalmic vein or veins.

Common Tendinous Ring of the Recti Muscles.—This tendon ta
the form of a fibrous ring, which is attached to the upper, inner,
lower margins of the optic foramen. It then crosses transvers
the inner portion of the superior orbital fissure to a prominent sp
on the lower margin of that fissure near its inner end. From
spine it recrosses the superior orbital fissure in a vertical direct
near its centre, and finally reaches the upper part of the optic foram
This latter portion gives origin to some fibres of the inferior head
the rectus lateralis. The *upper part* of the ring is sometimes kno
as the *tendon of Lockwood*, and gives origin from within outwa
to part of the rectus medialis, the rectus superior, and the supe
head of the rectus lateralis. The *lower part* is also sometimes ca
the *ligament of Zinn*, which gives ori
from within outwards to part of the rec
medialis, the rectus inferior, and the infe
head of the rectus lateralis.

Fig. 756.—The Superior Oblique Muscle.

Obliqui Muscles — Obliquus Superio
Origin.—The wall of the orbit directly
front of the upper and inner part of
optic foramen, close to the recti superio
medialis.

Insertion.—By an expanded tendon i
the upper and outer aspect of the sc
just beyond the outer border of the supe
rectus, and midway between the margin
the cornea and the entrance of the o
nerve.

The muscle is situated at the upper
inner part of the orbit, internal to
levator palpebræ superioris. It is directed forwards towards
inner angle of the orbit, on approaching which it ends in a sm
round tendon. This tendon passes through a fibro-cartilagin
pulley close to the medial angular process of the frontal bone.
then changes its direction, and passes downwards, outwards,
backwards beneath the tendon of the rectus superior to reach
insertion just lateral to that tendon.

The fibro-cartilaginous pulley or *trochlea* is attached by fibrous ssue to the *trochlear fossa* on the orbital plate of the frontal bone ose to the medial angular process. It is lined with synovial membrane lubricate the tendon and facilitate its movement at this abrupt ange in its course. The tendon receives a fibrous investment from e outer margin of the pulley.

Nerve-supply.—The trochlear nerve, which enters the muscle on s *superficial* or *orbital surface* near its origin.

Relations—*Superior.*—The roof of the orbit and the rectus superior. *ferior.*—The upper border of the rectus medialis, having the naso-iary nerve and the anterior and posterior ethmoidal vessels between em. *Lateral.*—The levator palpebræ superioris.

Obliquus ~~Superior~~ Inferior—*Origin.*—A small depression at the anterior and ner part of the floor of the orbit immediately lateral to the upper ening of the lacrimal canal.

Insertion.—The outer surface of the sclera under cover of the rectus teralis, and slightly posterior to the level of the insertion of the liquus superior.

Nerve-supply.—The lower division of the oculo-motor nerve, the anch of which is long and enters the *posterior border* of the muscle.

The muscle at first passes outwards and backwards upon the floor the orbit beneath the rectus inferior, and then it turns upwards tween the sclera and the rectus lateralis, where its tendon expands fore its insertion.

Relations.—Towards the eyeball the muscle is related to the ctus inferior and the sclera, and towards the orbit to the floor of e cavity and the rectus lateralis. The borders of the muscle are terior and posterior, the latter, as stated, receiving the nerve-pply.

Movements of the Eyeball.—The movements of the eyeball con-st of rotation round a point situated just behind the centre of its tero-posterior axis. When the eyeball rotates round its vertical is, horizontal or lateral movements take place, and the cornea directed outwards or inwards according to the muscle which acts. e rectus lateralis abducts the eyeball, so as to direct the cornea twards, and the rectus medialis adducts the eyeball, so as to rect the cornea inwards. When the eyeball rotates round its trans-rse axis vertical or upward and downward movements take place, d the cornea is directed upwards or downwards according to the uscle which acts. The rectus superior elevates the eyeball, and e rectus inferior depresses it. It is to be borne in mind, however, at these two muscles in passing forwards have each a slight in-nation *outwards*. Whilst, then, they respectively elevate and depress e cornea on the transverse axis of the eyeball, each of them also ves it a certain amount of inward movement on the vertical axis, companied by slight rotation on the antero-posterior axis. In e case of the rectus superior this inward and rotatory movement corrected by the *obliquus inferior* acting in association with it, and

in the case of the inferior rectus by the *obliquus superior* actin association with it.

Direct elevation of the eyeball is therefore effected by the re superior, aided by the obliquus inferior, and *direct depression* of eyeball is effected by the rectus inferior, aided by the obliquus supe The superior oblique, acting alone, would depress the cornea abduct it, making the eye look downwards and outwards, and obliquus inferior, acting alone, would elevate and abduct it, t movements in each case being accompanied by slight rotation on antero-posterior axis.

Fascia of the Orbit.—This fascia forms (1) the fascial sheath the eyeball, **fascia bulbi;** and (2) sheaths for the ocular muscles.

The **fascia bulbi** is practically the thickened wall of a lyn space round the sclerotic coat of the eyeball, and extends from point of entrance of the o nerve to near the margin of cornea. *Posteriorly* it is perfora by the ciliary vessels and ner and blends with the dura ma sheath of the optic nerve, *anteriorly* it fades away wher meets the ocular conjunctiva. outer surface of the capsule i contact with the orbital fat, anteriorly with the ocular c junctiva. The fascial sheath (c sule of Tenon) forms a cavity socket, within which the eye glides with perfect freedom fr friction.

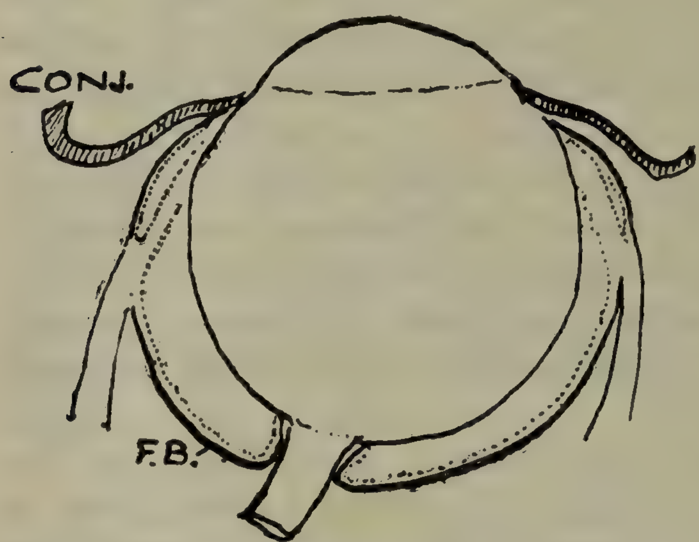


FIG. 757.—DIAGRAM TO SHOW FASCIA BULBI (F.B.) ROUND THE EYEBALL.

It has an endothelial lining (dotted line) which is reflected along the tendons to their insertions; the fibrous basis is reflected back towards the muscle.

The lower part of the fas sheath of the eyeball is said to thickened by the **suspensory li ment of the eye** (Lockwood). This is attached laterally to Whitna tubercle on the zygomatic bone, and medially to the lacrimal bo It is expanded beneath the eyeball, to the fore part of which it a as a sling or support.

The **muscular sheaths** are derived from the fascial sheath of eyeball. The tendons of the six ocular muscles pierce the fas sheath on their way to their insertions, which latter are under cove the fascial sheath, each muscle receiving a prolongation from the mar of the cleft in the sheath through which its tendon passes. Th prolongations extend backwards around the muscles, and ultimat blend with their perimysial sheaths. As regards the obliquus supe muscle, the prolongation around its tendon extends upwards, inwar and forwards as far as the margin of the pulley, to which it is attach The prolongation around the tendon of the obliquus inferior mus extends downwards as far as the outer part of the floor of the orbit

The sheaths of the four recti muscles give off important expan-
ons. The expansion from the sheath of the rectus lateralis is strong,
d is attached to the frontal process of the zygomatic bone, and
at from the sheath of the rectus medialis, also strong, is attached
the lacrimal crest of the lacrimal bone. These two expansions
their bony attachments are connected with the lateral extremities
the suspensory ligament of the eye. The expansion from the
eath of the rectus superior blends with the deep layer of the tendon
the levator palpebræ superioris, and that from the sheath of the
ctus inferior is connected with the inferior tarsus. These expansions
om the sheaths of the recti, especially from those of the recti lateralis
medialis, moderate the action of the muscles, and the latter two
e hence known as the **check ligaments.**

Nerves in the Orbit—Optic Nerve.—The optic nerve extends for-
rds and outwards from the optic chiasma, and enters the orbit
rough the optic foramen, having the ophthalmic artery below it
first, and then on its outer side. It receives sheaths from the
ra mater and arachnoid, the former being strong, and at its entrance
to the orbit it is surrounded by the origins of the four recti muscles.
s direction is forwards and outwards, with a slight inclination
wnwards, to the back part of the eyeball, where it pierces the sclera
out $\frac{1}{2}$ inch medial to, and a little below, the centre. It then pierces
e choroid coat, and ends in the nerve-fibre layer of the retina. The
iary ganglion is close to the outer side of the nerve towards the back
rt of the orbit, and in front of this the nerve is surrounded by the
iary nerves and vessels. It is crossed superiorly by the ophthalmic
tery, the superior ophthalmic vein, and the naso-ciliary nerve.
feriorly, about $\frac{1}{8}$ inch behind the eyeball, the central artery of the
tina enters it and then runs forward within it to the retina.

Third or Oculo-motor Nerve.—This nerve, having left the outer
ll of the cavernous sinus, breaks up at the superior orbital fissure into
o divisions, upper and lower. These enter the orbit between the
o heads of the rectus lateralis muscle, the naso-ciliary nerve being
uated between the two.

The superior division enters the deep surface of the rectus superior
pplying it, after which it pierces the muscle and ends in the levator
lpebræ superioris.

The *inferior division*, larger than the upper, has three branches,
ich supply the rectus medialis, the rectus inferior, and the obliquus
erior. The twigs to the recti medialis et inferior enter these muscles
their deep or ocular surfaces. The branch to the obliquus inferior
a long nerve which passes forwards between the recti inferior et
eralis, and its twigs enter the obliquus inferior muscle at its *posterior*
rder. Posteriorly it furnishes the *ganglionic branch*, which forms the
ort or parasympathetic root of the ciliary ganglion.

The **fourth, trochlear,** or **pathetic nerve,** of small size, having left
e wall of the cavernous sinus, enters the orbit through the superior
bital fissure above the muscles, and medial to, but on a slightly

higher plane than, the frontal nerve. Having passed inwards o the levator palpebræ superioris, it enters the posterior part of the ol quus superior muscle on its *superficial* or *orbital surface,* this bei the only muscle which it supplies.

The **sixth** or **abducent nerve,** having left the cavernous sinus, ent the orbit through the superior orbital fissure, and passes between t two heads of the rectus lateralis muscle. this situation it has the lower division of t oculo-motor nerve above it, and the super ophthalmic veins below it. It supplies t rectus lateralis, its twigs entering the mus on its deep or ocular surface.

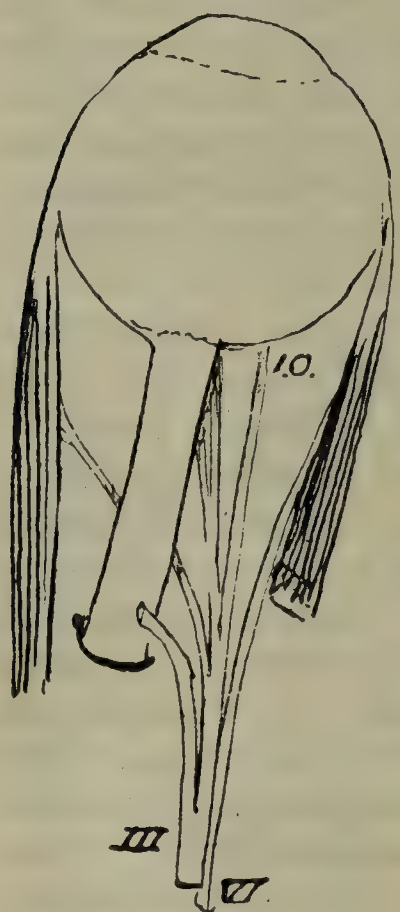


Fig. 758.—The Third and Sixth Cranial Nerves in the Orbit.

I.O., nerve to inferior oblique; other branches running directly forward from lower division of the third nerve are going to inferior rectus.

Branches of the Ophthalmic Division of t Trigeminal Nerve.—The ophthalmic ner having left the outer wall of the caverno sinus, and before reaching the superior orbi fissure, divides into frontal, lacrimal, a naso-ciliary nerves.

The **frontal nerve,** of large size, enters t orbit through the superior orbital fissure abo the muscles. In this situation it has the la rimal nerve lateral to, and on the same pla with it, and the trochlear nerve medial to but on a slightly higher plane. It then pass forwards on the upper surface of the levat palpebræ superioris, underneath the periosteu of the roof of the orbit, and before arrivi at the supra-orbital margin it divides into t branches, supra-orbital and supratrochlear.

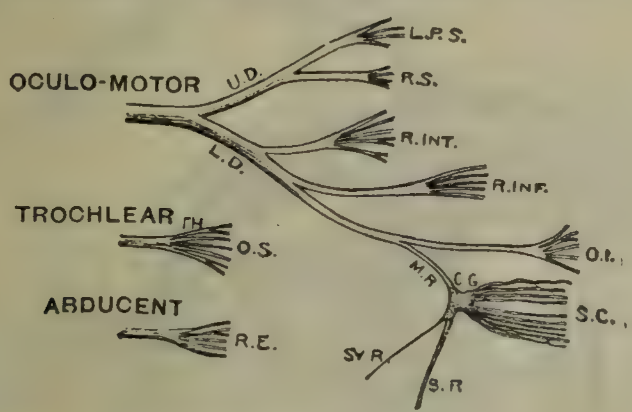
The *supra-orbital nerve,* which in size a direction is the continuation of the front passes forwards to the supra-orbital notch foramen, through which it leaves the orbit company with the supra-orbital artery. the forehead it divides into two branches, late and medial, which have been already describ (see p. 1153). Sometimes this division takes place within the orb and in these cases the inner branch usually passes through the sup orbital notch.

The *supratrochlear nerve,* of small size, passes forwards and inwa to the pulley to the obliquus superior muscle, above which it runs the forehead, where it has been already described (see p. 1154). Befo leaving the orbit it gives off a small twig, which passes downwar close to the pulley of the obliquus superior, to form a loop with t infratrochlear branch of the naso-ciliary nerve.

The **lacrimal nerve** enters the orbit through the superior orbi fissure above the muscles, and external to the frontal nerve. It th passes forwards and outwards along the upper border of the rec

eralis in company with the lacrimal artery. On reaching the lacrimal ınd it gives numerous branches to its deep surface, and is then con- ıued through the orbital septum to the skin and conjunctiva of the ter part of the upper eyelid, and the skin in the region of the zygo- ıtic process of the frontal bone. Near the lacrimal gland it sends wnwards a small twig, which joins the zygomatico-temporal nerve.

The **naso-ciliary nerve (nasal nerve)** is more deeply placed than the ntal and lacrimal. It enters the orbit through the superior orbital sure, and passes between the two heads of the rectus lateralis muscle, ng between the upper and lower divisions of the oculo-motor nerve. then passes obliquely inwards and forwards to the inner wall of the bit, lying beneath the rectus superior and above the optic nerve, d, later on, between the obliquus superior and the rectus medialis. ıving reached the inner wall of the orbit at the anterior ethmoidal



G. 759.—SCHEME OF THE DISTRIBUTION OF THE OCULO-MOTOR, TROCHLEAR, AND ABDUCENT NERVES (FLOWER).

Oculo-Motor Nerve
- U.D. Upper Division
  - L.P.S. Levator Palpebræ Superioris
  - R.S. Rectus Superior
- L.D. Lower Division
  - R.Int. Rectus Medialis
  - R.Inf. Rectus Inferior
  - O.I. Obliquus Inferior
- C.G. Ciliary Ganglion
- M.R. Motor Root

S.R. Sensory Root (from Naso-ciliary Nerve)
Sy.R. Sympathetic Root
S.C. Short Ciliary Nerves

Trochlear Nerve—O.S. Obliquus Superior

Abducent Nerve—R.E. Rectus Lateralis.

ramen, it parts with its infratrochlear branch, and then passes through e foramen in company with the anterior ethmoidal artery, and so ters the anterior fossa of the base of the skull. It then passes forwards ıd inwards in a groove on the upper surface of the cribriform plate the ethmoid bone, lying under cover of the dura mater. Having ached the nasal slit at the side of the fore part of the crista galli, descends through this slit, or through a small foramen just in front it, into the nasal cavity, and immediately gives off two *internal nasal anches*. Then the nerve descends in a groove on the posterior surface the nasal bone, giving offsets to the mucous membrane of the outer ıll of the nasal cavity in front of the superior and middle nasal nchæ. Finally, the nerve comes out, as the *external nasal branch*, tween the lower border of the nasal bone and the upper nasal cartilage, ıd supplies the skin of the tip and lower part of the side of the nose.

In connection with this remarkable course of the nerve it is to b noted that it is to be met with in four different regions—namel (1) in the orbit; (2) on the cribriform plate of the ethmoid bone the anterior cranial fossa; (3) in the nasal cavity; and (4) on the fa in the region of the tip of the nose.

Branches.—The *ramus communicans to the ciliary ganglion* forms t long or sensory root of that ganglion. It is slender, about ½ inch lon and arises from the naso-ciliary as it passes between the two hea of the rectus lateralis. It enters the ciliary ganglion at its poster superior angle.

The *long ciliary nerves,* usually two in number, arise from t naso-ciliary immediately after it has crossed the optic nerve, and th

FIG. 760.—DISSECTION OF THE ORBIT FROM ABOVE (HIRSCHFELD AND LEVEILLE).

communicate with the short ciliary nerves from the ciliary ganglio which they accompany to the back part of the sclera. Here they pier the sclera, and are distributed along with the short ciliary nerves.

The *infratrochlear nerve* arises from the naso-ciliary close to t anterior ethmoidal foramen, and passes forwards beneath the obliqu superior muscle. Near the pulley of that muscle it receives a tw from the supratrochlear nerve, and then, passing beneath the pulle it leaves the orbit at the medial angle to be distributed to the sk and conjunctiva of the inner parts of the eyelids, the side of the ro of the nose, the lacrimal sac, and the caruncula lacrimalis.

As the nerve traverses the anterior ethmoidal canal it gives twi to the mucous membrane of the frontal sinus and of the anterior et moidal sinus.

A *posterior ethmoidal nerve* is described as passing through the osterior ethmoidal canal to supply the mucous membrane of the osterior ethmoidal sinus and of the sphenoidal sinus.

For the branches of the naso-ciliary nerve to the exterior of the nose id to the nasal fossa, see p. 1276.

Ciliary Ganglion (Lenticular Ganglion).—This is a small quadriteral body, about the size of a moderately large pin-head, which is tuated in the posterior part of the orbit, where it lies flattened upon e outer side of the optic nerve. It is usually in close contact with

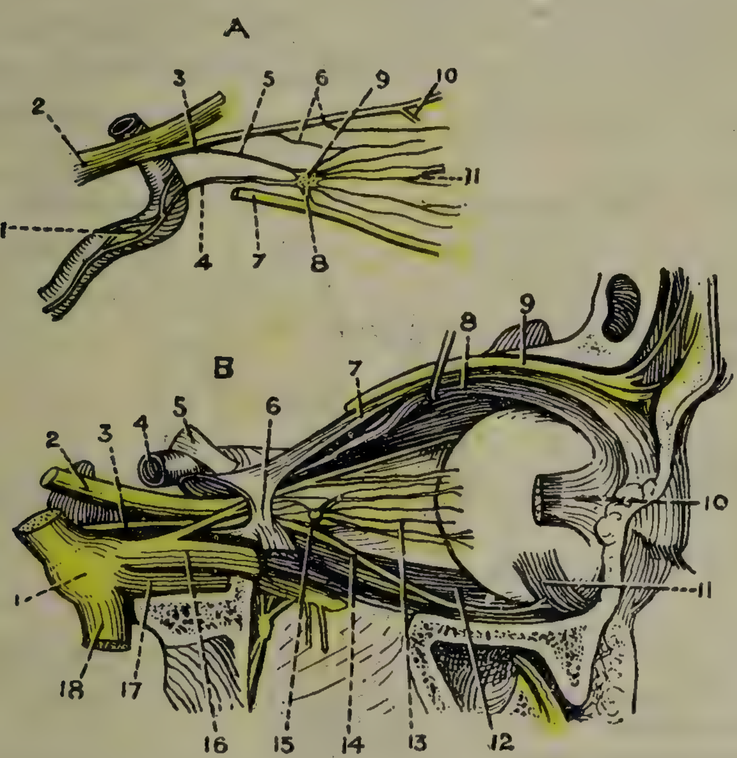


FIG. 761.—A, THE CILIARY GANGLION; B, THE NERVES OF THE ORBIT (LATERAL ASPECT) (HIRSCHFELD AND LEVEILLÉ).

A

iternal Carotid Plexus
phthalmic Nerve
aso-ciliary Nerve
ympathetic Root of Ciliary Ganglion
5. Sensory Root of Ciliary Ganglion
6. Long Ciliary Nerves
7. Branch of Oculo-motor Nerve to Obliquus Inferior
8. Motor Root of Ciliary Ganglion
9. Ciliary Ganglion
10. Infratrochlear Branch of Naso-ciliary Nerve
11. Short Ciliary Nerves

B

rigeminal Ganglion
culo-motor Nerve
bducent Nerve
iternal Carotid Artery
ptic Nerve
ommon Tendinous Ring for Recti
7. Levator Palpebræ Superioris
8. Rectus Superior
9. Frontal Nerve
10. Rectus Lateralis
11. Obliquus Superior
12. Rectus Inferior
13. Short Ciliary Nerves
14. Branch of Oculo-motor Nerve to Obliquus Inferior
15. Ciliary Ganglion
16. Ophthalmic Nerve
17. Maxillary Nerve
18. Mandibular Nerve

it nerve, and is recognized by its reddish-pink colour. Posteriorly receives its three roots, and anteriorly the short ciliary nerves pass wards from it. The roots are called sensory, motor, and sympathetic. e **sensory root** is derived from the naso-ciliary nerve as it passes tween the two heads of the rectus lateralis. It is slender, about nch long, and enters the postero-superior angle of the ganglion. e **motor root** is derived from the long branch of the lower division the oculo-motor nerve which supplies the obliquus inferior muscle, l it enters the postero-inferior angle of the ganglion. The **sym-**

pathetic root is a very minute nerve which is derived from the intern carotid plexus of the sympathetic, and it usually reaches the gangli in company with the sensory root. It may, however, join the gangli separately, and then it does so in close proximity to the entrance the long root.

The **branches** of the ciliary ganglion are called the *short cilia nerves*. They are from six to eight in number, and come off in t groups from the antero-superior and antero-inferior angles. T nerves of the lower group usually exceed those of the upper in numb As they pass forward above and below the optic nerve they divide, a give rise to from sixteen to twenty delicate filaments. Having reach the back of the eyeball, they pierce the sclera around the entran of the optic nerve. They then pass forwards between the sclera a

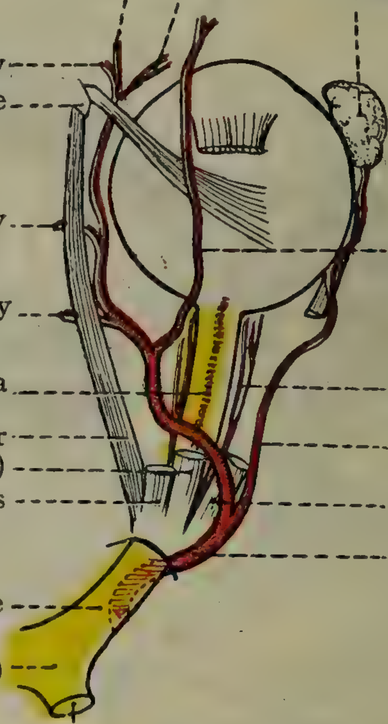


FIG. 762.—DISSECTION OF THE RIGHT ORBIT FROM ABOVE, SHOWING THE OP NERVE, OPHTHALMIC ARTERY, AND SUPERIOR OBLIQUE MUSCLE.

the choroid, giving twigs to the latter, and they are finally distribut to the ciliary muscle, the iris, and the cornea. The short cilia nerves thus convey to the eyeball sensory fibres from the ophthalm division of the trigeminal nerve, motor fibres from the oculo-mo nerve, and sympathetic fibres from the internal carotid plexus of t sympathetic.

Summary of the Ophthalmic Nerve.—This nerve is entirely sensory. supplies (1) the skin of (*a*) the frontal region and top of the skull; (*b*) the up eyelid, and (*c*) the root, tip, and lower part of the side of the nose; (2) the car cula lacrimalis and lacrimal sac; (3) the mucous membrane of the nasal cavi and the conjunctiva; (4) the eyeball; and (5) the lacrimal gland.

Summary of the Ciliary Ganglion.—The branches of this ganglion supply t cornea, iris, and ciliary muscle. The fibres which supply the **sphincter pupi** are derived from the *oculo-motor nerve* by means of the motor root of the gangli

ne fibres which supply the **dilator pupillæ** are derived from the *sympathetic* by eans of the sympathetic root of the ganglion, which is derived from the internal rotid sympathetic plexus.

Branch of the Maxillary Division of the Trigeminal Nerve.—The gomatic nerve (temporo-malar nerve), of small size, arises from the axillary in the pterygo-palatine fossa. It enters the orbit through ne inferior orbital fissure, and soon divides into two branches, zygo-atico-temporal and zygomatico-facial. The *zygomatico-temporal nerve* *emporal branch*) ascends upon the outer wall of the orbit, and, having ceived a communicating twig from the lacrimal nerve, it leaves the vity by passing through the zygomatico-temporal canal in the gomatic bone. Its destination is the skin of the anterior part of ne temporal region.

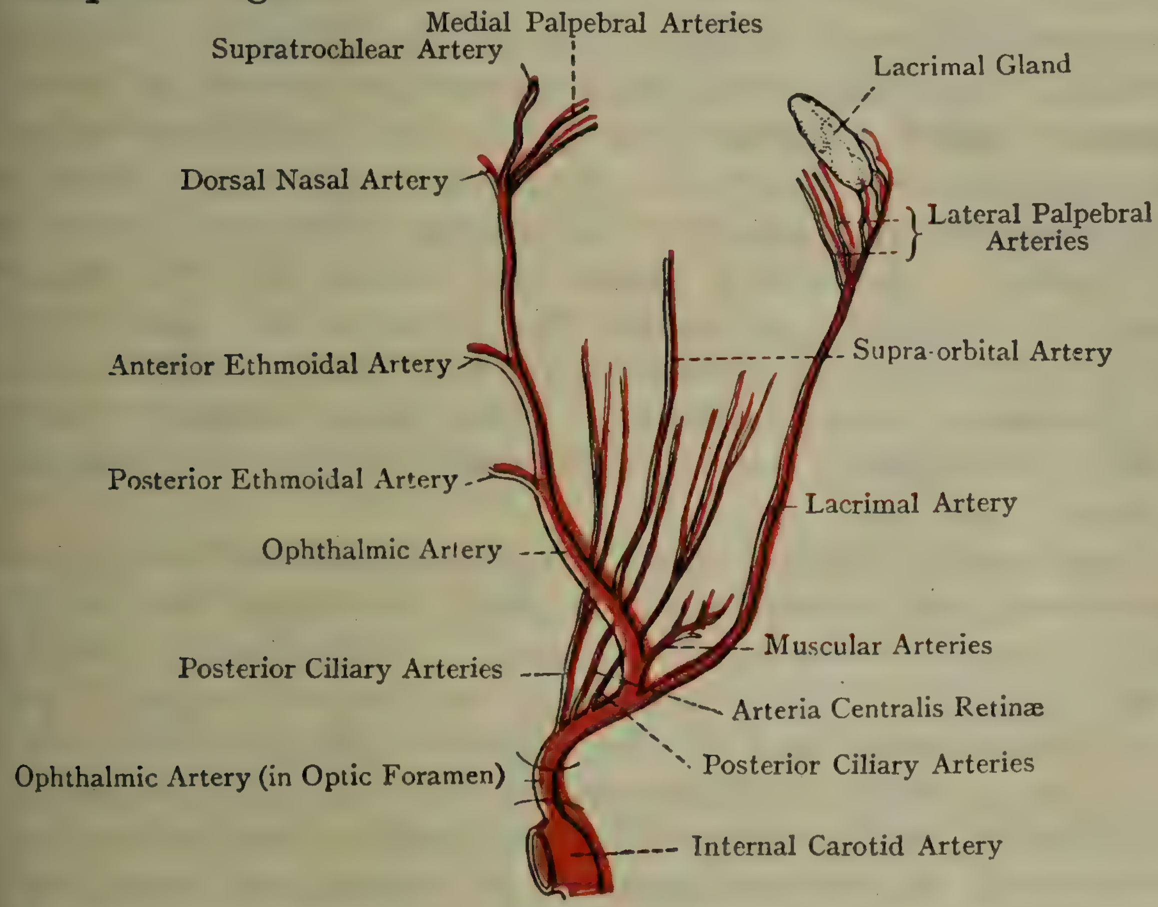


FIG. 763.—DIAGRAM OF THE OPHTHALMIC ARTERY AND ITS BRANCHES.

The *zygomatico-facial nerve* (*malar branch*) passes forwards in the ngle between the outer wall and floor of the orbit, and leaves the vity by passing through the zygomatico-facial canal, from which comes out through the corresponding foramen. It is distributed the skin over the zygomatic bone.

Ophthalmic Artery.—This vessel arises from the internal carotid tery on the inner aspect of the anterior clinoid process, and enters e orbit through the optic foramen, lying beneath the optic nerve. ithin the orbit it is situated for a short distance on the outer side the optic nerve, and then it passes obliquely inwards and forwards a tortuous manner over the nerve to the inner wall of the orbit. hen it passes forwards to the region of the medial angular process the frontal bone, near which it divides into its three terminal branches dorsal nasal, supratrochlear, and palpebral.

Branches.—These are as follows:

1. Central artery of the retina.
2. Posterior ciliary.
3. Lacrimal.
4. Muscular.
5. Supra-orbital.
6. Posterior ethmoidal.
7. Anterior ethmoidal.
8. Palpebral (two).
9. Nasal.
10. Frontal.

The **central artery of the retina (arteria centralis retinæ)** aris from the ophthalmic at the back part of the orbit below the opt nerve. Its direction is forwards beneath the nerve, and at a poi about $\frac{1}{2}$ inch behind the eyeball it enters the nerve, and passes forwar in its centre to the retina, upon which it ramifies. It must be unde stood that this is the only blood-supply of the retina, and that i obliteration means blindness of the eye to which it goes; it is therefor in spite of its small size, one of the most important arteries in the bod

The **posterior ciliary arteries** arise from the ophthalmic whilst is below the optic nerve. They are arranged in two sets, lateral an medial, which pass forwards on either side of the optic nerve to the bac part of the eyeball. Here they pierce the sclera, and the majorit of them enter the choroid coat under the name of the *short posteri ciliary arteries*. Two of them, however, are fairly large, and are know as the *long posterior ciliary arteries*. They pass forwards betwee the sclera and the choroid, one on each side, and are distributed t the ciliary muscle and iris.

The **lacrimal artery** arises from the ophthalmic on the outer sid of the optic nerve, and passes forwards along the upper border of th rectus lateralis muscle to the lacrimal gland. In its course it furnish the following branches: (1) a recurrent meningeal branch, whic passes through the outer part of the superior orbital fissure to th middle cranial fossa, where it anastomoses with the middle meninge artery; (2) muscular and anterior ciliary branches, the latter piercin the sclera very near the corneal margin; (3) zygomatic offsets, whic pass through the zygomatico-temporal and zygomatico-facial canals the zygomatic bone to the face and temporal region in company wit the respective branches of the temporo-zygomatic nerve; (4) tw lateral palpebral arteries, superior and inferior, which pass inwar in the upper and lower eyelids, and anastomose with the medi palpebral branches of the ophthalmic, thus forming arterial arche and (5) glandular branches to the lacrimal gland.

The **muscular branches** arise from the ophthalmic in two set outer and inner, and also from some of its branches—*e.g.*, the lacrim and supra-orbital. They furnish a few of the anterior ciliary arteries

The **supra-orbital artery** arises from the ophthalmic as it crosse inwards over the optic nerve. It courses forwards to the supra orbital notch, through which it passes, with the corresponding nerv to the forehead. It supplies the upper eyelid and the frontal regio and anastomoses with the superficial temporal and supratrochlea arteries.

The **posterior ethmoidal artery,** a small vessel, passes through the osterior ethmoidal canal on the inner wall of the orbit, and is distributed the mucous membrane of the posterior ethmoidal sinus and the ucous membrane of the upper and back part of the outer wall of e nasal cavity. The latter branches pass through foramina in the ibriform plate.

The **anterior ethmoidal artery** is larger than the preceding. It isses through the anterior ethmoidal canal with the naso-ciliary erve, and enters the anterior fossa of the base of the skull. Here crosses the cribriform plate of the ethmoid bone to the nasal slit the side of the crista galli. It then descends through this slit, averses the nasal groove on the posterior surface of the nasal bone, id finally passes between the lower border of the nasal bone and the oper nasal cartilage to the tip of the nose. Its branches supply the ura mater in the anterior cranial fossa, the mucous membrane of e anterior ethmoidal sinus and corresponding frontal sinus, the mucous embrane of the upper and terior parts of the nasal ssa, and the skin of the tip the nose.

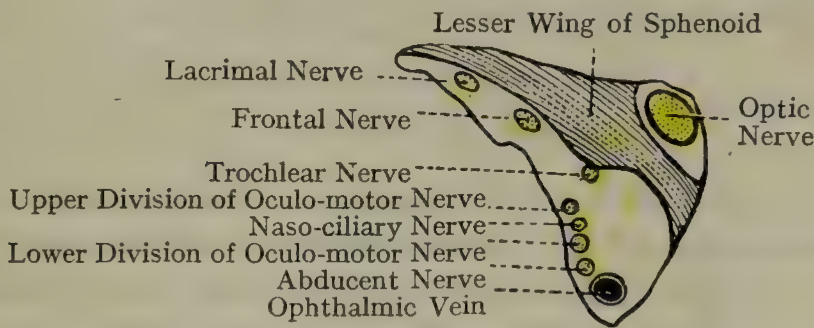


FIG. 764.—DIAGRAM OF THE LEFT SUPERIOR ORBITAL FISSURE, SHOWING THE TRANSMITTED STRUCTURES (POSTERIOR VIEW).

The **medial palpebral ar- ies** are superior and in- ior, and are distributed the eyelids. They arise, parately or conjointly, from e ophthalmic close to the lley of the obliquus su- rior muscle, and each takes an outward course in the corresponding elid. They anastomose with the two lateral palpebral branches of e lacrimal artery, thus forming arterial arches.

The **dorsal nasal artery** leaves the orbit above the medial palpebral ament, and is distributed to the upper part of the side of the nose the region of the root, where it anastomoses with the angular and teral nasal branches of the facial artery.

The **supratrochlear artery (frontal artery)** is the third terminal anch of the ophthalmic. It leaves the orbit at the inner angle, d then ascends to the frontal region, along with the supratrochlear rve, to be distributed to the integument by the side of the median ie. It anastomoses with the supra-orbital artery and its fellow the opposite side. The above description is fairly typical, but the ode of origin of the orbital arteries is very variable and, as in most rts of the body, the normal is seldom seen.

Ophthalmic Veins.—These are superior and inferior. The **superior hthalmic vein,** of large size, begins at the inner angle of the orbit, iere it communicates freely with the facial through the angular in. It accompanies the ophthalmic artery, passing outwards and ckwards over the optic nerve. Having reached the inner end of the perior orbital fissure, the vessel passes between the two heads of the

rectus lateralis muscle, and through the fissure, after which it ope into the anterior part of the cavernous sinus. Its tributaries corr spond for the most part to the branches of the ophthalmic arter It does not, however, receive the supratrochlear nor the supra-orbit vein. The **inferior ophthalmic vein** arises in connection with t lower posterior ciliary and lower muscular veins. It passes backwar along the floor of the orbit, and may join the superior ophthalmic vei open independently into the cavernous sinus, or pass through t inferior orbital fissure into the pterygoid plexus, with which in a case it freely communicates.

Structures passing through the Superior Orbital Fissure (Sphenoid Fissure).—These structures are as follows:

1. The oculo-motor nerve.
2. The trochlear nerve.
3. The naso-ciliary, lacrimal, and frontal nerves.
4. The abducent nerve.
5. The sympathetic root of the ciliary ganglion.
6. The ophthalmic veins.
7. The orbital branch of t middle meningeal arter
8. The recurrent branch of t lacrimal artery.
9. The dura mater.

The lacrimal, frontal, and trochlear nerves enter the orbit abo the rectus lateralis muscle, in the order named from without inwards

The oculo-motor nerve, the naso-ciliary nerve, and the abduce nerve enter the orbit between the two heads of the rectus latera muscle, the oculo-motor nerve having already broken up into tv divisions; and the ophthalmic veins leave the orbit between the tv heads of the rectus lateralis. The order of parts between the two hea of the rectus lateralis, from above downwards, is as follows:

1. The superior division of the oculo-motor nerve.
2. The naso-ciliary nerve.
3. The inferior division of the oculo-motor nerve.
4. The abducent nerve.
5. The ophthalmic veins (or vein).

The sympathetic root of the ciliary ganglion passes through t superior orbital fissure independently, or along with the naso-cilia nerve, or sometimes with the oculo-motor nerve.

Structures passing through the Inferior Orbital Fissure (Spher maxillary Fissure):

1. Infra-orbital vessels.
2. Infra-orbital nerve.
3. Zygomatic nerve.
4. Inferior ophthalmic vein.
5. Orbital branches of the spheno-palatine ganglion.
6. Lymphatics.

The opening is bridged over by fascia in which involuntary mus fibres, representing Müller's muscle of the lower animals, are found.

THE FACE.

Landmarks.—The glabella can be seen between the eyebrows, and xtending outwards from it on either side is the superciliary arch, ehind the inner part of which is the corresponding frontal sinus. elow the superciliary arch the supra-orbital margin can readily be lt, and at the junction of its inner third and outer two-thirds is the ipra-orbital notch, or foramen for the passage of the supra-orbital erve and artery. A line drawn from the position of the supra-bital notch to the base of the mandible in such a manner as to pass etween the lower premolar teeth, or, which comes to the same thing, the angle of the mouth, crosses in succession the infra-orbital and ental foramina. The infra-orbital foramen lies in this line at a point bout ¼ inch below the infra-orbital margin, and it indicates the exit the infra-orbital nerve and artery from the infra-orbital canal. The ental foramen in the adult lies midway between the alveolar and asilar borders of the mandible, and locates the exit of the mental erve and artery from the mandibular canal.

In line with the tragus of the auricle the zygomatic arch can be lt, and leading backwards from it above the orifice of the external uditory meatus is the posterior root of the zygoma. This root is ontinued into the supramastoid crest, which corresponds to the level the tegmen tympani. Below the supramastoid crest, and just above nd behind the external auditory meatus, is the suprameatal triangle. his triangle lies superficial to the tympanic antrum, and is a most nportant surgical landmark.

The superficial temporal artery and auriculo-temporal nerve lie rectly in front of the tragus, the division of the artery into its anterior nd posterior branches taking place about the level of the upper part the auricle. The anterior branch of the artery lies nearly an inch ehind the zygomatic process of the frontal bone, and the posterior ranch about an inch above the upper part of the auricle.

The parotid gland is situated in front of the auricle. It is limited bove by the zygoma, behind by the auricle, and inferiorly it extends r a limited distance into the digastric triangle of the neck. Anteriorly extends for a short distance superficial to the masseter muscle, and e parotid duct issues from its anterior border. The course of this uct may be indicated by a line drawn from the intertragic notch to a oint midway between the nostril and the red margin of the upper lip. bout the middle third of this line corresponds to the duct. Above is the transverse facial artery, and below it are the infra-orbital ranches of the facial nerve.

The posterior border of the ramus of the mandible is easily felt. leads superiorly to the condyloid process and mandibular joint, nd inferiorly to the angle of the bone. Extending forwards from e angle is the base of mandible, which, about an inch from the angle, as a groove for the facial artery, pulsation being readily felt during e in this part of the vessel in front of the masseter muscle, the

anterior vein intervening between the two. In this situation lymphatic gland lies in contact with the artery. From this po the facial artery extends in a tortuous manner to the medial an of the eye, passing close to the angle of the mouth, the anterior fac vein pursuing a comparatively straight course.

Near the mid-line of the face the structures to be noted are nasal bones, nasal cartilages, dorsum and apex of the nose, alæ na columna, and the philtrum, which latter is the median groove lead from the columna to the upper lip.

For the component parts of the auricle, see p. 1294.

The eyelids or palpebræ are to be noted, along with the palpeb fissure between them, and the medial and lateral angles at eitl extremity. The tarsus of the upper eyelid can be demonstrated everting the eyelid, and connected with its inner extremity is medial palpebral ligament. This latter may be made tense by draw the eyelids outwards. It crosses the lacrimal sac a little above centre. The eyelids being everted, the outlines of the tarsal glar may be seen as yellowish streaks perpendicular to the palpeb margins. Behind the eyelashes, or cilia, on the margins of the eyel are the minute orifices of the ducts of the tarsal glands, which arranged in a row. Along the line of the eyelashes the skin of eyelid becomes continuous with the conjunctiva, and along the line reflection of the conjunctiva on to the eyeball the recess, known the fornix, is to be noted. At the medial angle, where the eyelids not meet, there is a recess, known as the *lacus lacrimalis*, between lids and the eyeball, which lodges a small red fleshy protuberan called the caruncula lacrimalis, provided with a few delicate hai Lateral to this is the fold called the plica semilunaris, which is a vest of the nictitating membrane or third eyelid of birds. Upon eyelids at their inner ends the lacrimal papillæ are visible, and each papilla is a minute orifice, called the punctum lacrimale. T lower papilla is larger than the upper, and is placed a little farther o Each punctum leads into a lacrimal canaliculus, and by these can the tears are conveyed into the lacrimal sac, and thence by the na lacrimal duct into the inferior meatus of the nose. The position the lacrimal sac may be indicated by drawing the eyelids outwar so as to render tense the medial palpebral ligament, which, as stat crosses the sac a little above its centre.

Muscles of the Face.

Orbicularis Oculi (Orbicularis Palpebrarum)—Orbital Portion
Origin.—The outer surface of the frontal process of the maxilla, a the medial angular process of the frontal bone.

Insertion.—It is usually said that the orbicular fibres form compl circles, but it is almost certain that they are serially inserted into t skin, and their place taken by fresh fibres rising from the skin. It only necessary to watch the puckering of the skin on the outer si

ıe orbit, where the ' crow's feet ' are formed, or the wince of pain
w the lower eyelid, to be convinced that there are distinct insertions
bres into the skin in these parts.

Palpebral Portion—*Origin.*—The upper and lower surfaces of the
lial palpebral ligament.

Insertion.—The upper and lower surfaces of the lateral palpebral
ıé.

Nerve-supply.—Temporal and zygomatic branches of the facial
ve, in which there may be fibres derived from the nucleus of the
o-motor nerve.

Action—**Orbital Portion.**—(1) The upper half depresses the eye-
v, and antagonizes the frontal belly of the occipito-frontalis muscle;
the lower half elevates the skin of the infra-orbital region. **Palpe-
Portion.**—This closes the eyelids, as in winking, the upper lid
ıg depressed and the lower raised, the former movement being
e free than the latter. By means of its connection with the medial
ebral ligament the palpebral portion draws forwards the front
: of the lacrimal sac, and so contributes to the removal of the tears.
en the entire muscle contracts, the lids are forcibly closed and
wn slightly inwards.

The upper part of the muscle is related by its deep surface to the
tal belly of the occipito-frontalis, the supra-orbital vessels and
ve, and the supratrochlear nerve, the chief deep relations of the
er part of the levator labii superioris, and, beneath that, the infra-
tal nerve.

**Medial Palpebral Ligament (Internal Tarsal Ligament or Tendo-
li).**—It is attached medially to the outer surface of the frontal
cess of the maxilla immediately in front of the naso-lacrimal groove.
direction is outwards in front of the lacrimal sac, and it bifurcates
he medial angle, the divisions diverging, and being attached to
inner extremities of the corresponding tarsus. As the ligament
ses just in front of the lacrimal sac it gives origin to the palpebral
tion of the orbicularis oculi, which explains the action of that
tion of the muscle upon the sac.

Lateral Palpebral Raphé (External Tarsal Ligament).—This is
ched laterally to the frontal process of the zygomatic bone. Its
ction is inwards, and it bifurcates at the lateral angle of the eye
the outer extremities of the tarsi.

**Lacrimal Portion of Orbicularis Oculi (Tensor Tarsi or Muscle of
ner)**—*Origin.*—The crest of the lacrimal bone behind the lacrimal

Insertion.—By means of two slips into the inner extremities of the
i of the eyelids, where the fibres become continuous with the ciliary
es of the orbicularis oculi.

Nerve-supply.—As for the rest of orbicularis oculi.

The direction of the muscle is outwards and forwards, and its two
s pass behind the lacrimal canaliculi.

Action.—To draw backwards the outer part of the medial palpebral

ligament, and in this manner compress the lacrimal sac, the effec
which is to force the tears into the naso-lacrimal duct.

Corrugator Supercilii—*Origin.*—The inner extremity of the su
ciliary arch of the frontal bone.

Insertion.—The deep surface of the skin of the eyebrow at
centre.

Nerve-supply.—Temporal branches of the facial nerve.

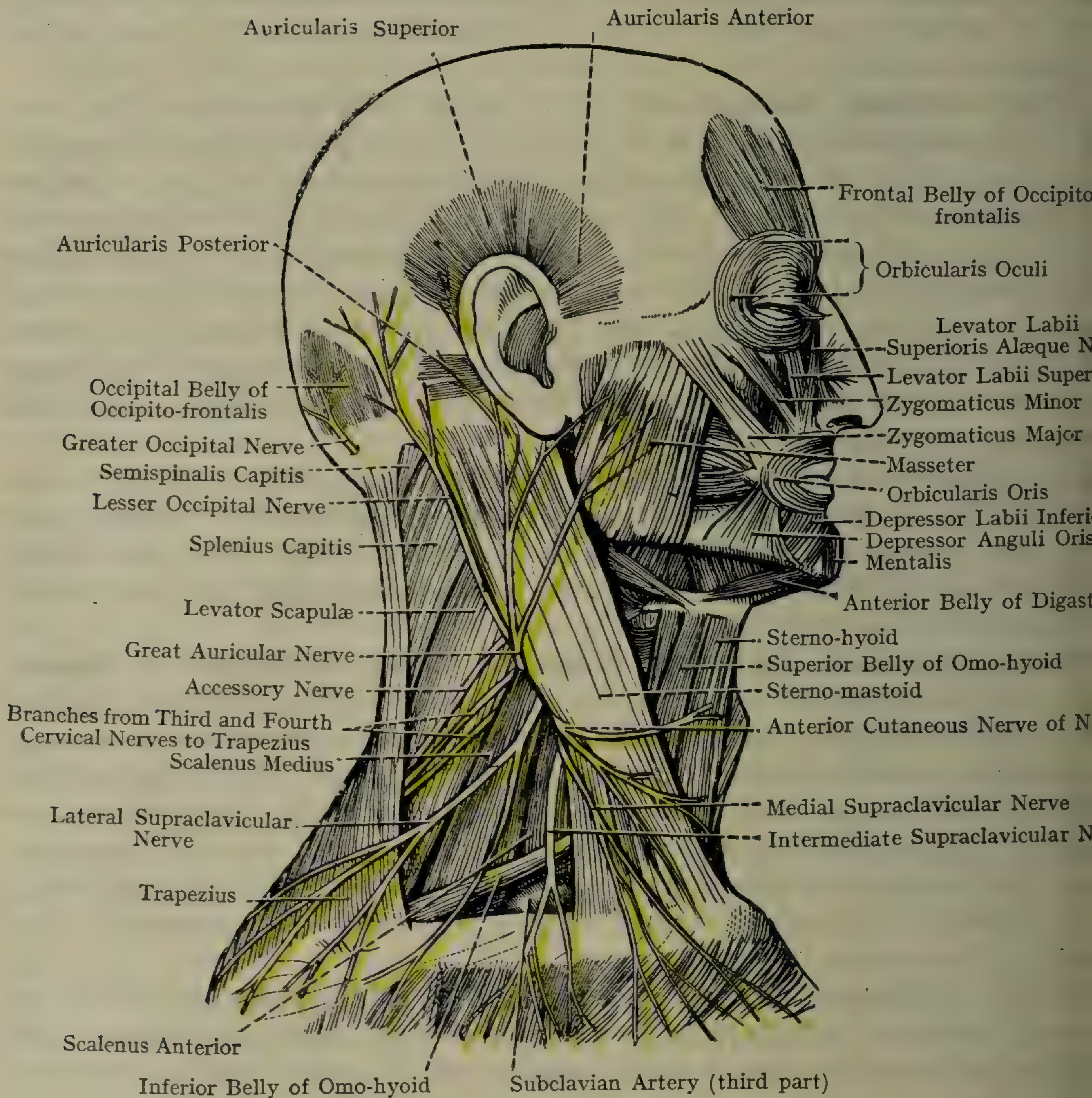


FIG. 765.—THE RIGHT SIDE OF THE HEAD AND NECK.

The platysma has been removed, and the nerves are shown.

The direction of the muscle is outwards and upwards, and to re
the skin the fibres pass through the upper part of the orbicularis o
and the adjacent portion of the frontal belly of occipito-frontalis.

Action.—To draw the skin of the eyebrow inwards and do
wards, giving rise to vertical wrinkles between the eyebrows, a
frowning.

The muscle is under cover of the inner portion of the upper

the orbicularis oculi, and it conceals the supratrochlear nerve as
merges from the orbit.

Muscles of the Nose—Procerus (Pyramidalis Nasi)—*Origin.*—The
neurosis of the compressor naris over the lower part of the nasal
e.

Insertion.—The deep surface of the skin over the glabella of the
ntal bone. Some of the fibres become continuous with the medial
tion of the frontal belly of occipito-frontalis.

Nerve-supply.—Upper buccal branches of the facial nerve.

Action.—To draw downwards the skin between the eyebrows,
ng rise to transverse wrinkles.

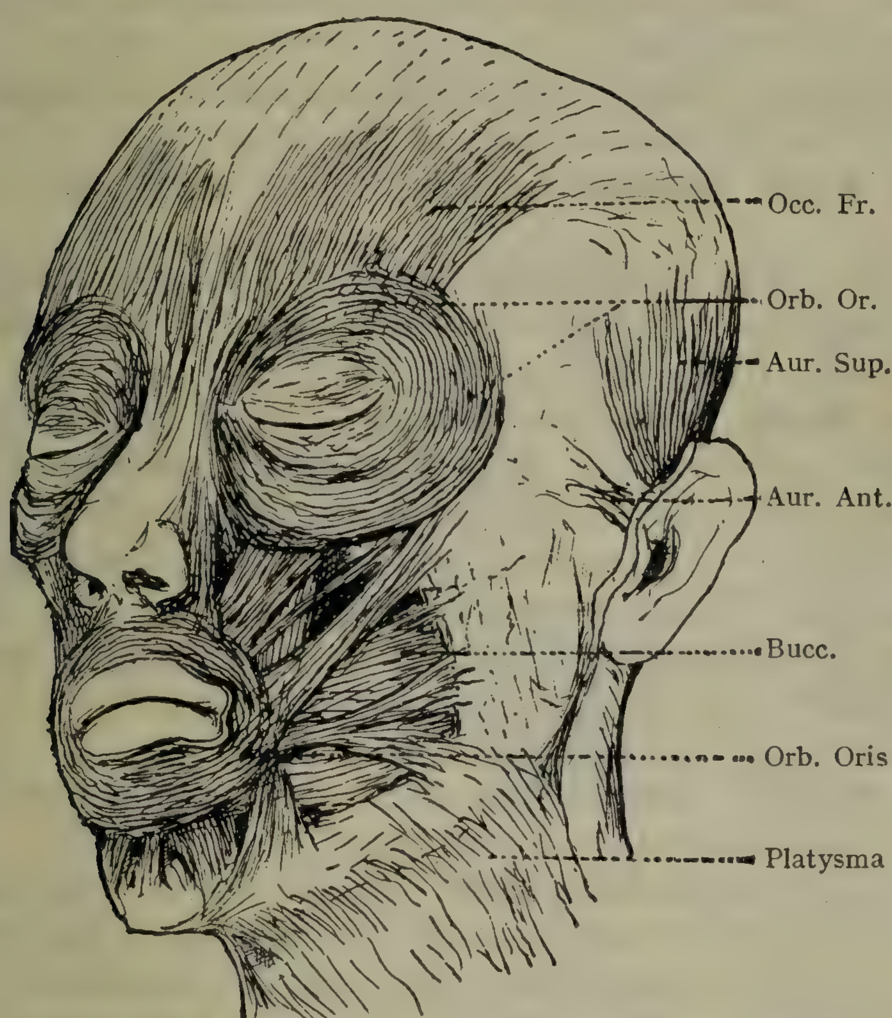


FIG. 766.—DISSECTION OF MUSCLES OF FACE.

Compressor Naris—*Origin.*—The maxilla between the canine fossa
. the nasal notch.

Insertion.—By means of an expanded aponeurosis which blends
h its fellow of the opposite side over the cartilaginous portion of
nose, and gives origin superiorly to the procerus.

Nerve-supply.—Upper buccal branches of the facial nerve.

Action.—To depress the cartilaginous portion of the nose.

The muscle is triangular, and at its origin is under cover of the
ator labii superioris alæque nasi.

Levator Labii Superioris Alæque Nasi—*Origin.*—The outer surface
he frontal process of the maxilla by a pointed extremity.

Insertion.—By means of two slips. The **medial** or **nasal slip** is

inserted into the skin of the ala of the nose, and is often absent. T **lateral** or **labial slip** is inserted into the skin of the upper lip, some its fibres blending with the levator labii superioris, and others w the upper part of the orbicularis oris.

Nerve-supply.—Buccal branches of the facial nerve.

Action.—(1) To raise the upper lip, and (2) to raise and dilate nostril.

The muscle is triangular, and covers the origin of the compres naris.

Depressor Alæ Nasi or Depressor Septi—*Origin.*—The incisive fo of the maxilla.

Insertion.—The posterior part of the ala, and the adjacent part the septum of the nose.

Nerve-supply.—Upper buccal branches of the facial nerve.

Action.—To depress the ala of the nose.

Dilator Naris Anterior—*Origin.*—The cartilage of the aperture the nose.

Insertion.—The deep surface of the skin over the ala of the nose

Nerve-supply.—Upper buccal branches of the facial nerve.

Action.—To dilate the nostril.

Dilator Naris Posterior—*Origin.*—(1) The margin of the na notch of the maxilla; and (2) the accessory cartilages of the nose.

Insertion.—The skin over the back part of the ala of the nose.

Nerve-supply.—Upper buccal branches of the facial nerve.

Action.—To dilate the nostril.

Levator Labii Superioris—*Origin.*—The maxilla between the inf orbital foramen and the lower margin of the orbit.

Insertion.—The skin of the upper lip.

Nerve-supply.—Buccal branches of the facial nerve.

Action.—To raise the upper lip.

The muscle is quadrilateral. At its origin it is overlapped by t lower half of the orbicularis oculi, and it covers the infra-orbital ne and artery as they leave the infra-orbital foramen. At its inserti the fibres interlace with those of the upper half of the orbicularis ori

Levator Anguli Oris—*Origin.*—The upper part of the canine fo of the maxilla under cover of the levator labii superioris.

Insertion.—The angle of the mouth, where some of the fibres a inserted into the skin, whilst others decussate with those of the pressor anguli oris, and enter the lower lip, mingling with those of t lower half of the orbicularis oris.

Nerve-supply.—Buccal branches of the facial nerve.

The direction of the muscle is downwards and slightly outwards

Action.—To raise the angle of the mouth, and at the same time draw it slightly inwards.

The infra-orbital nerve and artery are superficial to the muscle.

Zygomaticus Minor—*Origin.*—The anterior and lower part of t zygomatic bone close to the maxilla.

Insertion.—The skin of the upper lip immediately lateral to t

ıtor labii superioris, with the outer border of which muscle some ts fibres blend.

Nerve-supply.—Buccal branches of the facial nerve.

The muscle is directed downwards and inwards, and is often ırded as part of the orbicularis oculi.

Action.—To raise feebly the upper lip, and at the same time to w it slightly outwards.

Zygomaticus Major—*Origin.*—The outer surface of the zygomatic e near the zygomatico-maxillary suture.

Insertion.—The skin at the angle of the mouth, where its fibres ıd with those of the orbicularis oris.

Nerve-supply.—Buccal branches of the facial nerve.

The muscle is directed downwards and inwards.

Action.—To draw the angle of the mouth upwards and outwards.

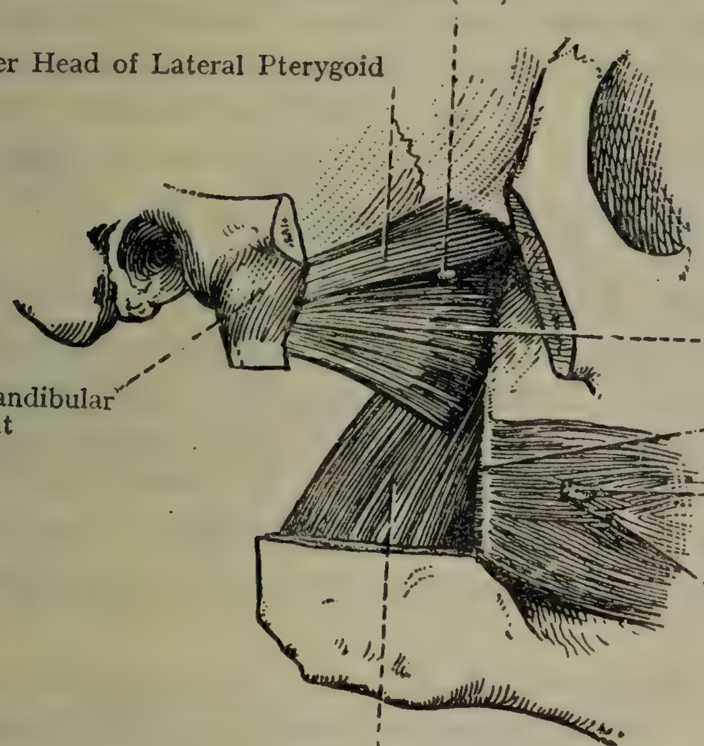


FIG. 767.—THE PTERYGOID AND BUCCINATOR MUSCLES.

Risorius—*Origin.*—The deep fascia which covers the masseter scle and parotid gland.

Insertion.—The skin at the angle of the mouth, where its fibres ıd with the orbicularis oris.

Nerve-supply.—Buccal branches of the facial nerve.

The direction of the muscle is inwards, some of its fasciculi also ending.

Action.—To draw the angle of the mouth outwards and slightly nwards. It is often the first muscle affected in tetanus, and gives to the ' risus sardonicus.'

The muscle consists of a few scattered fasciculi, which are em- ded in the adipose tissue over the buccinator; it is a detached tion of the platysma.

Buccinator—*Origin.*—(1) The outer surfaces of the alveolar pro-

cesses of the maxilla and mandible, opposite the three molar sock and (2) the anterior aspect of the pterygo-mandibular ligament.

Insertion.—The orbicularis oris at the angle of the mouth.

The central fibres decussate, those from above entering the lo lip, and those from below entering the upper lip. The highest lowest fibres take no part in this decussation, the highest pas directly into the upper lip, and the lowest into the lower lip Fig. 768).

Nerve-supply.—Lower buccal branches of the facial nerve.

Action.—To draw the angle of the mouth outwards, and p the lips and cheeks against the teeth, thus preventing the food f accumulating between the lips and the teeth during masticat and to contract the vestibular part of the mouth spasmodically, a whistling.

The muscle is expanded over the cheek, but towards the angl the mouth it becomes narrow and thick. It is pierced by the par duct opposite the second upper molar tooth, and the buccal ne also passes through it on its way to the mucous membrane of cheek. Externally the muscle is overlapped by the anterior bo of the masseter, from which it is separated by the suctorial of fat.

Suctorial Pad of Fat (Buccal Pad).—This is a well-defined collect of fat which is situated upon the buccinator muscle close to the ante border of the masseter. Well developed in healthy young adults may be absorbed or replaced very quickly, causing marked chang the facial expression.

Depressor Anguli Oris (Triangularis Menti)—*Origin.*—The obli line of the mandible from about the level of the canine socket to t of the first molar.

Insertion.—The angle of the mouth, where some of the fibres attached to the skin, whilst others decussate with those of the leva anguli oris and enter the upper lip, in which they mingle with upper part of the orbicularis oris.

Nerve-supply.—The mandibular branch of the facial nerve.

Action.—To depress the angle of the mouth.

Depressor Labii Inferioris (Quadratus Menti)—*Origin.*—The lo part of the outer surface of the body of the mandible close to symphysis, and extending outwards to below the mental foramen.

Insertion.—The skin of the lower lip.

Nerve-supply.—The mandibular branch of the facial nerve.

The muscle is directed upwards and inwards.

Action.—To draw the lower lip downwards and slightly outward

The muscle is overlapped laterally by a portion of the depres anguli oris, and medially it is in contact superiorly with its fellow the opposite side. The deep surface is related laterally to the men foramen and the mental nerve and vessels, and medially to part the mentalis. In the lower lip its fibres pass amongst those of t lower part of the orbicularis oris.

Mentalis (**Levator Menti**)—*Origin.*—The incisive fossa of the andible.

Insertion.—The skin of the chin.

Nerve-supply.—The mandibular branch of the facial nerve.

The muscle is directed downwards and forwards.

Action.—(1) To raise the integument of the chin, and (2) to elevate d protrude the lower lip.

Orbicularis Oris.—This is a complex muscle composed of three ata. The *superficial stratum* consists of fibres which are prolonged m the elevators and depressors of the angles of the mouth, and tend as far as the centre of the lip, but are not continuous with ose of the opposite half. They are *inserted* into the skin, and are rtially reinforced by fibres from the elevators of the upper lip, the gomatic muscles, the risorius, the posterior fibres of the platysma, d the depressor labii inferioris.

The *intermediate stratum* consists of fibres which are derived from e buccinator muscles. These fibres are disposed transversely, and

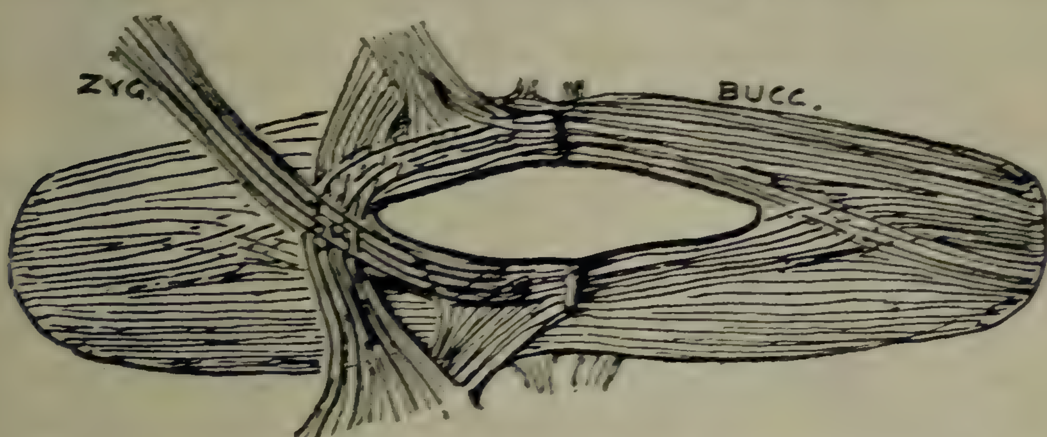


FIG. 768.—PLAN OF COMPOSITION OF ORBICULARIS ORIS.

ose of opposite sides are directly continuous. The fibres of this atum extend to the margins of the lips.

The foregoing fibres are destitute of bony and cartilaginous attach-ents.

The *deepest stratum* consists of fibres which arise from the incisive ssæ of the upper and lower jaws, as well as from each side of the terior nasal spine.

Nerve-supply.—The lower buccal and mandibular branches of the cial nerve.

Action.—(1) To close the oral aperture; and (2) to press the lips ainst the alveolar margins.

The muscle is separated from the buccal mucous membrane by the bial arteries and the labial mucous glands.

The **labial mucous glands,** which are racemose, or acino-tubular, e numerous, and each is about the size of a small pea. They are uated on the deep surface of the mucous membrane of the lips, ere they lie in the loose areolar tissue between the mucous mem-ane and the orbicularis oris. Their ducts open into the vestibule the mouth.

The **buccal mucous glands,** also racemose, or acino-tubular, situated between the mucous membrane of the cheek and the d surface of the buccinator.

The **molar mucous glands,** also racemose, or acino-tubular, superficial to the buccinator in the vicinity of the terminal part the parotid duct. They are four or five in number, and their du having pierced the buccinator, open into the vestibule of the mo opposite the molar teeth.

Nerves of the Face.

The nerves of the face are thirteen in number on either si Twelve of these are sensory nerves, and one is motor—namely, facial nerve.

The **facial** or **seventh cranial nerve** will only be described h after its emergence from the facial canal in the petrous part of temporal bone. It comes out of that canal through the stylo-mast foramen, after which it passes downwards and then forwards into parotid gland. Near the posterior border of the ramus of the mandi it breaks up into two terminal parts, called the temporo-facial a cervico-facial divisions.

Branches.—The posterior auricular, digastric, stylo-hyoid, a the terminal divisions.

The **posterior auricular nerve** arises from the facial close to stylo-mastoid foramen. It ascends between the auricle and mastoid process, where it lies deeply, and divides into two branch auricular and occipital. The *auricular branch* passes upwards beh the auricle and deep to the auricularis posterior, to be distributed that muscle, and it may be to the auricularis superior, as well as the small intrinsic muscles on the inner aspect of the auricle. T *occipital branch* passes backwards to supply the occipital belly of occipito-frontalis muscle. The posterior auricular nerve communica with the great auricular, the lesser occipital, and the auricular bran of the vagus.

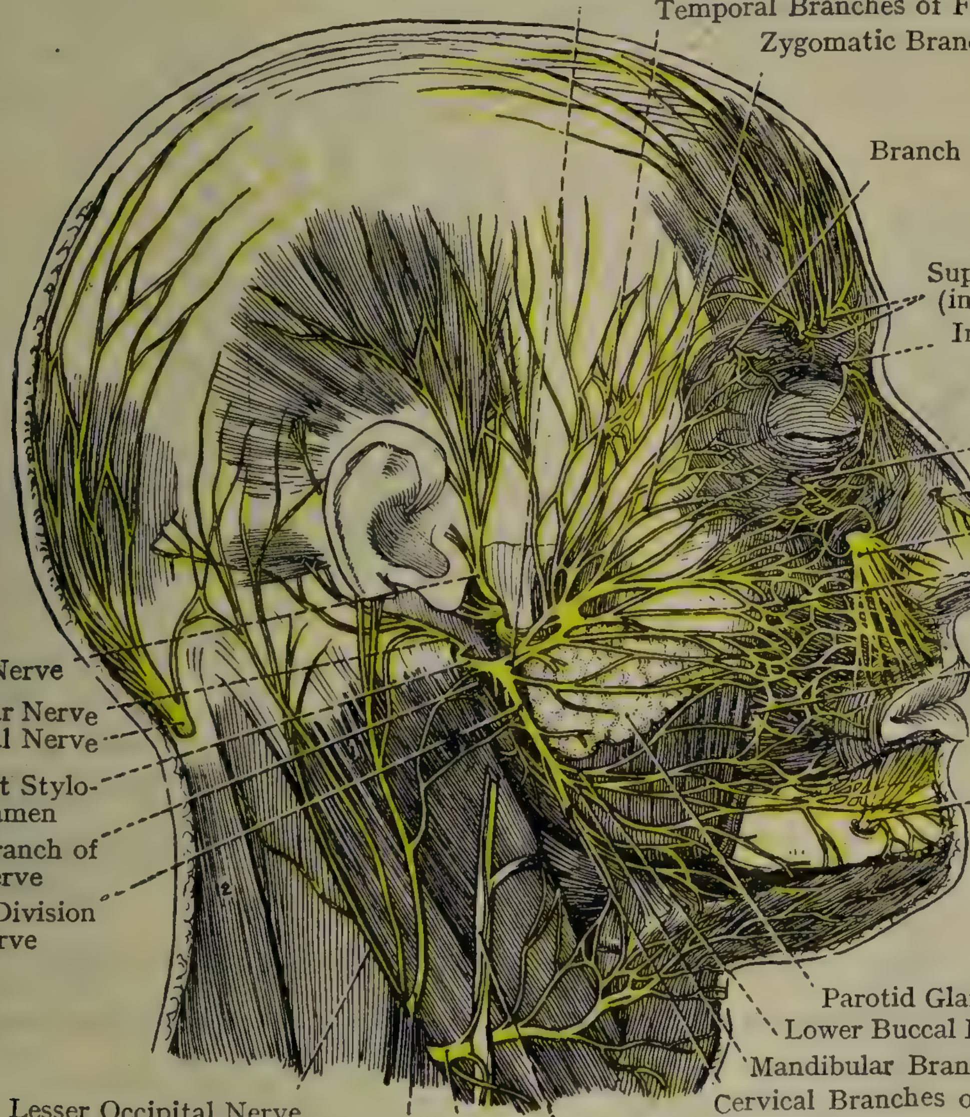
The **digastric branch** is directed downwards to the posterior be of the digastric muscle. One of the digastric branches communica with the glosso-pharyngeal nerve.

The **stylo-hyoid branch** usually arises in common with the p ceding. It is of some length, and, passing forwards, it enters the sty hyoid muscle about its centre.

The **terminal branches** continue to pass forwards in the paro gland, crossing superficially the posterior facial vein and the exter carotid artery, the direction of these vessels being vertical. In t part of their course these branches receive the following communi tions: two branches from the auriculo-temporal nerve, and branc from the great auricular nerve. Each terminal branch breaks within the gland into smaller branches, and as these pass in vario directions over the face and upper portion of the neck they ram

ely. The latter branches frequently communicate with each other a plexiform manner, both in the parotid gland and on the face, the exus thus formed being known as the *parotid plexus* (*pes anserinus*). ie ramifications also communicate with the branches of the three visions of the trigeminal nerve which appear on the face, these being nsory nerves.

The terminal branches of the facial nerve are: The *temporal branches* cend over the zygomatic arch to the temporal region, and are dis-



IG. 769.—SUPERFICIAL DISSECTION OF THE RIGHT SIDE OF THE HEAD AND UPPER PART OF THE NECK (HIRSCHFELD AND LEVEILLÉ).

1, sterno-mastoid; 2, trapezius.

ibuted to the auriculares anterior et superior, the intrinsic muscles the outer surface of the auricle, the frontal belly of the occipito-ontalis, the upper part of the orbicularis oculi, and the corrugator percilii. These branches communicate with the supra-orbital and crimal branches of the ophthalmic, the zygomatico-temporal nerve om the maxillary, and the auriculo-temporal of the mandibular, l of these being sensory nerves.

The *zygomatic branches* pass forwards over the zygomatic bone wards the outer angle of the orbit, and supply the outer part of the

orbicularis oculi. They form communications with the lacrimal bran of the ophthalmic and with the zygomatico-facial nerve.

The *upper buccal branches* pass forwards to the region betwe the lower margin of the orbit and the upper lip. They supply t lower part of the orbicularis oculi, the muscles of the nose, the elevat of the upper lip, and the upper part of the orbicularis oris. Th communicate with the following sensory nerves: the infra-orbital the maxillary, the infratrochlear of the naso-ciliary, and the exter nasal branch of the naso-ciliary from the ophthalmic. The commu

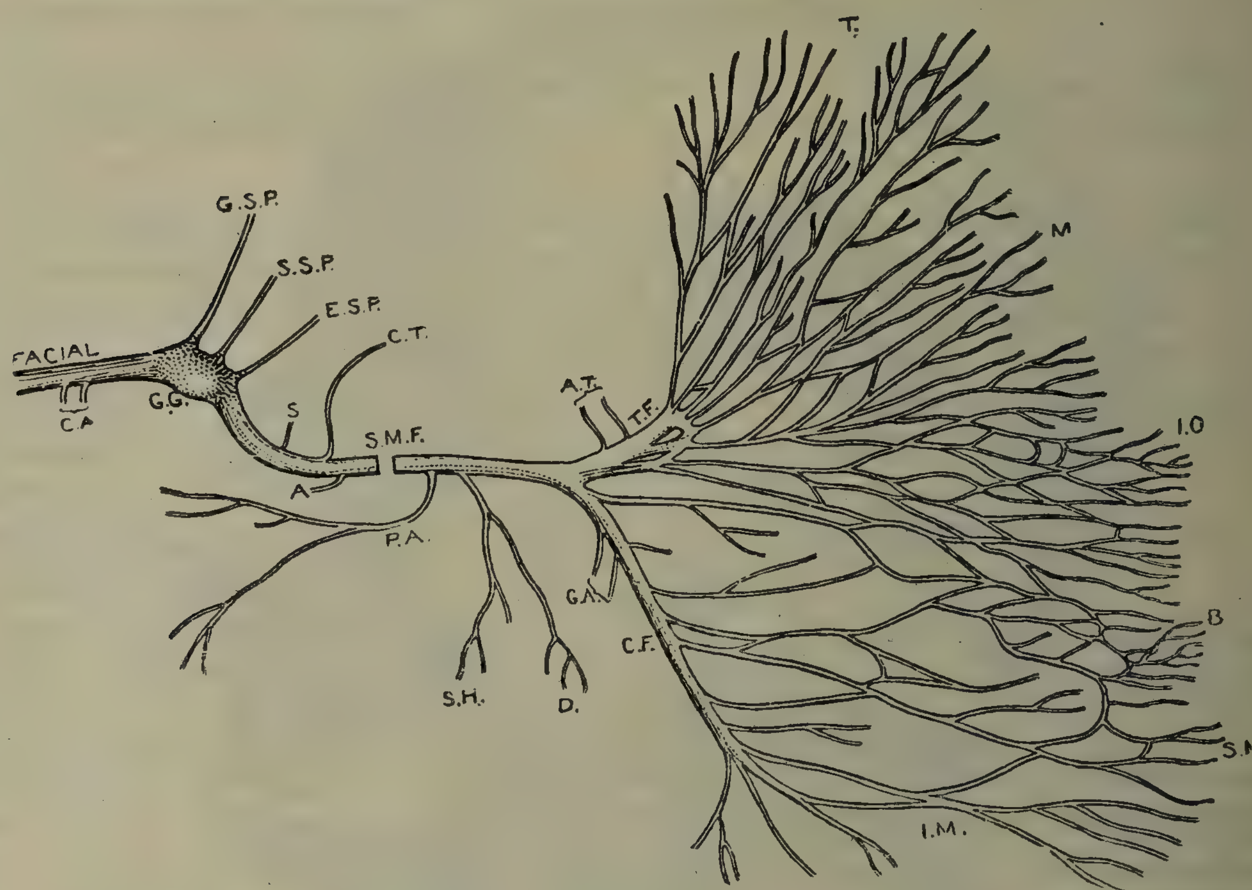


FIG. 770.—SCHEME OF THE FACIAL NERVE (FLOWER).

C.A. Communicating Twigs with Auditory
G.G. Facial Ganglion
G.S.P. Greater Superficial Petrosal
S.S.P. Branch to Lesser Superficial Petrosal
E.S.P. External Petrosal
S. Branch to Stapedius Muscle
C.T. Chorda Tympani
A Auricular Branch
S.M.F. Stylo-mastoid Foramen
P.A. Posterior Auricular
S.H. Branch to Stylo-hyoid Muscle
D. Branch to Posterior Belly of Digastric
A.T. Communicating Branches from Auriculo-temporal
T.F. Upper Terminal Division
T. Temporal Branches
M. Zygomatic Branches
I.O. Upper Buccal Branches
G.A. Communicating Branches from Great Auricular
C.F. Lower Terminal Division
B. Lower Buccal Branches
S.M. Mandibular Branches
I.M. Cervical Branches

cations with the infra-orbital nerve take place under cover of t levator labii superioris muscle, and form a somewhat intricate plex called the *infra-orbital plexus.*

The *lower buccal branches* pass forwards over part of the masse and the buccinator muscles to the angle of the mouth. They supply t buccinator and the outer part of the orbicularis oris, and are connect with the infra-orbital branches of the temporo-facial division, and wi the *buccal nerve,* which is a branch of the mandibular division of t trigeminal nerve. The latter communications take the form of a plex

ituated on the superficial surface of the buccinator muscle, called the uccal *plexus.*

The *mandibular branches* pass forwards over the mandible to the egion below the lower lip. They supply the lower part of the orbicuaris oris, depressor anguli oris, depressor, labii inferioris and mental uscles. They communicate with the mental branch of the inferior ental from the mandibular nerve under cover of the depressor anguli ris.

The *cervical branch* descends beneath the upper part of the platysma nd the deep cervical fascia to the suprahyoid region. Having pierced he deep fascia, it divides into branches which curve forwards and upply the platysma on its deep surface. It communicates freely

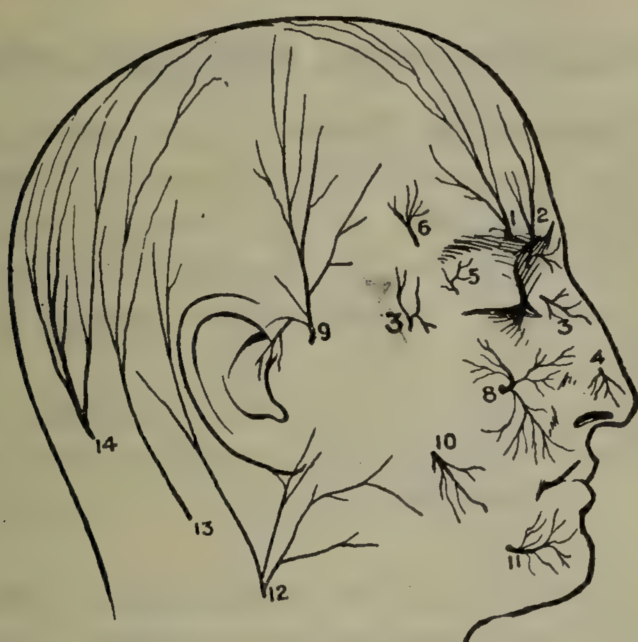


FIG. 771.—DIAGRAM OF THE SENSORY NERVES OF THE RIGHT SIDE OF THE HEAD.

1. Supra-orbital
2. Supratrochlear
3. Infratrochlear
4. External Nasal
5. Lacrimal
6. Zygomatico-temporal
7. Zygomatico-facial
8. Infra-orbital
9. Auriculo-temporal
10. Buccal
11. Mental
12. Great Auricular
13. Lesser Occipital
14. Greater Occipital

ith the upper branch of the anterior cutaneous nerve of the neck from he cervical plexus.

Summary of the Facial Nerve.—The facial nerve, after leaving the facial anal through the stylo-mastoid foramen, supplies the following muscles: (1) the xtrinsic and intrinsic muscle of the auricle; (2) the posterior belly of the digastric nd the stylo-hyoid; (3) the occipito-frontalis; (4) the superficial muscles of the ice, including the buccinator, but not the masseter, nor the levator palpebræ uperioris; and (5) the platysma. All these muscles, except the posterior belly f the digastric and the stylo-hyoid, are spoken of as muscles of expression. The erve establishes free communications with all three divisions of the trigeminal erve, which are sensory. It also communicates with the lesser occipital, great uricular, and anterior cutaneous nerve of neck, which are branches of the ervical plexus.

Sensory Nerves of the Face.—These, with one exception, are deived from the trigeminal nerve, the exception being the great auricular, vhich is a branch of the cervical plexus.

A. Branches of the Trigeminal Nerve.

Distal Sources.	Proximate Sources.	Terminations.
1. Ophthalmic nerve.	(*a*) Frontal	Supra-orbital. Supratrochlear.
	(*b*) Lacrimal.	Lacrimal.
	(*c*) Naso-ciliary.	Infratrochlear. External nasal.
2. Maxillary nerve.	(*a*) Maxillary.	Infra-orbital.
	(*b*) Zygomatic.	Zygomatico-temporal. Zygomatico-facial.
3. Mandibular nerve.	(*a*) Anterior division.	Buccal.
	(*b*) Posterior division.	Auriculo-temporal.
	(*c*) Inferior dental of posterior division.	Mental.

B. Facial Branches of the Great Auricular Nerve.

Branches of the Trigeminal Nerve.—The **supra-orbital** and **supr trochlear nerves** have been already described (see p. 1153). Tl former is distributed to the skin of the frontal region and the upp part of the scalp; and the latter to the skin of the lower and centr portion of the frontal region. Both these nerves furnish twigs to tl skin of the upper eyelid.

The **lacrimal nerve** pierces the orbital septum, and is distribute to the skin and conjunctiva of the outer part of the upper eyelid, as we as to the skin in the immediate vicinity of the zygomatic process the frontal bone.

The **infratrochlear branch of the naso-ciliary nerve** leaves the orb below the pulley of the obliquus superior muscle, and furnishes twig to the skin and conjunctiva of the inner parts of the eyelids, the sic of the root of the nose, the lacrimal sac, and the caruncula lacrimalis.

The **external nasal branch of the naso-ciliary nerve** emerges betwee the lower border of the nasal bone and the upper nasal cartilage, an descends beneath the compressor naris muscle to the apex of the nos Its twigs supply the skin of the tip and lower part of the side of th nose.

The **infra-orbital nerve** is the terminal part of the maxillary divisio of the trigeminal. It leaves the infra-orbital canal through the infra orbital foramen, where it is under cover of the levator labii superiori In this situation it communicates with the upper buccal branches the facial, forming the *infra-orbital plexus*, and it divides into three se of branches—namely, palpebral, nasal, and labial. The *palpebra branches* ascend to supply the skin and conjunctiva of the lower eyelic The *nasal branches* pass inwards, and are distributed to the skin of th side of the nose. The *labial branches*, long and large, descend to suppl the skin and mucous membrane of one half of the upper lip. As the descend they furnish twigs to the skin between the infra-orbital forame and the upper lip.

The **zygomatico-temporal nerve** (**temporo-malar nerve**) is of sma size. Having traversed the zygomatico-temporal canal in the zygomat

one, it pierces the temporal fascia about 1 inch above the front part f the zygoma, and behind the marginal process on the postero-superior r temporal border of the zygomatic bone, and is distributed to a mited portion of the skin over the anterior part of the temporal egion.

The zygomatico-facial nerve (temporo-malar nerve) is of small size, nd emerges from the zygomatico-facial canal in the zygomatic bone hrough the zygomatico-facial foramen. It is distributed to the skin ver the malar bone.

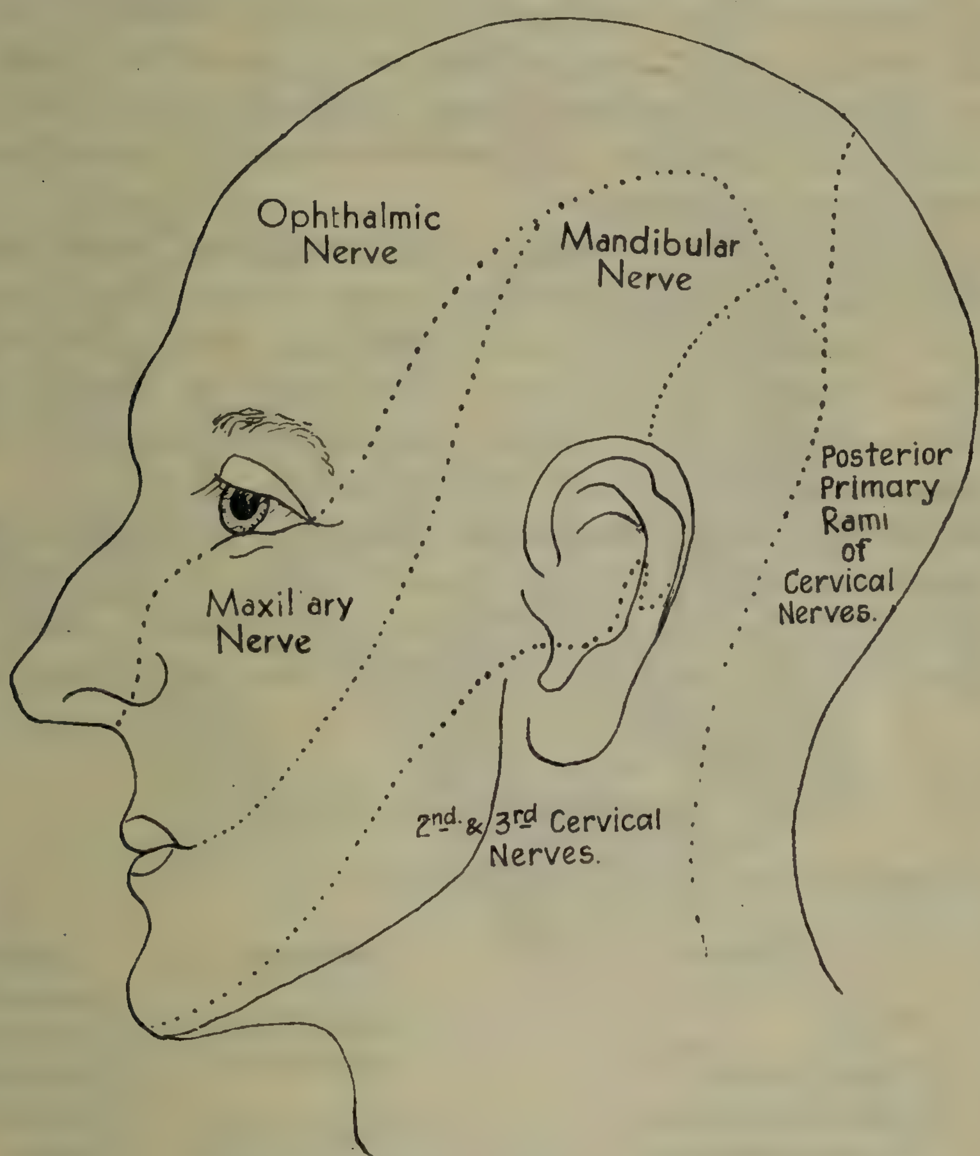


FIG. 772.—THE SENSORY NERVE AREAS OF THE HEAD.

The **buccal nerve** is a branch of the anterior division of the mandib-lar nerve. Coming from under cover of the middle of the anterior order of the masseter on to the superficial surface of the buccinator, divides into branches which communicate freely with the buccal ranches of the facial nerve, forming the *buccal plexus*. Its final istribution is to the skin and mucous membrane of the cheek, the ranches to the latter piercing the buccinator.

The **auriculo-temporal nerve,** which is a branch of the posterior ivision of the mandibular nerve, has been already described as egards its cutaneous distribution (see p. 1157).

The **mental nerve** is one of the terminal branches of the inferior ental, which in turn is a branch of the posterior division of the

mandibular nerve. Leaving the mental foramen under cover of t depressor anguli oris, and in line with the interval between the t lower premolar sockets, its branches supply the skin and muco membrane of one half of the lower lip, and the skin covering the bo of the mandible.

The supra-orbital, infra-orbital, and mental nerves being frequent the seat of neuralgia, their positions for purposes of operative tre ment can readily be ascertained in the following manner: A line dra upwards from the position of the mental foramen, which is in line wi the interval between the two lower premolar sockets, to the supr orbital notch, which is situated at the junction of the outer two-thir and the inner third of the supra-orbital arch, will cross the infra-orbi foramen. This line, therefore, is over the points of emergence of the three important sensory nerves.

From a clinical point of view it is sometimes more important recognize the areas supplied by the three divisions of the trigemi nerve than to identify the distribution of each particular branc These areas are shown in Fig. 772. It must be clearly understoo however, that here, as in all other parts of the surface of the bod one nerve area overlaps another very greatly.

Branches of the Great Auricular Nerve.—The facial branches the great auricular nerve, which is a branch of the cervical plex are distributed to the skin over the parotid gland. They send tw into the gland which communicate with the branches of the fac nerve.

Arteries of the Face.

The arteries of the face are as follows:

Sources.	Arteries.	Sources.	Arteries.
External carotid.	Facial.	Superficial temporal.	Transverse facial. Anterior temporal Zygomatic.
Ophthalmic, from internal carotid.	Dorsal nasal. Supra-trochlear. Supra-orbital. Medial palpebral (superior and inferior).	Maxillary.	Infra-orbital. Buccal.
Lacrimal, from ophthalmic.	Lateral palpebral (superior and inferior). Zygomatic.	Inferior dental, from maxillary.	Mental.

The chief of these arteries are the facial and the transverse faci

Facial Artery.—The facial artery (*external maxiliary*) is the highe of the three anterior branches of the external carotid. It is situat at first in the upper portion of the anterior triangle of the neck, whe it has been previously described (see p. 1217). It leaves the neck a enters upon its facial course by mounting over the body of t mandible in front of the anterior border of the masseter, where it very superficial, being covered only by the platysma and the integ ment. From this point it has a very tortuous course to the angle

e mouth, the angle of the nose, and the inner angle of the eye, though may end at either of the two former points. The facial part of the ssel is never very deeply placed.

Relations—*Superficial.*—The skin and platysma, the risorius, the gomatic muscles, and branches of the facial nerve. It may be deep superficial to the levator labii superioris; where it crosses the body the mandible the anterior facial vein is often superficial to it. *Deep.* -The body of the mandible (where pulsation can readily be felt in the ssel), the buccinator, the levator anguli oris, and the infra-orbital rve.

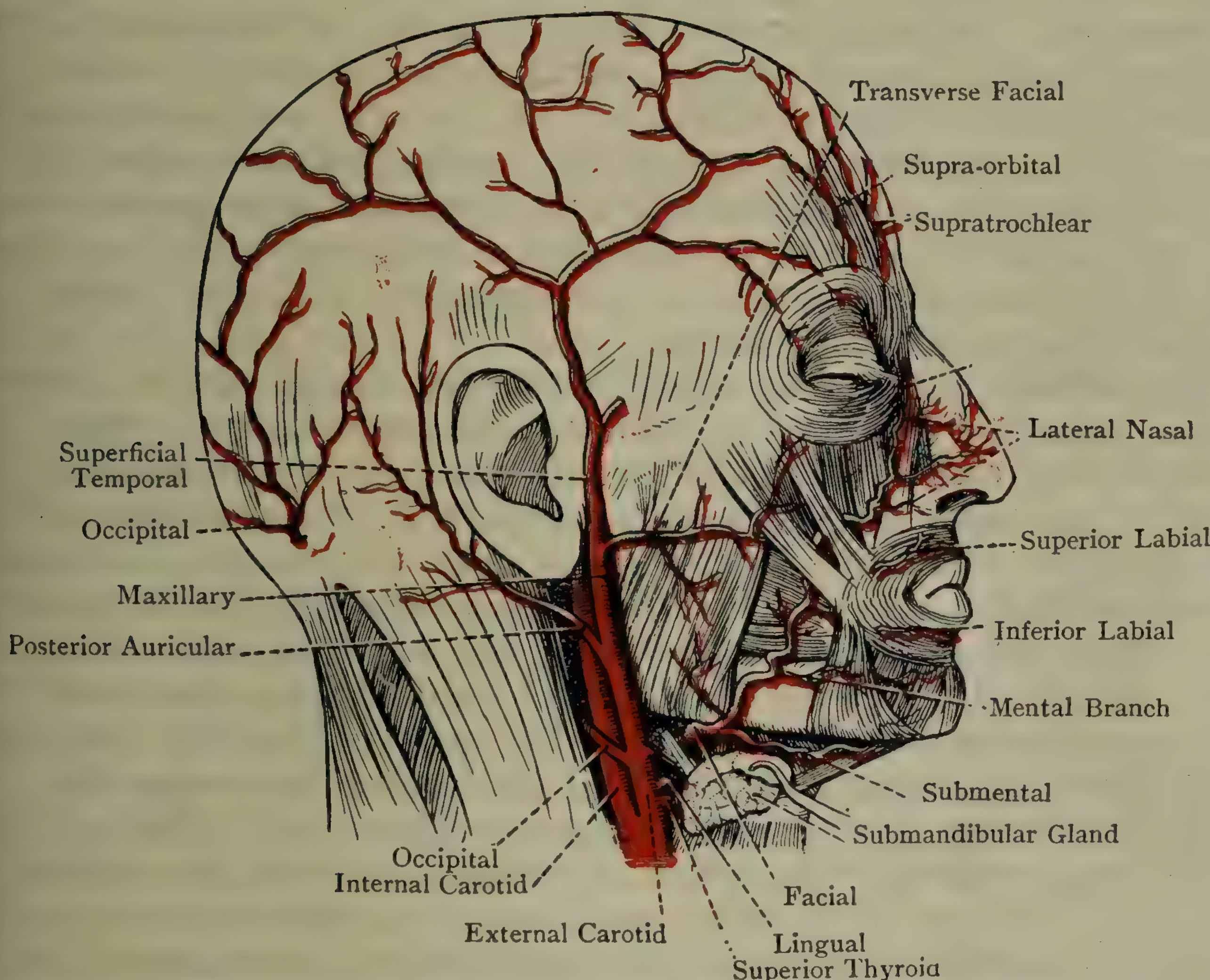


FIG. 773.—THE ARTERIES OF THE RIGHT SIDE OF THE HEAD (AFTER L. TESTUT'S 'ANATOMIE HUMAINE').

Facial Branches.—(1) *Muscular branches,* of small size, arise from e outer side of the vessel, and are distributed to the structures in the asseteric, buccal, and infra-orbital regions, where they anastomose ith the buccal, transverse facial, and infra-orbital arteries. (2) The *ental branch* (*inferior labial artery* of the O.T.) passes forwards over e body of the mandible, and deep to the depressor anguli oris, to pply the structures between the lower lip and the base of the mandible. anastomoses with the inferior labial, mental, and submental arteries.) The *inferior labial artery* (*inferior coronary artery*) arises just below e angle of the mouth, and passes inwards deep to the depressor guli oris. In the lower lip it lies near the margin, between the bicularis oris and the mucous membrane, and anastomoses with its llow of the opposite side, and with the previous branch. (4) The

superior labial artery (*superior coronary artery*), of larger size than t inferior, arises just above the angle of the mouth under cover of t zygomaticus major. Its position in the upper lip is similar to that the inferior labial in the lower lip, and it anastomoses with its fell of the opposite side. Near the middle line it furnishes the *sep branch,* which ramifies on the columna as far as the tip of the no The superior and inferior labial arteries of each side sometimes ar together. The vessels of each side, superior and inferior, form in ea lip a tortuous arterial arch, which is necessarily divided in operatic upon one or other lip. (5) The *lateral nasal branch* arises oppos the nose, and lies on the sulcus above the ala. It anastomoses w the dorsal nasal branch of the ophthalmic, the septal branch, t terminal branch of the anterior ethmoidal artery, and its fellow of t opposite side, the facial ~~artery~~ at the medial artery of the eye. lies either deep to, or embedded in, the levator labii superioris alæq nasi, and supplies the side of the root of the nose and the adjace part of the orbicularis oculi. It anastomoses with the dorsal na branch of the ophthalmic artery.

The **anterior facial vein** starts above the medial angle of the e by the union of the supratrochlear and supra-orbital veins. T course of the vessel is a straight one, downwards and outwards, late to the artery, and at a little distance from it, except over the low border of the mandible, where it lies close to its outer side and contact with the anterior border of the masseter. In its course crosses the end of the parotid duct. The cervical part of the ve which ends in the internal jugular, has been already described. T muscular relations of the vein are the same as those of the arte except that it is always superficial to the levator labii superioris.

Its **tributaries** are: (1) the supratrochlear vein (frontal vei (2) the supra-orbital vein, which communicates with the ophthalm vein; (3) the lateral nasal veins, and laterally a few superior palpeb veins, whilst posteriorly it communicates with the superior ophthalm vein, and may communicate with its fellow of the opposite side by mea of the *transverse nasal vein,* which lies over the bridge of the nos (4) a few inferior palpebral veins, which are in communication wi the infra-orbital vein; (5) the superior labial vein, which issues from plexus in the upper lip (the blood from the similar plexus in the low lip passing to the submental region, where it takes part in the formati of the anterior jugular vein); (6) the deep facial vein, of variable si which, coming from the pterygoid plexus, appears deep to the anter border of the ramus of the mandible and of the masseter muscle; a (7) parotid, masseteric, and buccal branches.

Facial Lymph Glands.—These glands lie on the face along t course of the anterior facial vein. Some are situated upon the mandil deep to the platysma, one of them being placed upon the base of t mandible close to the facial vessels; others (*buccal*) rest upon t fascia covering the buccinator muscle; and the remaining glan of this group are met with between the angle of the mouth and t

edial angle of the eye. They receive their *afferent* vessels from ie neighbouring structures, and their *efferent* vessels pass to the ibmandibular lymph glands.

Transverse Facial Artery.—This vessel arises from the superficial mporal in the parotid gland, and passes horizontally forwards. fter leaving the anterior border of the gland it crosses the masseter, iving the zygoma above it and the parotid duct below it, the upper iccal branches of the facial nerve being in turn below the parotid ict. The order of structures from above downwards is, accordingly, tery, duct, and nerves. The artery is distributed to the parotid and, the masseter muscle, and the structures on the side of the ce, and it anastomoses with the infra-orbital, zygomatic, facial, id buccal arteries.

The **transverse facial vein** joins the superficial temporal vein.

The **dorsal nasal artery** is one of the terminal branches of the hthalmic, and leaves the orbit at the medial angle of the eye above e medial palpebral ligament. It is distributed to the lacrimal sac id the side of the root of the nose, and anastomoses with the terminal anches of the facial artery. Sometimes it gives off a transverse isal branch, which crosses the root of the nose and anastomoses th its fellow of the opposite side.

The **supra-orbital** and **supratrochlear arteries** have been already scribed (see p. 1153).

The **medial palpebral arteries,** *superior* and *inferior,* arise from e ophthalmic and leave the orbit at the medial angle, one passing ove and the other below the medial palpebral ligament. Their urse is outwards between the palpebral fibres of the orbicularis uli and the tarsi of the eyelids, and they anastomose and form arches th the lateral palpebral branches of the lacrimal artery. They e distributed to the palpebral structures, the lacrimal sac, and e caruncula lacrimalis.

The **corresponding veins** from the upper and lower eyelids open to the commencement of the anterior facial vein.

The **terminal branch of the anterior ethmoidal artery** emerges, ng with the terminal branch of the naso-ciliary nerve, between e lower border of the nasal bone and the upper nasal cartilage. is distributed to the skin of the apex and the lower part of the le of the nose.

The **lateral palpebral arteries,** *superior* and *inferior,* are branches the lacrimal artery within the orbit. Their course is inwards tween the palpebral fibres of the orbicularis oculi and the tarsi the eyelids, and they anastomose and form arches with the palpebral inches of the ophthalmic.

The **lateral palpebral veins** end in the zygomatic vein, which opens o the middle temporal, and this in turn joins the superficial temporal in.

The **zygomatic branches** of the lacrimal artery accompany the gomatico-facial and zygomatico-temporal nerves.

The **zygomatic artery** and **anterior branch** of the superficial tempo
artery have been already described (see p. 1158).

The **infra-orbital artery** arises from the third part of the maxill
in the pterygo-palatine fossa. Having passed horizontally forwar
with the infra-orbital nerve, through the infra-orbital canal, it r
with that nerve through the infra-orbital foramen, lying under co
of the levator labii superioris muscle. It then gives branches upwa
to the lower eyelids, inwards to the side of the nose, and downwa
towards the upper lip. It anastomoses with the palpebral, fac
transverse facial, and buccal arteries.

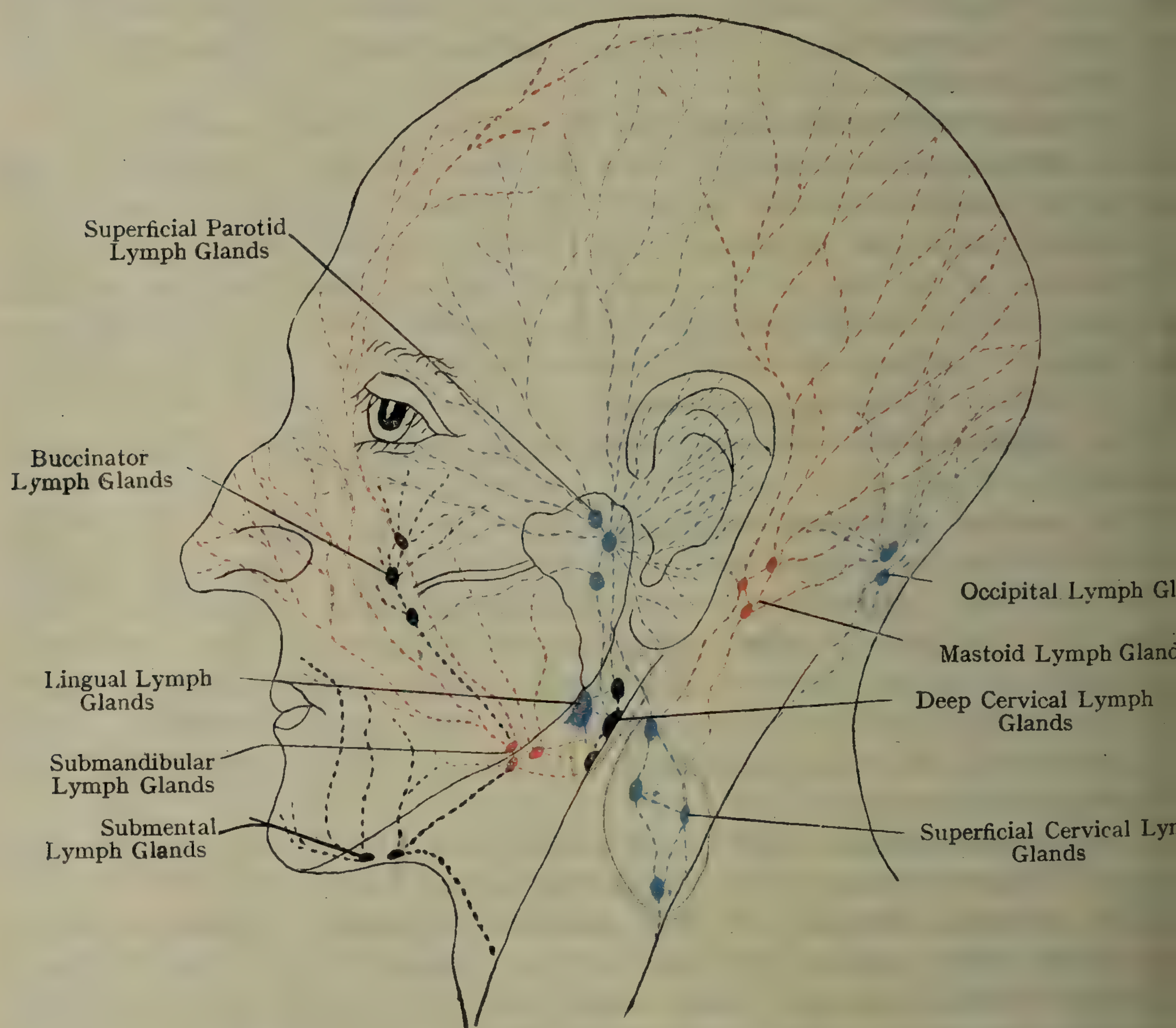


FIG. 774.—SCHEME OF THE SUPERFICIAL LYMPHATICS OF THE HEAD.

Sometimes, when the facial artery ends at the angle of the mou
the infra-orbital is very large, and supplies all the upper part of
face, including the nose. This arrangement, common enough
pronograde mammals, shows that the infra-orbital, and not
superficial temporal, is morphologically the terminal twig in
external carotid arterial tree.

The **infra-orbital vein,** having traversed the infra-orbital ca
opens into the pterygoid plexus.

The **buccal artery** is a branch of the second part of the maxilla
It accompanies the buccal nerve to the superficial surface of

ccinator muscle, and is distributed to that muscle and to the mucous ·mbrane of the cheek. It anastomoses with branches of the facial :ery.

The **mental branch** of the inferior dental from the first part of the ıxillary is found with the mental nerve at the mental foramen, lying der cover of the depressor anguli oris muscle. It supplies the uctures here, and anastomoses with the inferior labial and sub- ·ntal arteries.

The **mental vein** joins the inferior dental vein, which opens into e pterygoid plexus.

Lymphatics.—The lymphatics of the face are arranged in two :s, superficial and deep. The *superficial lymphatics* for the most rt take a course similar to that of the anterior facial vein, and end the submandibular lymph glands. They receive the lymphatics (1) the inner part of the frontal region at the medial angle of the eye; the inner parts of the eyelids; (3) the side of the nose; (4) the part the face between the lower eyelid and upper lip; and (5) sometimes e upper lip. The lymphatics from the temporal and outer part of e frontal regions, from the front of the auricle, from the greater rt of the eyelids, and from the outer part of the cheek end in the perficial parotid lymphatic glands. The *deep lymphatics*, including ose of the orbit, anterior part of the nasal cavity, roof of the mouth, d temporal and infratemporal fossæ, run to the deep facial lymph ınds.

Parotid Lymph Glands (Pre-auricular Lymph Glands).—These ınds are arranged in *two groups*—superficial and deep.

The **superficial parotid lymph glands** lie upon the superficial surface the parotid salivary gland immediately beneath the parotid fascia, d in front of the tragus of the auricle. They receive their *afferent* ssels from the following sources.

1. The outer surface of the auricle.
2. The anterior wall of the external auditory meatus.
3. The eyebrow, and upper and lower eyelids.
4. The root of the nose.
5. The upper part of the cheek.

Their *efferent vessels* pass to (1) the upper superficial cervical lymph ınds, and (2) the superior deep cervical lymph glands.

The **deep parotid lymph glands** lie within the parotid salivary gland ɔng the terminal part of the external carotid artery. They receive eir *afferent* vessels from the following sources:

1. The tympanic cavity in part.
2. The frontal region of the scalp.
3. The anterior temporo-parietal region of the scalp.
4. The parotid salivary gland.
5. The deep facial lymph glands.

Their *efferent* vessels pass to the superior cervical lymph glands.

Buccinator Lymph Glands.—These glands are situated on buccinator muscle. They receive a few afferent lymphatics from zygomatic region and the lateral aspect of the face, but most of t drainage is from the inner side of the cheek, and their efferent lympha pass to the parotid and submandibular lymph glands.

Parotid Gland.—This gland is an inverted pyramid, having sides and a base, and fills the space which is left by the ramus of mandible anteriorly, the sterno-mastoid muscle posteriorly, the sty process medially, and the articular eminence and root of the zyg

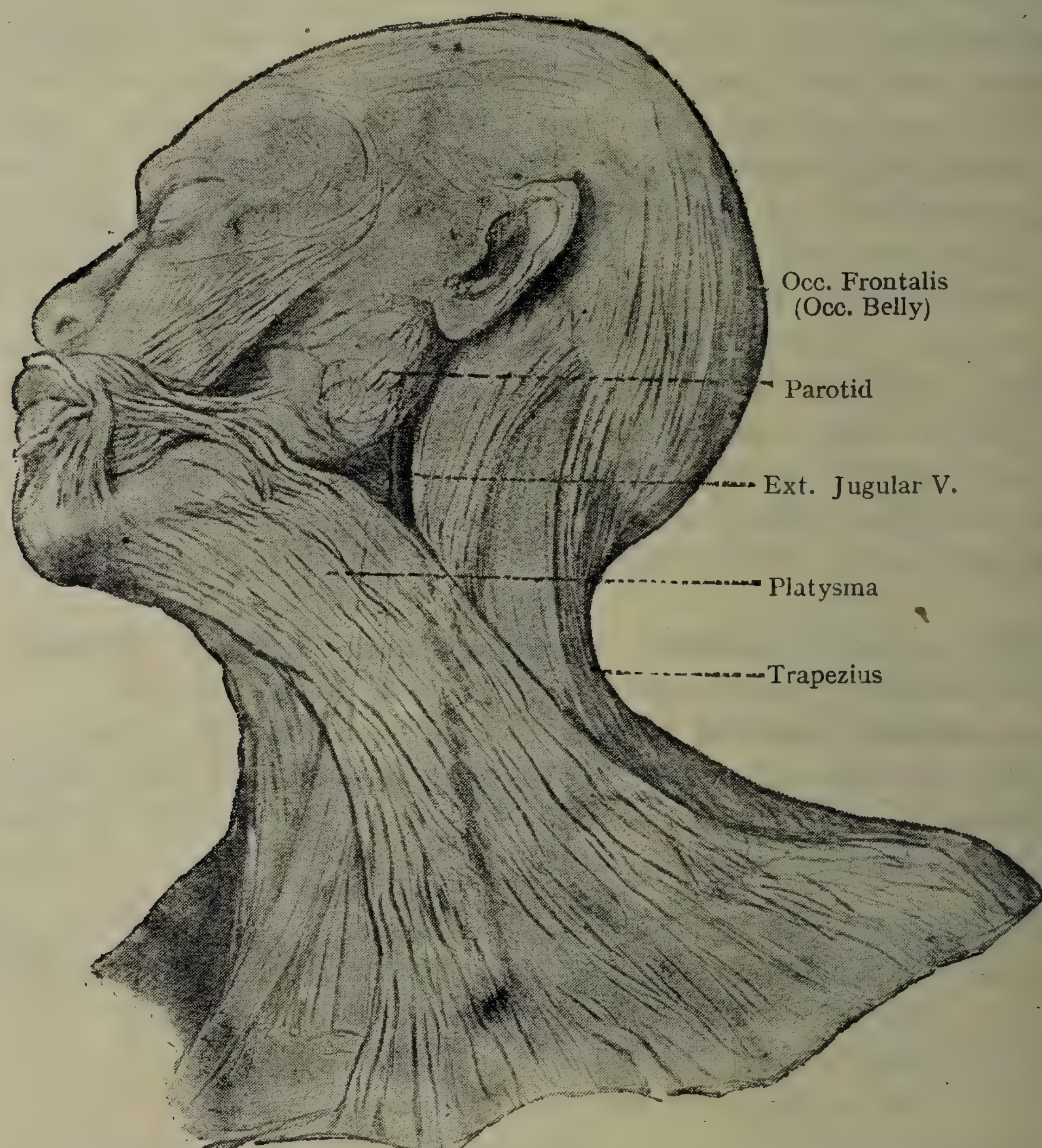


FIG. 775.—THE PAROTID GLAND IN POSITION.

superiorly. Where the anterior border of the sterno-mastoid touc the angle of the mandible the apex is situated. The anterior, poster and medial surfaces are grooved by the structures which bound gland.

The lateral surface is flat, flush with the side of the face, overlaps the ramus of the mandible and masseter muscle for a c siderable extent, forming the accessory part, from the anterior bor of which the parotid duct, the transverse facial artery, and the branches of the facial nerve leave the gland.

Embedded in the upper part of the lateral surface are the superficial otid lymph glands already described (p. 1283), while from the surface gs of the great auricular nerve come out to supply the skin covering gland.

The anterior surface is very deeply grooved by the posterior border the ramus of the mandible and of the masseter muscle, the outer of the groove projecting forwards as the accessory part already ken of, while the inner or deep lip pushes its way forwards into triangular space left between the lateral and medial pterygoid scles. It is at the anterior border of the latter part of the gland t the maxillary artery leaves and the maxillary vein enters the

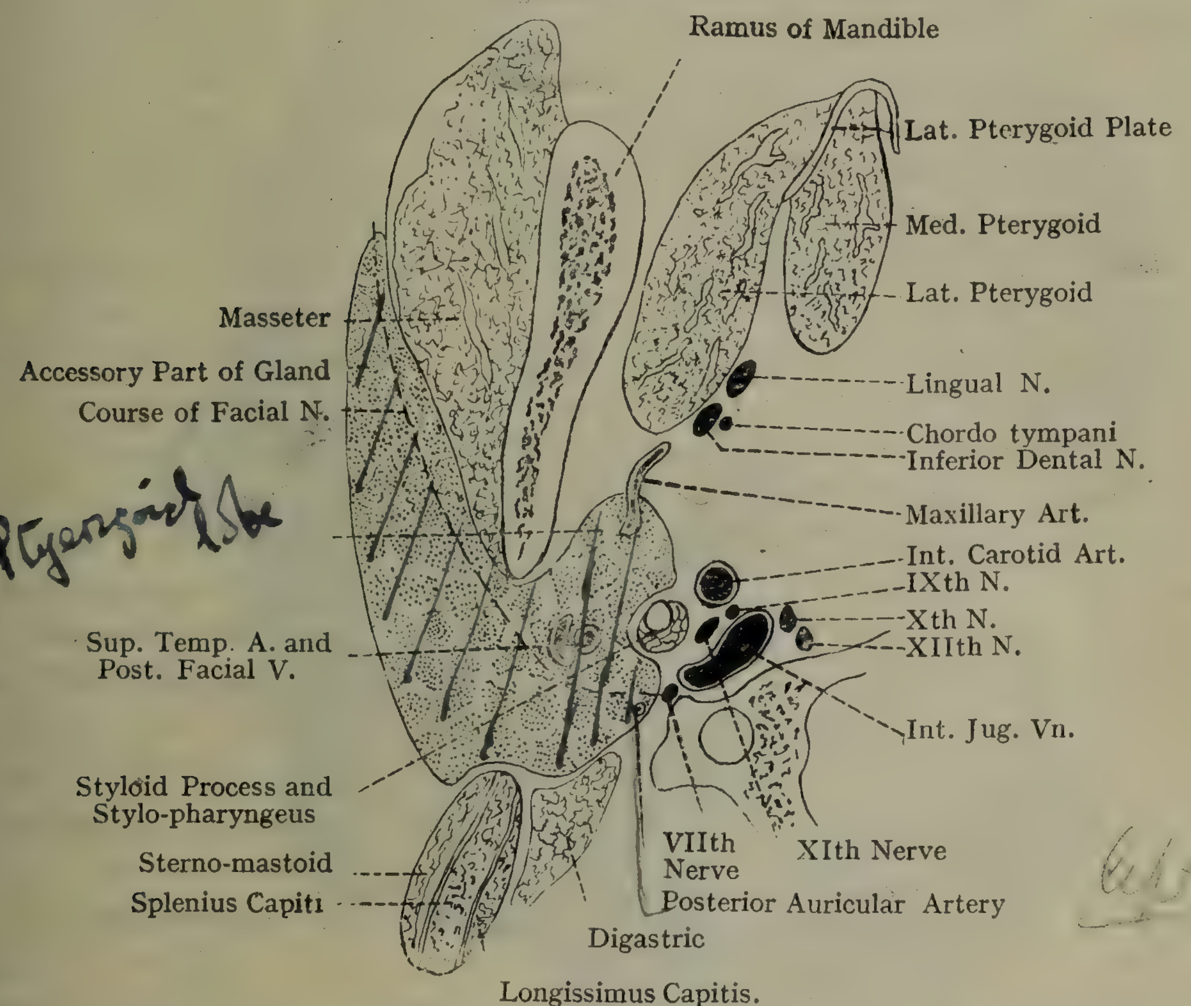


FIG. 776.—HORIZONTAL SECTION THROUGH PAROTID GLAND AND NEIGHBOURING STRUCTURES.

nd. The deep surface is grooved by the styloid process and the scles rising from it, though not very deeply, and the lips of the ove may be conveniently referred to as pre- and post-styloid ridges. pre-styloid ridge is in contact with the internal carotid artery, le the post-styloid is, perhaps, the most important and interes ting t of the whole gland, because it touches the internal jugular vein the accessory and glosso-pharyngeal nerves, which are so closely ociated with that vein, and also because, near its upper end, the facial ve, and near its lower end the external carotid artery enter the nd. In addition to these, the posterior auricular artery runs up ner just deep to or embedded in the post-styloid ridge until it lies t behind the point of entry of the facial nerve.

The projection of the post-styloid ridge is evidently due to the gland pushing its way in between the styloid process in front and the transverse process of the atlas behind, and that part of the deep surf of the gland which lies behind the post-styloid ridge is close to the transverse process and to the muscles rising from it; while, near the apex, the posterior facial vein leaves the gland on this aspect.

The posterior surface is usually grooved by the mastoid proc above and the sterno-mastoid muscle lower down, and entering t

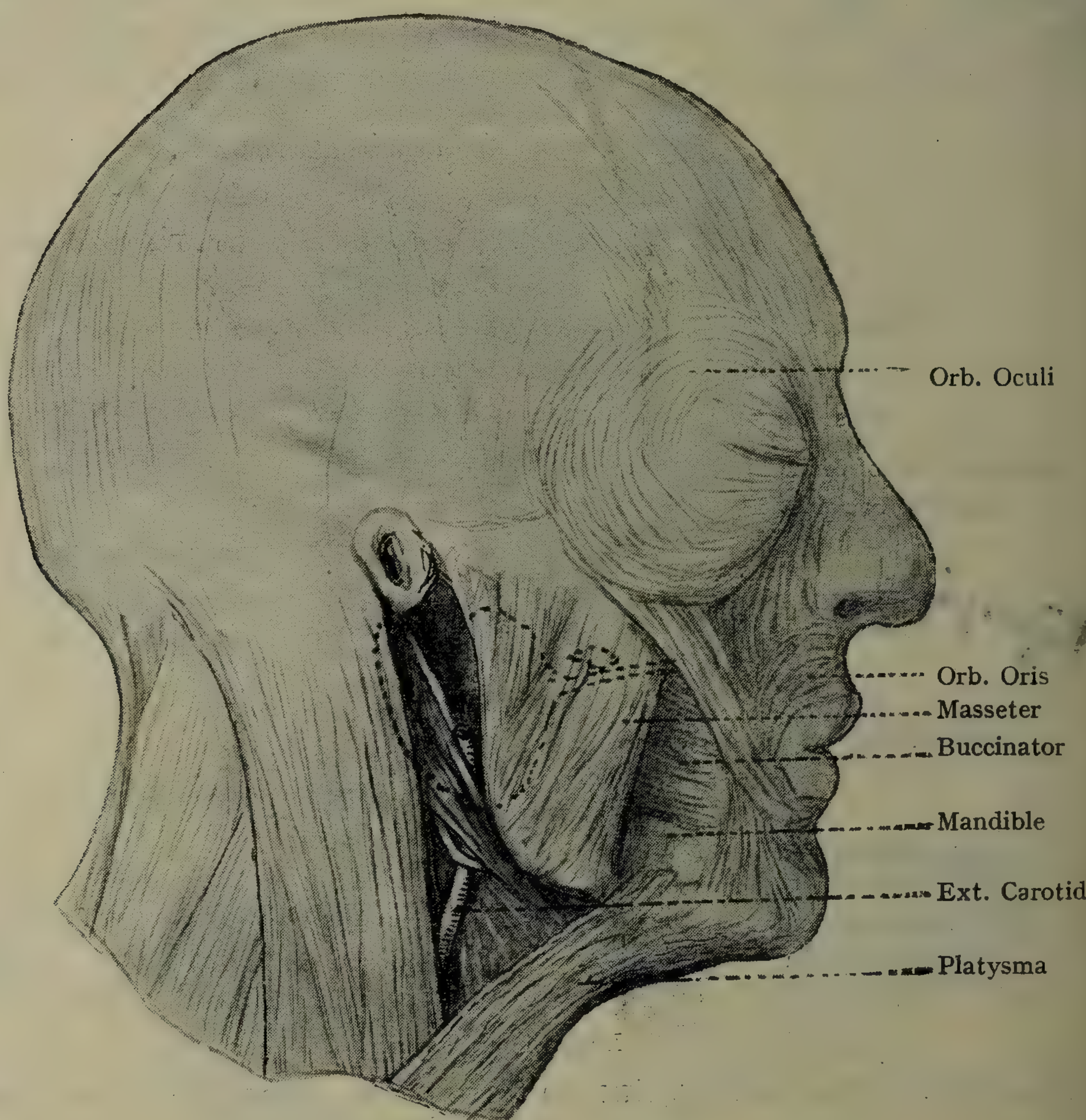


Fig. 777.—To show Deep Relations of Parotid (Interrupted Line)

lower part of the superficial lip of this groove is the great auricu nerve.

The base of the gland is very deeply notched anteriorly by the ne of the condyloid process, behind which the superficial temporal arte and vein are seen leaving and entering the gland, the vein being sup ficial; in front of them the temporal branch of the facial nerve ru from the gland across the root of the zygoma, while behind them the superficial temporal branch of the auriculo-temporal nerve. Th nerve is, as a rule, not really embedded in the gland, but rests for t most part on its base, between the parotid and the skull, as it ru

ıck from the region of the foramen spinosum, where it embraces the iddle meningeal artery. Having passed back on the deep aspect of e superficial temporal vessels, the nerve gives off its auricular, parotid, ıd articular branches, and then runs outwards and upwards just ehind the articulation and just in front of a thin, tongue-like process the gland which moulds itself into the non-articular part of the ticular fossa, behind the squamo-tympanic fissure, and in contact ith the tympanic plate.

Summing up the foregoing, it will be understood that the parotid and forms an accurate cast of the cavities which the surrounding ructures have left for it, pushing its processes and its pre- and post-yloid ridges into every available cranny. Doubtless, too, it is able adapt its shape to these cavities as they change with every movement of the jaw.

Several important structures traverse the gland: (1) The external arotid artery ascends deeply in it as high as the level of the neck f the mandible, where it divides into the superficial temporal and axillary arteries, which are at first embedded in the gland. Whilst the gland the superficial temporal artery gives off its transverse facial nd auricular branches. (2) The superficial temporal and maxillary eins unite in the gland, at the level of the neck of the mandible, to form he posterior facial vein, which descends from that level within the land, lying superficial to the external carotid artery, and close to the ower border of the gland it breaks up into an anterior and a posterior ivision. (3) The external jugular vein is formed near the lower part f the gland by the union of the posterior auricular vein with the osterior division of the posterior facial vein. (4) The facial nerve raverses the gland from behind forwards, and in doing so breaks p into its terminal divisions, the branches of which leave the gland nteriorly and superiorly. The nerve is superficial to the external arotid artery and posterior facial vein. (5) Entering the lower part f the gland are branches of the great auricular nerve, which communicate within the gland with the facial nerve. (6) The auriculo-emporal nerve is related to the upper part of the gland, where it ives branches to it which communicate with the facial nerve.

Parotid duct, or duct of Stensen, dense and tough, leaves the anterior order of the gland, and passes forwards on the masseter muscle, ying fully ½ inch below the zygomatic arch. In this part of its course t is accompanied for a short distance by the accessory part of the arotid gland which, with the transverse facial artery, lies above it, whilst the upper buccal branches of the facial nerve are placed below t. After leaving the surface of the masseter muscle the duct dips eeply through the fat covering the buccinator, and pierces that muscle. It then passes forwards for a very short distance between the muscle nd the buccal mucous membrane, which it finally pierces to end in minute opening on a small papilla situated opposite the crown of he *second* upper molar tooth. The duct is about the size of a crow-quill, its diameter being about ⅛ inch, except at its buccal orifice,

where it becomes narrow. It is about 2 inches in length, and it course may be indicated by a line drawn from the intertragus notch or from the junction of the lobule and cartilage of the auricle, to point midway between the nostril and the red margin of the uppe lip. About the middle third of this line corresponds to the duct.

Blood-supply.—The arteries are derived from (1) the externa carotid, (2) the superficial temporal, (3) the transverse facial, an (4) the posterior auricular.

Lymphatics.—These pass to the superficial and deep cervical lymp glands, having previously traversed the parotid lymph glands, and in the case of some, the submandibular glands.

Nerve-supply.—(1) The auriculo-temporal nerve, which conveys t the gland secretory fibres of the glosso-pharyngeal nerve through it

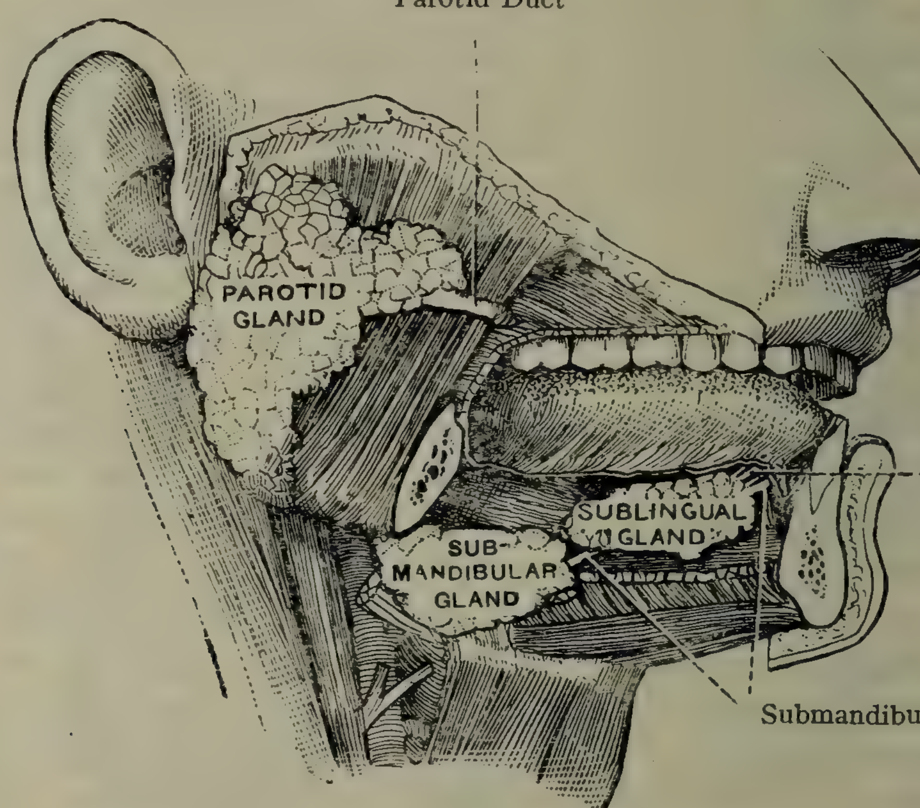


Fig. 778.—The Salivary Glands of the Right Side.

tympanic branch, the lesser superficial petrosal nerve, and the oti ganglion; (2) the great auricular nerve; (3) the sympathetic plexu on the external carotid artery; and (4) the facial nerve.

Structure.—The parotid gland is a compound racemose or acino-tubular gland and is composed of large lobules, which are united by connective tissue. Eacl of these is made up of smaller lobules, likewise connected by connective tissue Each small lobule is a gland on a minute scale, and is made up of a group of mor or less sacculated tubules, called **alveoli** or **acini.** A duct passes from each smal lobule, which unites with adjacent ducts, and these in turn unite, larger and stil larger ducts being formed, the resultant being the principal duct, called th parotid duct. Each alveolus is *serous* or *albuminous* as regards the nature of it secretion, and is composed of a basement membrane continuous with the wal of the duct, and surrounded by a plexus of capillaries. The alveolus is line with polyhedral cells, which contain albuminous granules, and almost com pletely fill the tube, leaving only a small lumen. The first portion of the duct called the *intercalary duct,* is lined with flattened epithelium. Beyond this th

; becomes constricted into a *neck*, which is lined with cubical cells, these being aced in the intralobular duct by columnar cells. These cells are granular ırds the lumen of the tube, but striated in the outer part. Each of the larger :s is composed of a basement membrane, strengthened externally by a layer onnective tissue, superadded to which there stratum of plain muscular fibres.

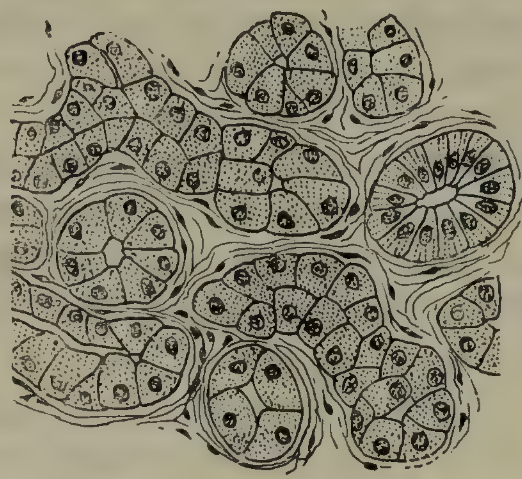


Fig. 779.—Structure of the Parotid Gland.

Development of the Salivary Glands.—The ɔtid is of ectodermal origin, the submandib- and sublingual are derived from entoderm. y appear as solid outgrowths of the epi- ium of the buccal cavity, which grow into adjacent mesodermic connective tissue. The helial constituents of each gland are derived ı the buccal lining, whilst the capsule and ıective-tissue elements are of *mesodermic* in.

Each solid epithelial outgrowth ramifies ͵ freely, and these ramifications, as well as primary outgrowth, become tubular. The owing process commences in the primary ;rowth, and extends thence throughout its ıerous ramifications. The primary outgrowth represents the principal duct ach gland, and the acini, or alveoli, appear as dilatations of the walls of the ıinal ramifications.

The sublingual gland, from its numerous ducts, is to be regarded as a cluster mall **alveolo-lingual glands.**

Appendages of the Eye.

The appendages of the eye consist of the eyelids and the lacrimal ɔaratus.

Eyelids.—The **eyelids,** or **palpebræ,** are two movable curtains placed front of the eyeball, to which they form an important protection. : inner surface of each is covered by mucous membrane, which stitutes the **conjunctiva.** The upper eyelid is larger than the lower, l, when closed, covers the transparent part of the eye or cornea. s also more movable than the lower, being provided with a special ʋator muscle, the levator palpebræ superioris. The elliptical ərval between the lids is called the **palpebral fissure,** and the lateral remities of this fissure are called the angles of the eye. The **lateral ;le (canthus)** is formed by the junction between the two lids. At **medial angle (canthus)** the lids are separated by a recess, called **lacus lacrimalis,** in which there is a small body, called the **caruncula rimalis.** In this region the eyelids are separated from the eyeball a vertical, semilunar fold of the conjunctiva, called the **plica semi- aris.** The margin of each eyelid shows, at the commencement of lacus lacrimalis, a slight conical elevation, called the **papilla lacri- lis,** the apex of which presents a small orifice, termed the **punctum rimale,** its direction being towards the eyeball. Each punctum is entrance to a passage, called the **lacrimal canaliculus,** by which the rs are conveyed from the surface of the eyeball into the lacrimal , and thence, through the naso-lacrimal duct, into the inferior ıtus of the nasal cavity.

The free margins of the eyelids, lateral to the puncta lacrima are provided with hairs, called the **eyelashes.** They are short, sto and curved, and are arranged in two rows. Those of the upper are more numerous and larger than those of the lower. The up eyelashes are curved upwards and the lower downwards, and in t manner intermingling is avoided. Within the lines of attachment the eyelashes there is a row of modified sweat-glands, known as **ciliary glands (glands of Moll),** the openings of which are associa with the follicles of the eyelashes, and with the condition known as s

Structure of the Eyelids.—Each eyelid is composed of the follow structures, from before backwards:

1. Skin.
2. Subcutaneous tissue.
3. Palpebral fibres of the orbicularis oculi.
4. Cellular tissue.
5. The tarsi.
6. Tarsal glands.
7. Conjunctiva.

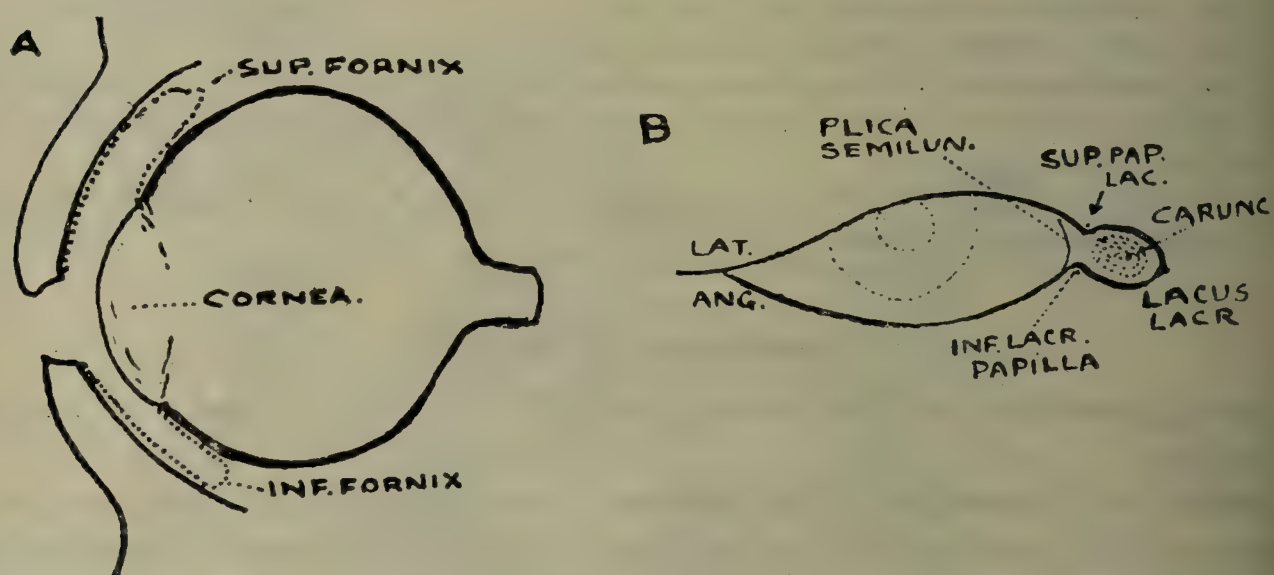


FIG. 780.—A, TO SHOW THE REFLECTION OF CONJUNCTIVA AT UPPER ANI LOWER FORNICES; B, PLAN OF THE PALPEBRAL FISSURE.

In addition to the foregoing structures the upper eyelid conta the tendinous insertion of the levator palpebræ superioris muscle.

The **skin** is very thin, and at the ciliary margins of the eye it becomes continuous with the conjunctiva, which is a mucous m brane. The **subcutaneous connective tissue** is scanty and devoid fat, and in consequence the slightest contraction of the muscle cau a noticeable movement of the skin. The **palpebral fibres of the orbi laris oculi** form a very delicate, pale sheet. The **cellular layer,** d to the orbicularis oculi, is lax, and allows the muscle to move fre over the tarsal plate. The **tarsus** in each eyelid is composed of co pact fibrous tissue. The **upper tarsus** is larger than the inferior, is semilunar, its depth at the centre being about $\frac{1}{4}$ inch. Its up part gives insertion to the levator palpebræ superioris. The **lo tarsus** is narrow, and is almost of the same depth throughout. *ciliary margins* of the tarsi are free, straight, and comparatively th The *orbital margins* are attached to the circumference of the orbit a membranous expansion, called the **orbital septum.** The *upper*

the orbital septum (superior palpebral ligament) is attached above the upper part of the circumference of the orbit, where it blends h the periosteum, and below it blends with the tendon of insertion the levator palpebræ superioris on the upper tarsus. The *lower t* of the orbital septum (inferior palpebral ligament) extends between lower part of the circumference of the orbit and the lower margin the lower tarsus.

Laterally and medially the tarsi are attached to the palpebral aments. The **lateral palpebral ligament** is formed by the junction the upper and lower parts of the orbital septum, and is attached the malar bone. The **medial palpebral ligament** is independent the orbital septum. *Medially* it is attached to the lateral sure of the frontal process of the maxilla in front of the lacrimal cus. From this point it passes horizontally outwards for about nch, and then divides into two laminæ, which are attached to the si of both eyelids. It passes in front of the lacrimal sac, giving an set, which passes behind the sac to be attached to the crest of the rimal bone. The ligament gives origin to a few fibres of the icularis oculi.

The **tarsal glands (Meibomian glands)** are situated on the deep face of each tarsus, and lie between the plate and the conjunctiva right angles to the ciliary margin. There are about thirty in the per eyelid and about twenty in the lower, and they are arranged in rallel rows, which occupy grooves on the ocular surface of each sus. Each gland opens by an independent orifice, and these orifices arranged in a single row, lying a little behind the ciliary margin the eyelid.

Structure.—The tarsal glands are modified sebaceous glands, and their retion lubricates the margins of the eyelids, and prevents them from adhering. ch consists of a tube, closed at one end, and having its sides beset with erticula. The wall of the tube is composed of a basement membrane, which lined with cubical epithelium throughout the greater part of the gland, but se to the orifice this is replaced by stratified epithelium.

In the neighbourhood of the closed ends of the tarsal glands there some convoluted tubules, which are known as the **posterior tarsal ands,** the orifices of which are placed close to the conjunctival fornix.

Conjunctiva.—This is the mucous membrane which covers the ular surfaces of the eyelids and the front of the eyeball. It consists two parts—palpebral and ocular.

The **palpebral portion** lines the ocular or deep surfaces of the elids, and at their ciliary margins it is continuous with the skin on eir outer surfaces. It is also continuous through the puncta lacrialia with the lining membrane of the lacrimal canaliculi, lacrimal c, naso-lacrimal duct, and inferior meatus of the nose. In the region the medial angle of the eye it gives rise to the plica semilunaris, and at e outer part of the upper eyelid it is continuous with the lining embrane of the lacrimal ducts. The palpebral portion is fairly thick d highly vascular, and it has numerous papillæ.

The **ocular portion** consists of two portions—sclerotic and cornea It is continuous with the palpebral portion, and the line of reflectic from the eyelids is known as the **conjunctival fornix, superior** ar **inferior** respectively. Here the orifices of the posterior tarsal glanc are met with. The conjunctiva is loosely connected to the scler and is thin, non-papillary, transparent, and contains only a fe bloodvessels, the whiteness of the sclera being unaffected by it.

The palpebral portion is covered by columnar epithelium, whic at the ciliary margin passes into the stratified epithelium of the skin the sclerotic portion is also covered by columnar epithelium, but th corneal part is represented by the stratified epithelium of the corne

The conjunctiva is supplied with blood by offsets from the palpebr branches of the ophthalmic artery and its lacrimal branch. Th vessels are disposed in a tortuous manner, and are movable upon th eyeball when the conjunctiva is pressed upon and displaced. Th nerves are numerous, and form plexuses. The lymphatics begin clos to the corneal margin in a network, from which vessels proceed to network in each eyelid behind the tarsus. The efferent vesse ultimately reach the parotid and submandibular lymph glands.

The **caruncula lacrimalis** occupies the lacus lacrimalis in the regio of the medial angle of the eye. It is a small, reddish, spong body, consisting of a detached portion of skin containing modifie sweat and sebaceous glands. The latter open into the follicles of ver delicate hairs with which the surface of the caruncle is provided, an they furnish the white secretion which may accumulate at the media angle.

The **plica semilunaris** is a vertical, semilunar fold of the conjunctiv which is situated on the outer side of the caruncle, its concave margi being directed outwards. It corresponds to the *membrana nictitans* or third eyelid, of some animals.

Development of the Eyelids and Tarsal Glands.—The **eyelids** make thei appearance as two folds of skin, above and below the developing eyeball. Eac fold contains some mesodermic tissue which gives rise to the **connective-tissu element** and **tarsus** of the lid, muscle cells extending into the lids later from th platysma sheet. The ectoderm of the posterior surfaces of the lids acquires th characters of mucous membrane, and forms the **conjunctival epithelium.** In th course of the third month the eyelids grow together and unite along their margins a space being thereby enclosed between the lids and the front of the developin eyeball. The union affects the epithelium only, and persists until near the en of intra-uterine life.

During the period of fusion of the eyelids the tarsal glands and the cilia o eyelashes are formed. The **tarsal glands** are developed from the epitheliur along the line of fusion of the lids. Solid rods of epithelial cells are forme which grow into the mesodermic tissue of the two lids and give off lateral pro cesses. These solid rods become hollow, and so form the tarsal glands. Som of the epithelial rods give rise to the **ciliary glands.** A short time before birt the eyelids become separated, and the **palpebral fissure** is thereby formed.

The **plica semilunaris** is developed as a vertical fold of conjunctiva near th medial angle of the eye, external to the caruncle, but it attains little developmen in man.

The **caruncle** is developed from that portion of the margin of the lowe

-lid which intervenes between the inferior punctum lacrimale and the medial -gle. The tarsal glands in this region become modified, and the tissue con-ning these modified glands becomes raised, and forms the reddish, spongy **-uncle.**

Lacrimal Apparatus.—The constituent parts of the lacrimal -paratus are as follows:

1. The lacrimal gland.
2. The lacrimal canaliculi.
3. The lacrimal sac.
4. The naso-lacrimal duct.

The **lacrimal gland** will be found described on p. 1247.

The **lacrimal canaliculi** are two in number, superior and inferior. -ey commence at the puncta lacrimalia on the summit of the papillæ -crimales, which latter are situated on the ciliary margins of the -elids close to the lacus lacrimalis. The **superior canaliculus** at first -cends vertically for about $\frac{1}{12}$ inch, after which it makes a sudden

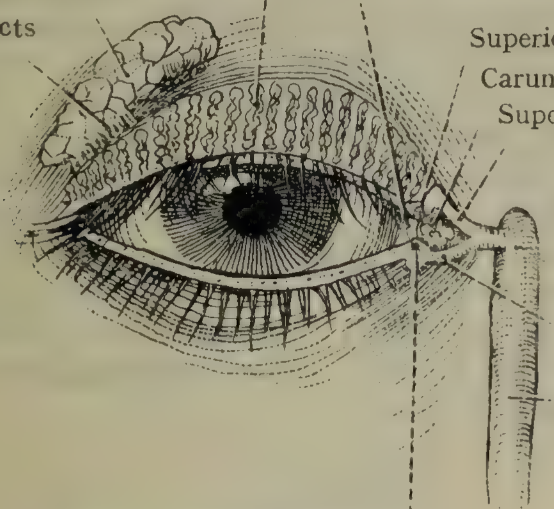


FIG. 781.—THE LACRIMAL APPARATUS OF THE RIGHT EYE.
The tarsal glands of the upper eyelid are also shown.

-end, and passes inwards and downwards to the lacrimal sac. The **-ferior canaliculus** at first descends vertically for about $\frac{1}{12}$ inch, after -hich it makes a sudden bend, and passes almost horizontally inwards - the lacrimal sac. The two canaliculi open into the lacrimal sac, -ther close together or by a common orifice, and their mucous mem--rane is lined with stratified squamous epithelium. The two slips - the lacrimal portion of the orbicularis oculi are closely related to the -orizontal portions of the canaliculi.

The **lacrimal sac** is the dilated upper part of the passage by which -e tears are conveyed from the lacrimal canaliculi to the inferior -eatus of the nose. It occupies the lacrimal groove of the lacrimal -ne and frontal process of the maxilla. Above it has a round, closed -tremity, and below it opens into the naso-lacrimal duct. Externally - receives the lacrimal canaliculi separately or conjointly, and in front - is crossed by the medial palpebral ligament. Behind it is related - the lacrimal part of the orbicularis oculi.

The **naso-lacrimal duct** (**nasal duct**) extends from the lower end the lacrimal sac to the anterior part of the inferior meatus of the n under cover of the front part of the inferior nasal concha. Its leng is about $\frac{3}{4}$ inch, and its diameter about $\frac{1}{8}$ inch. It is directed dov wards, outwards, and backwards, and its opening into the anterior p of the inferior meatus of the nose is usually guarded by an imperf mucous fold, known as the **lacrimal fold** (**valve of Hasner**). The na orifice of the duct is about $1\frac{1}{4}$ inches from the anterior nasal apertur

Structure of the Lacrimal Sac and Naso-lacrimal Duct.—The wall is compo of fibro-elastic tissue, which adheres closely to the periosteum of the bo and is covered by mucous membrane. The epithelial lining is of the colum variety, and at intervals the cells are furnished with cilia. The mucous m brane is continuous superiorly with the conjunctiva through the lacrimal ca iculi and puncta, and inferiorly it is continuous with the nasal mucous membra In the naso-lacrimal duct it may present one or two folds.

Development of the Naso-lacrimal Duct and its Appendages.—The effer lacrimal apparatus consists of (1) the lacrimal canaliculi, (2) the lacrimal s and (3) the naso-lacrimal duct.

In the course of the development of the face, the maxillary process and lateral nasal process of either side are separated by a groove which exte from the inner angle of the eye to the olfactory pit. This groove is called **naso-optic,** or **oculo-nasal groove,** and it indicates deeply the position of lacrimal duct. In the bottom of this groove a solid epithelial cord makes appearance, which, becoming hollow, forms the **naso-lacrimal duct.** The up extremity of the duct bifurcates, its two divisions becoming connected w the margins of the eyelids near their inner ends, and forming the **lacrimal ca iculi.** The lower end of the naso-lacrimal duct at a much later period opens i the lower part of the nasal cavity. The **lacrimal sac** is the upper expan extremity of the naso-lacrimal duct.

Auricle.

The auricle, or pinna, is that part of the external ear which proje from the side of the head. It has two surfaces, outer and inner.

The **outer surface** is irregularly concave, and about its centre th is a large deep fossa, called the **concha of the auricle,** which leads the external auditory meatus. Towards the upper and anterior p of the concha there is an elevation, called the **crus of helix,** which directed upwards and forwards to the anterior border of the auri The concha is thus divided into two parts, upper and lower. In fr of the concha there is a small, somewhat conical prominence, called **tragus,** which projects slightly backwards over the orifice of external auditory meatus, and is provided with hairs on its in aspect. A short distance behind the tragus, and on a lower le than it, there is another prominence, called the **antitragus,** which separated from the tragus by a deep notch, called the **intertragic not** The skin over the antitragus is also provided with hairs. Below antitragus and intertragic notch is the most dependent part of auricle, called the **lobule,** which is comparatively soft in consiste The prominent rim of the auricle is called the **helix.** It is incurv and begins at the upper and front part of the concha in the crus

e helix, already referred to. It then surrounds the margin of the ıricle, and ends below in the back part of the lobule. In some cases e **auricular tubercle** (**Darwin's tubercle**) is situated on the incurved argin slightly above the level where the antihelix, to be presently scribed, bifurcates into its crura. This projection is well developed the ears of quadrupeds, and forms the *point* or *tip*. A short distance ithin the helix there is another curved elevation, called the **anti-lix.** This begins at the back part of the antitragus and ascends hind the concha, above which it divides into two diverging crura, pper and lower. Between the helix and the antihelix is an elongated, ırrow fossa, called the **scaphoid fossa,** and between the diverging ura of the antihelix there is a depression, called the **triangular fossa.**

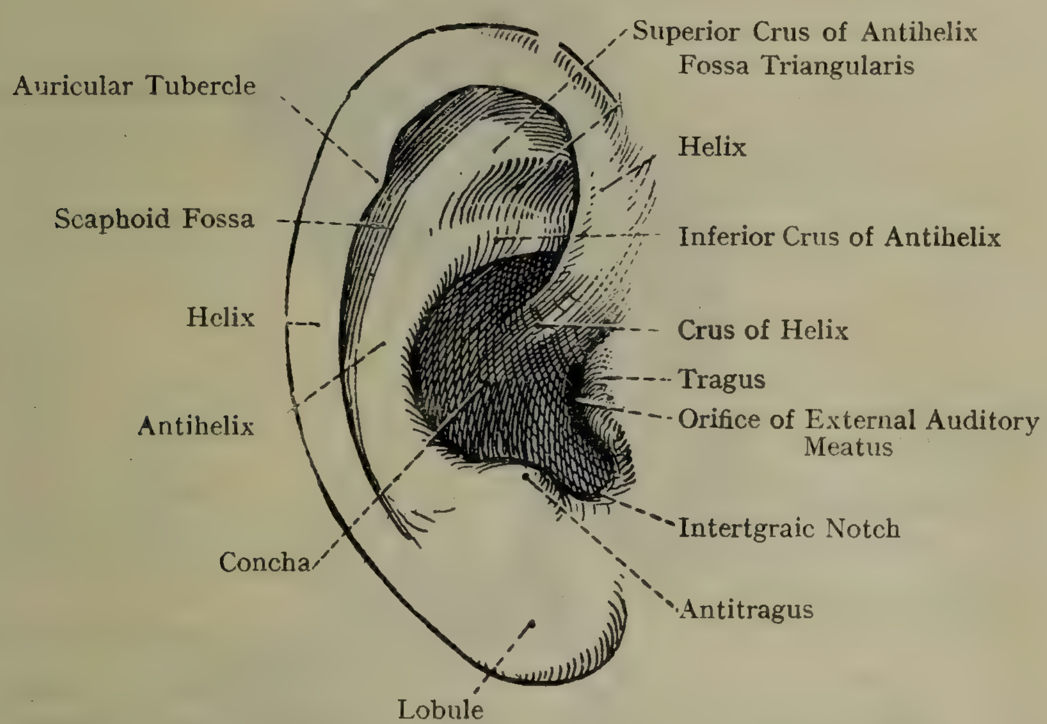


FIG. 782.—THE RIGHT AURICLE (LATERAL SURFACE).

The **inner** or **cranial surface** of the auricle presents convexities rresponding to the fossæ on the outer surface, the convexity opposite e concha being especially prominent.

Structure of the Auricle.—The auricle, with the exception of the lobule, is mposed of a plate of yellow elastic fibro-cartilage covered by skin. This ate imparts firmness and elasticity to it, and is provided with ligaments and trinsic muscles. The skin is thin, and adheres closely to the fibro-cartilaginous ate. It is provided with hairs, which are most plentiful in the regions of the agus and antitragus. The cartilage of the auricle is rolled upon itself so as to rm the outer or cartilaginous part of the external auditory meatus. This rtion of it is attached medially to the external auditory process of the temporal ne by fibrous tissue. The rolled or tubular portion has a deficiency at the terior and upper part, between the tragus and the helix, which is occupied by fibrous membrane. It has also a variable number of transverse clefts, which e filled with fibrous tissue. The lower extremity of the cartilage of the helix separated from the cartilage of the antihelix by a deep cleft. The part of the rtilage of the helix behind this cleft is known as the **tail of the helix.** At the per and anterior part of the auricle, where the helix begins to curve backwards, e cartilage has a small sharp projection called the **spine of the helix.**

Ligaments of the Auricle.—These are anterior and posterior. T **anterior ligament** extends from the spine of the helix to the zygoma the temporal bone close to its root. The **posterior ligament** exten from the cranial aspect of the concha, under cover of the auricula posterior, to the mastoid process.

Intrinsic Muscles.—These muscles, which are very thin and pa are confined to the auricle, and are six in number, four being situa on the outer surface and two on the inner surface.

Muscles on Outer Surface.—These are: (1) the helicis major; (2) helicis minor; (3) the tragicus; and (4) the antitragicus.

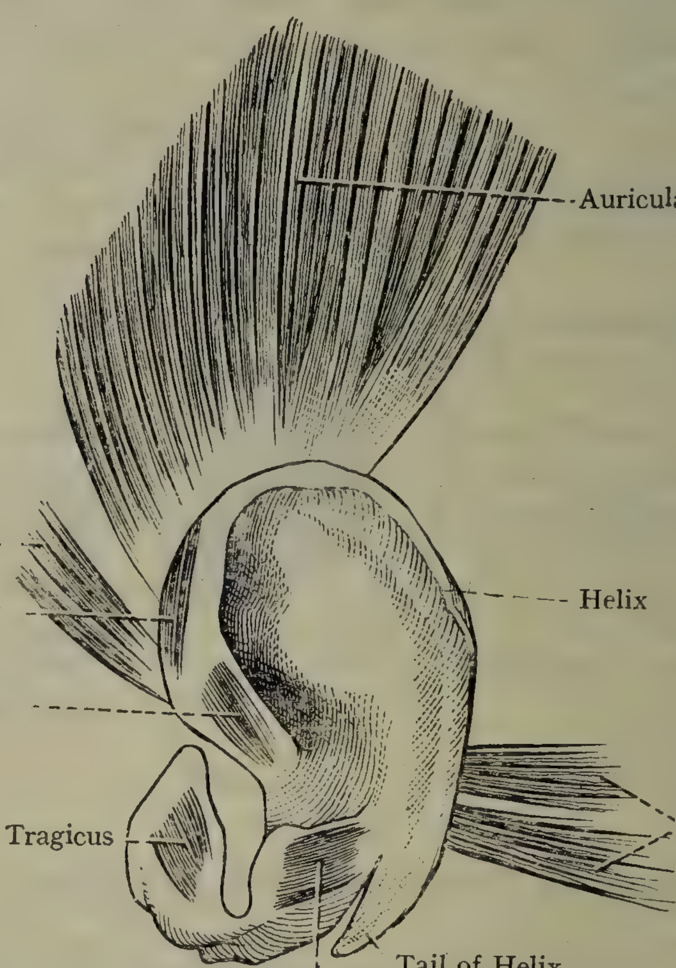


FIG. 783.—THE OUTER SURFACE OF THE LEFT AURICULAR CARTILAGE AND MUSCLES (ARNOLD).

The **helicis major** extends from the spine of the helix along t anterior part of the helix as high as the level at which it curves bac wards.

The **helicis minor** lies upon the crus helicis.

The **tragicus** lies upon the outer surface of the tragus, its fib being almost vertical.

The **antitragicus** extends from the outer surface of the antitrag backwards and slightly upwards, to be attached to the tail of the hel

Muscles on Inner Surface.—These are: (1) the transversus auricu and (2) the obliquus auriculæ.

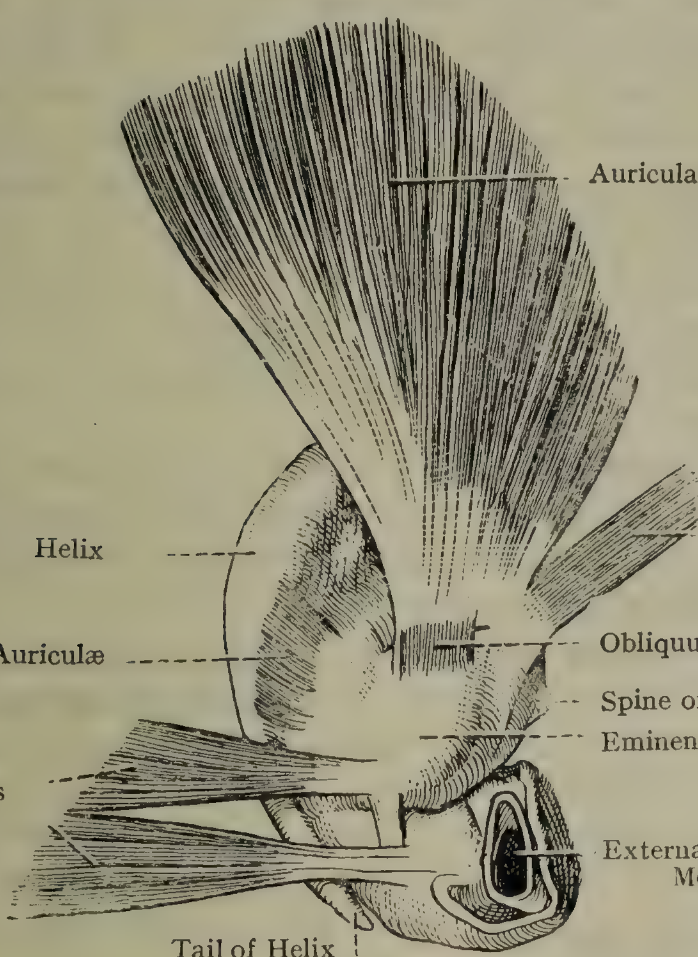
The **transversus auriculæ** extends over the depression which cor sponds to the antihelix on the outer surface, its attachments being

convexity of the concha on the one hand, and the convexity of the a of the helix on the other.

The **obliquus auriculæ** extends over the depression corresponding he lower crus of the antihelix on the outer surface.

Action of the Intrinsic Muscles.—The tragicus and antitragicus inish the orifice of the external auditory meatus, and the muscles of helix, major and minor, have an opposite effect.

Blood-supply of the Auricle.—The arteries are derived from (1) the terior auricular branch of the external carotid, (2) the anterior icular branches of the superficial temporal, and (3) the deep auricular nch of the first part of the maxillary, the last named giving offsets he cartilaginous part of the external auditory meatus.



. 784.—The Inner Surface of the Left Auricular Cartilage and its Muscles (Arnold).

The **veins** end in the posterior auricular, superficial temporal, and xillary veins, and one or two of them may open into the mastoid issary vein.

The **lymphatic vessels** of the *inner surface* of the auricle pass chiefly the mastoid lymph glands; but a few end in the superior deep vical lymph glands. The lymphatics of the *lobule* pass to (1) the erficial cervical lymph glands, and (2) the superior deep cervical ıph glands. The lymphatics of the *outer surface* of the auricle pass :he superficial parotid lymph glands.

Nerve-supply.—The **inner surface** receives three cutaneous nerves. e great auricular supplies about the lower three-fourths, the lesser ipital about the upper fourth, and the auricular branch of the vagus

supplies the integument over the convexity of the concha. The **out** **surface** is supplied by two cutaneous nerves. The auriculo-tempo nerve supplies the upper two-thirds, and the great auricular suppl the lower third. The motor nerve of the intrinsic muscles is the fac nerve.

The Nose.

The nose has a **root,** situated below the glabella of the frontal bon an **apex** (**tip**), situated inferiorly; and the **dorsum nasi,** which occup an intermediate position. The upper part of the dorsum is kno as the **bridge of the nose.** At the lower part of the nose there are t openings of the **nostrils,** or **nares.** The outer margin of each nost is slightly prominent and curved, and is called the **ala.** The nostr are separated from each other by a septum, called the **columna na** which, as well as the ala, is composed of fibrous tissue and skin. With the circumference of each nostril there are several stout hairs or *vibriss*

The superficial or facial aspect of the nose derives its **arteries** fro (1) the lateral nasal branches of the facial, (2) the dorsal nasal bran of the ophthalmic, and (3) the infra-orbital branch of the maxillary.

The **nerves** are derived from the naso-ciliary and infra-orbi nerves, the branches from the naso-ciliary being the infratrochlear a the terminal cutaneous offsets.

The **cutaneous lymphatics** of the *root* of the nose pass to the sup ficial parotid lymph glands. Those from the greater part of the na integument pass to the submandibular lymph glands, the lymph glan forming gland-stations in their path.

The framework of the nose is both osseous and cartilaginous.

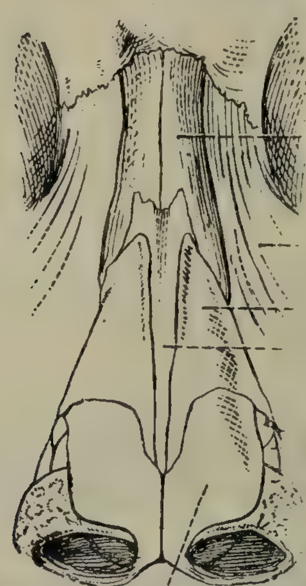


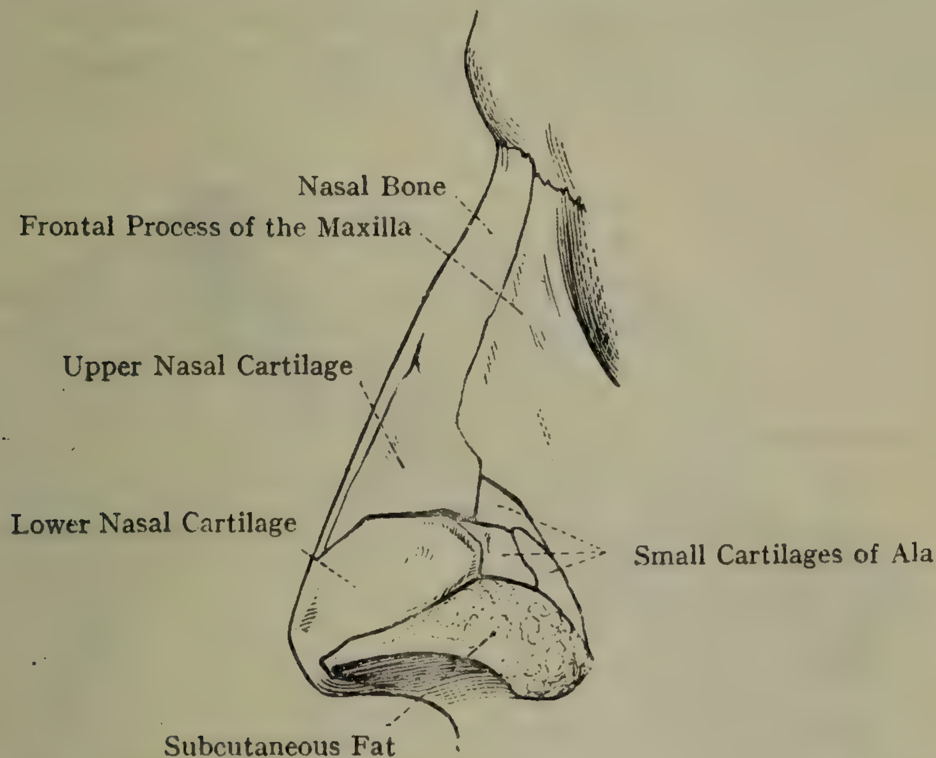
Fig. 785.—The Cartilages of the Nose (Anterior View) (Arnold).

Cartilages of the Nose.—The na cartilages are five:

Upper nasal cartilage.
Lower nasal cartilage.
Septal cartilage.

The **upper nasal cartilages** (**upp** **lateral cartilages**) are situated imm diately below the nasal bones. Th are triangular, and their *anter* *borders* are continuous with ea other, and with the anterior marg of the septal cartilage, in each ca superiorly. Inferiorly, the anter borders are separated by a slig interval, in which the anterior ma gin of the septal cartilage is visible. The *posterior border* of ea cartilage is attached to the lower sloping border of the nasal bone, a also to the upper part of the nasal notch on the medial border of t maxilla. The *lower border* is connected by fibrous tissue to the up margin of the lower nasal cartilage.

The **lower nasal cartilages (lower lateral cartilages)** are situated ɔw the upper pair, and each is bent so as to lie in front and on each ɛ of the nostril, which it keeps open. Its outer portion is called lateral process, and its inner portion the septal process.



ɪG. 786.—THE CARTILAGES OF THE NOSE (LATERAL ASPECT) (ARNOLD).

The *lateral process* is attached by fibrous tissue to the upper nasal tilage, and to the lower part of the nasal notch on the medial border the maxilla. The septal process is folded backwards, and touches fellow of the opposite side. It lies along the upper part of the umna nasi, and along the antero-inferior border of the septal carti- e. Anteriorly it is separated from its fellow by a notch.

In the fibrous tissue which con- ɛts the lateral process to the xilla two or more isolated por- ns of cartilage are met with, led the **small cartilages of the ala inor cartilages**).

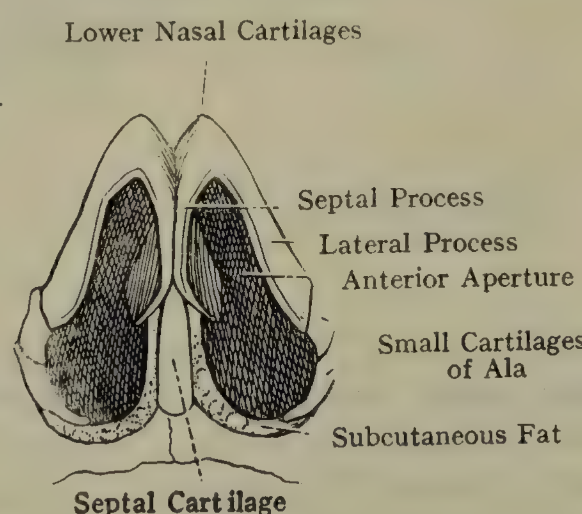


FIG. 787.—THE CARTILAGES OF THE NOSE (INFERIOR ASPECT) (ARNOLD).

Development.—The upper and lower ɜal cartilages are developed in the ɜral nasal process.

The **septal cartilage** is medially ɪced, and is usually inclined slightly one side, most frequently the left. forms a large part of the nasal ɔtum anteriorly, and has the form an irregularly four-sided, later- y compressed plate. Its *anterior border* is attached to the back of ɛ nasal bones, along the course of the internasal suture; below this is connected to the anterior borders of the upper nasal cartilages;

and below these it lies between the septal processes of the lower na cartilages. Its *posterior border* is accurately applied to the irregu anterior margin of the perpendicular plate of the ethmoid bone. *inferior border* is received into the front part of the groove on the anter border of the vomer. The *antero-inferior border* passes upwards a forwards from the front part of the inferior border to the anter border. In early life the septal cartilage is prolonged backwards

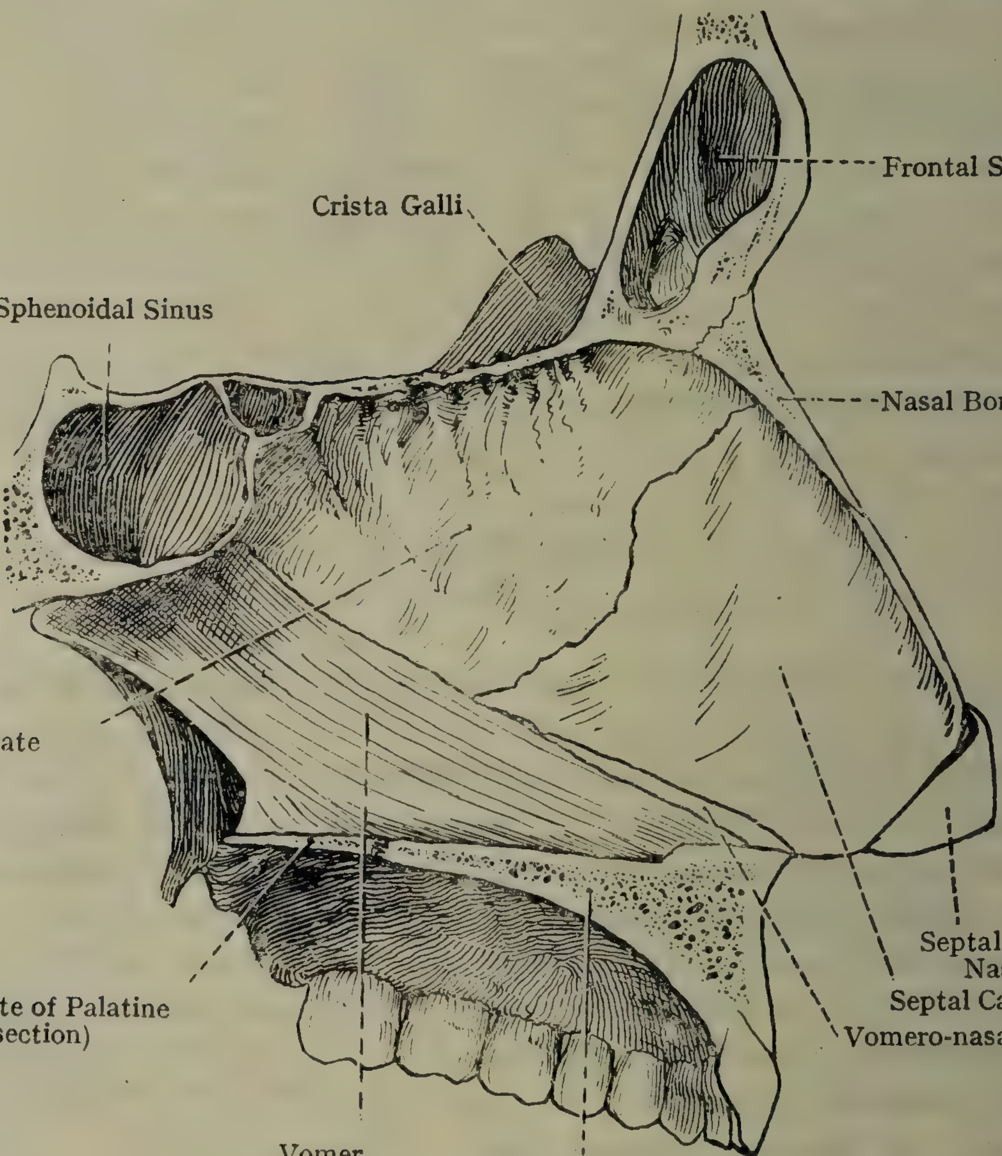


FIG. 788.—THE OSSEOUS AND CARTILAGINOUS NASAL SEPTUM (RIGHT LATERAL ASPECT).

the body of the sphenoid bone in the form of a narrow strip, whi intervenes between the lower border of the perpendicular plate the ethmoid and the vomerine groove. This portion is known the *sphenoidal process*. Along the inferior border of the sept cartilage, between it and the anterior border of the vomer, there a two narrow, elongated strips of cartilage, right and left, which a called the **vomero-nasal cartilages (cartilages of Jacobson).**

Development.—The septal cartilage is derived from the chondrocranium

The Temporal and Infratemporal Regions.

Muscles of Mastication.—These are four in number—namely, the sseter, temporal, lateral pterygoid, and medial pterygoid.

Masseter—*Origin*—(1) **Superficial Portion.**—The anterior two-ds of the lower border of the zygomatic arch. (2) **Deep Portion.** he posterior third of the lower border, and the whole of the medial ace of the zygomatic arch.

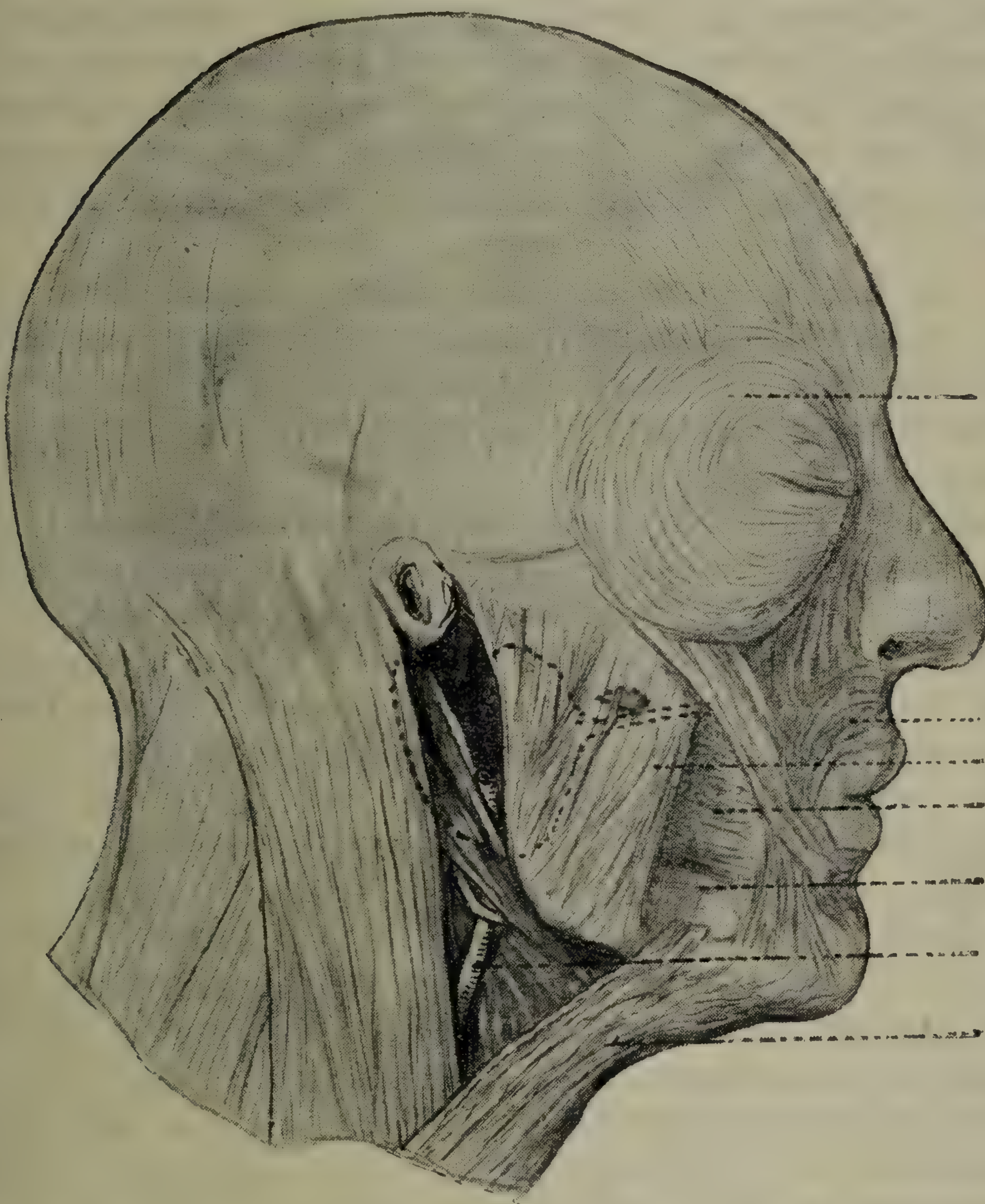


FIG. 789.—THE MASSETER MUSCLE.

Insertion.—The superficial portion is inserted into the lower margin d the deep portion into the upper half of the outer surface of the nus of the mandible. The superficial fibres extend as far as the gle, and the deep fibres encroach on the coronoid process.

Nerve-supply.—The masseteric branch of the anterior portion of mandibular division of the trigeminal nerve. This branch leaves pterygoid region by passing over the mandibular notch of the nus of the mandible below the zygoma, and it therefore enters the scle on its deep surface accompanied by the masseteric artery.

The superficial portion of the muscle is directed downwards and

slightly backwards, and the deep portion downwards and very sligl forwards.

Action.—To elevate the mandible. The superficial portion a draws it slightly forwards.

Relations—*Superficial.*—The parotid gland and its duct, branc of the facial nerve, the transverse facial artery, the risorius, and platysma. *Deep.*—The ramus of the mandible, and the masset nerve and artery. The *anterior border* overlaps the buccinator, fr which it is separated by the suctorial pad of fat.

Temporalis—*Origin.*—(1) The temporal fossa, extending as higl the inferior temporal line of the frontal and parietal bones, and as as the infratemporal crest on the external surface of the greater w of the sphenoid, but excluding the portion of the fossa formed by zygomatic bone; and (2) the deep surface of the temporal fascia o its upper part.

Insertion.—(1) The medial surface, summit, and anterior bor of the coronoid process of the mandible; and (2) the elongated triangu surface on the medial surface of the ramus of the mandible, close wit the anterior border, and extending as low as a point on the inner s of the last molar socket.

Nerve-supply.—The deep temporal nerves, usually three in numb which are branches of the anterior portion of the ~~maxillary~~ divis of the trigeminal nerve, and which enter the deep surface of the mus

The muscle is fan-shaped. The anterior fibres descend alm vertically; the middle fibres pass obliquely downwards and forwa and the posterior fibres pass forwards almost horizontally.

Action.—To raise the mandible, as in closing the mouth. T posterior fibres also retract the mandible, and act in opposition to lateral pterygoid, which protracts it.

Relations—*Superficial.*—The temporal fascia, supporting the auri lares anterior et superior; the superficial temporal artery, auricu temporal nerve, and temporal branches of the facial nerve; the zygon and fat, which is continuous with the suctorial pad. *Deep*—T temporal fossa, the deep temporal arteries and nerves, and the late pterygoid muscle.

The buccal nerve passes downwards and forwards under cover the muscle close to the anterior border of the ramus of the mandib and the masseteric nerve and artery pass outwards close to the poster border in the region of the mandibular notch.

For the temporal fascia, see p. 1161.

Lateral Pterygoid (External Pterygoid)—*Origin*—(1) **Upper Head** The infratemporal surface and infratemporal crest of the greater w of the sphenoid. (2) **Lower Head.**—The outer surface of the late pterygoid plate of the sphenoid. The upper head is small, and the lov head is of large size.

Insertion.—(1) The depression on the front of the neck of t mandible; and (2) the front of the articular capsule and disc of t mandibular joint.

Nerve-supply.—The nerve to the lateral pterygoid, from the anterior ision of the mandibular nerve.

The direction of the muscle is backwards and slightly outwards.

Action.—(1) To draw forwards the neck and condyloid process of mandible, and also the articular disc. When the muscles of opposite es act in concert the mandible is protruded, and the lower incisor l canine teeth project beyond the level of those of the maxilla. The scles of opposite sides, however, usually act alternately and thus duce the oblique or grinding movement, the lower molars of one e being carried forwards and inwards under the corresponding per molars, and *vice versa*. At the same time the elevators of the ndible are in action. (2) To take part in opening the mouth by wing the condyloid process of the mandible and articular disc forrds on to the *articular eminence* of the temporal bone. The lateral

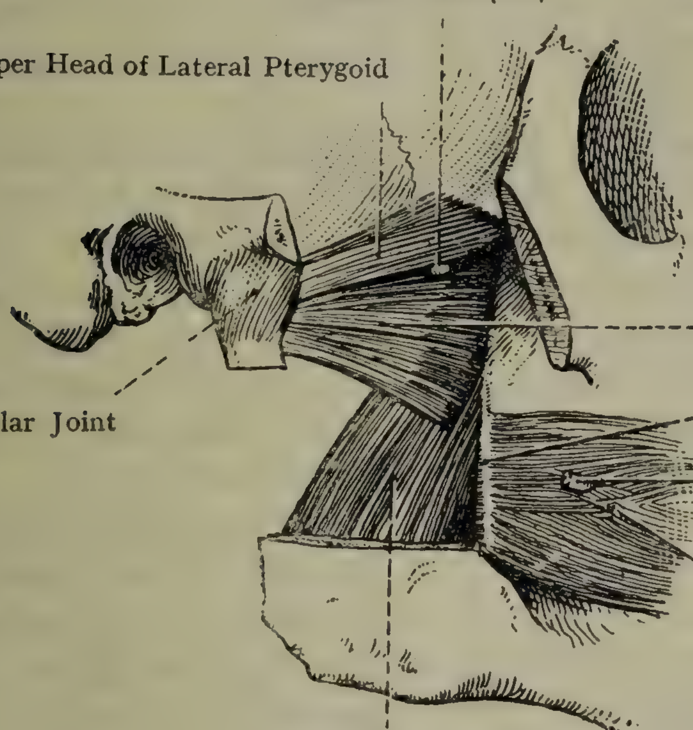


FIG. 790.—THE PTERYGOID AND BUCCINATOR MUSCLES.

erygoid is antagonistic to the posterior portion of the temporalis iscle.

Relations—*Superficial.*—Part of the ramus of the mandible, the wer part of the temporalis, part of the pterygoid plexus of veins, the ccal nerve, and perhaps the second part of the maxillary artery. *eep.*—The upper portion of the medial pterygoid muscle, the sphenoandibular ligament, in some cases the second part of the maxillary tery, the middle meningeal artery, a part of the pterygoid plexus of ins, the mandibular nerve, the otic ganglion, and the chorda tympani rve. *Superior.*—The masseteric and deep temporal nerves. *Inferior.* The inferior dental and lingual nerves, and the spheno-mandibular ament. The buccal nerve, with the anterior deep temporal nerve, akes its appearance between the upper and lower heads, and the axillary artery may sink between them.

Medial Pterygoid (Internal Pterygoid)—*Origin.*—(1) The inner surfa of the lateral pterygoid plate of the sphenoid, and the portion of t tubercle of the palatine bone which forms the lower part of the pterygo fossa; and (2) the outer surface of the tubercle of the palatine bo and the adjacent portion of the tuberosity of the maxilla.

Insertion.—(1) The inner aspect of the angle of the mandib and (2) the back part of the inner surface of the ramus, between t angle and the mandibular foramen.

Nerve-supply.—The medial pterygoid branch of the anterior porti of the mandibular nerve.

The direction of the muscle is downwards, backwards, and ou wards.

Action.—(1) To elevate the mandible; and (2) to draw it forwar

Relations—*Superficial.*—The lateral pterygoid muscle to a slig extent superiorly, the spheno-mandibular ligament, the maxillary a inferior dental vessels, and the inferior dental and lingual nerv *Deep.*—The tensor palati muscle, and the superior constrictor musc of the pharynx.

For a description of the spheno-mandibular ligament, see p. 1316.

The Maxillary Artery (Internal Maxillary Artery).—This vessel the larger of the two terminal branches of the external carotid. arises from that artery opposite the neck of the mandible and within t parotid gland. Its course is at first forwards and inwards behind t neck of the mandible, and superficial to the spheno-mandibular lig ment. It then inclines upwards and forwards through the infr temporal fossa, usually passing superficial to the lateral pterygo muscle, though in many cases it passes deep to it. Having reached t interval between the two heads of the lateral pterygoid, it sinks deep between them, and, passing through the pterygo-maxillary fissure, enters the pterygo-palatine fossa, where it gives off its terminal branche In those cases in which the artery passes deep to the lateral pterygo muscle it forms a projecting curve between the two heads of the muscl The course of the vessel is very tortuous in adaptation to the mobilit of the surrounding structures.

Owing to its complexity it is convenient to divide the artery int three parts. The **first** or **mandibular part** is situated between th neck of the mandible and the spheno-mandibular ligament, and it course is horizontally forwards and inwards. It is accompanied b the maxillary vein, and lies along the back part of the lower border o the lateral pterygoid muscle, crossing in front of the inferior dent nerve and embedded in the parotid gland. The **second** or **pterygoi part** usually lies superficial to the lower head of the lateral pterygoi and under cover of the insertion of the temporalis. Its course throug the infratemporal fossa is upwards and forwards, and it sinks betwee the two heads of the lateral pterygoid on its way to the pterygo maxillary fissure. In many cases, however, the second part of th vessel passes deep to the lower head of the lateral pterygoid, crossin in front of the medial pterygoid muscle and lingual nerve. Unde

se circumstances it forms a projecting curve between the two ds of the lateral pterygoid beneath the long buccal nerve. The **d or pterygo-palatine part** is situated in the pterygo-palatine fossa, ch it enters by passing through the pterygo-maxillary fissure. In fossa the vessel and its branches are intimately related to the cillary nerve and the spheno-palatine ganglion, with its branches.

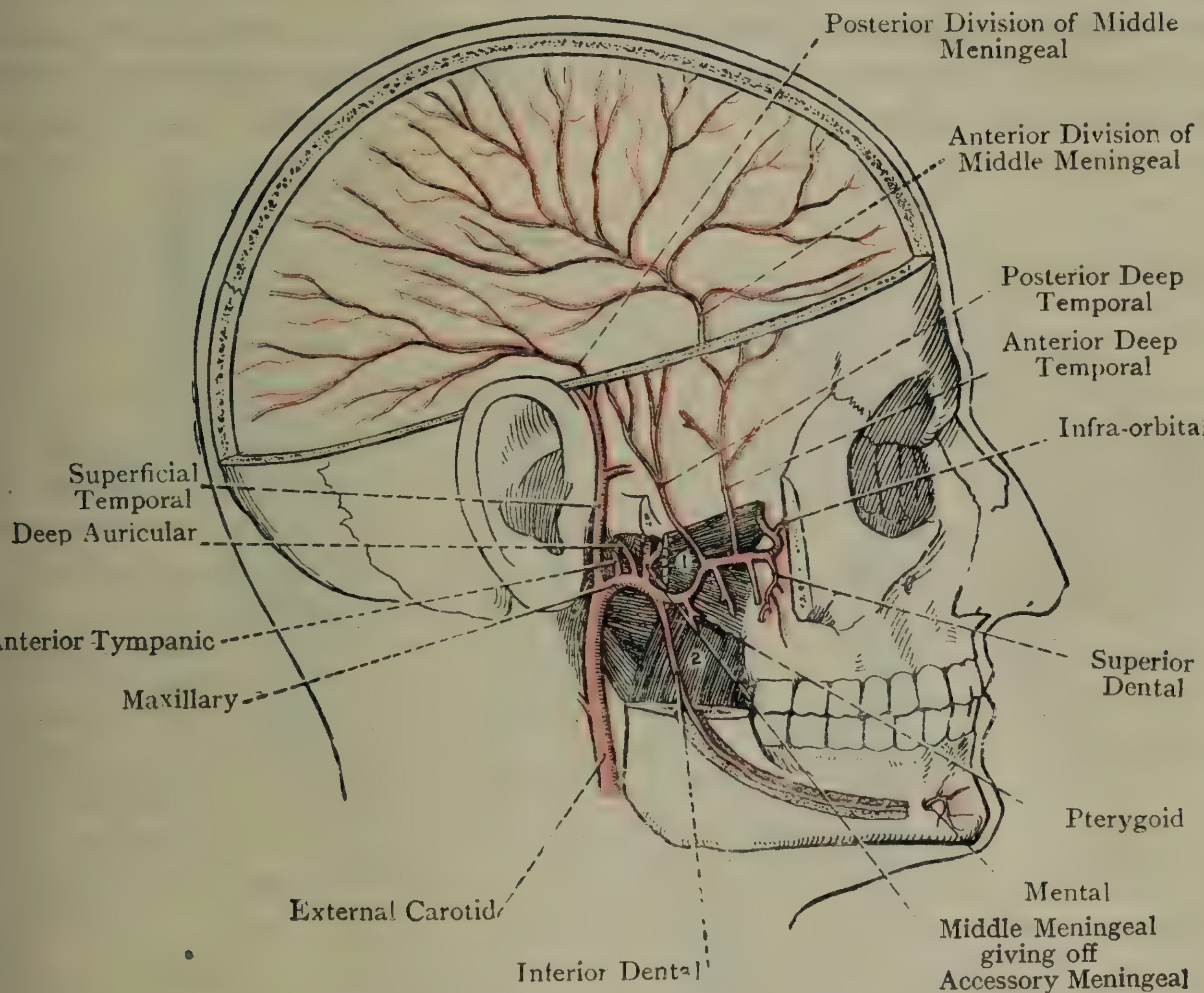


FIG. 791.—THE MAXILLARY ARTERY AND ITS BRANCHES.
ramus of the mandible and one half of the calvaria have been removed. 1, lateral pterygoid muscle; 2, medial pterygoid muscle.

Branches.—These are as follows:

First Part.	**Second Part.**	**Third Part.**
p auricular.	Masseteric.	Posterior superior dental.
erior tympanic.	Pterygoid.	Infra-orbital.
dle meningeal, giving ff accessory meningeal.	Posterior deep temporal.	Greater palatine.
erior dental.	Anterior deep temporal.	Artery of the pterygoid canal.
	Buccal.	Pharyngeal.
		Spheno-palatine.

Branches of the First Part.—The **deep auricular artery,** of small e, ascends within the parotid gland just behind the mandibular nt, and pierces the anterior cartilaginous wall of the external auditory atus. It supplies the cutaneous lining of that passage and the ter surface of the tympanic membrane.

The **anterior tympanic artery** may be associated with the preced at its origin. It ascends beneath the lateral pterygoid, and enters t tympanic cavity by passing through the squamo-tympanic fissu It is distributed to the structures within the tympanic cavity and the inner surface of the tympanic membrane. Around the circu ference of that membrane it forms an arterial ring with an offset the stylo-mastoid artery, which is a branch of the posterior auricula

The **middle meningeal artery,** of large size, ascends beneath t lateral pterygoid muscle, and, passing between the two roots of ori of the auriculo-temporal nerve, it enters the cranial cavity throu

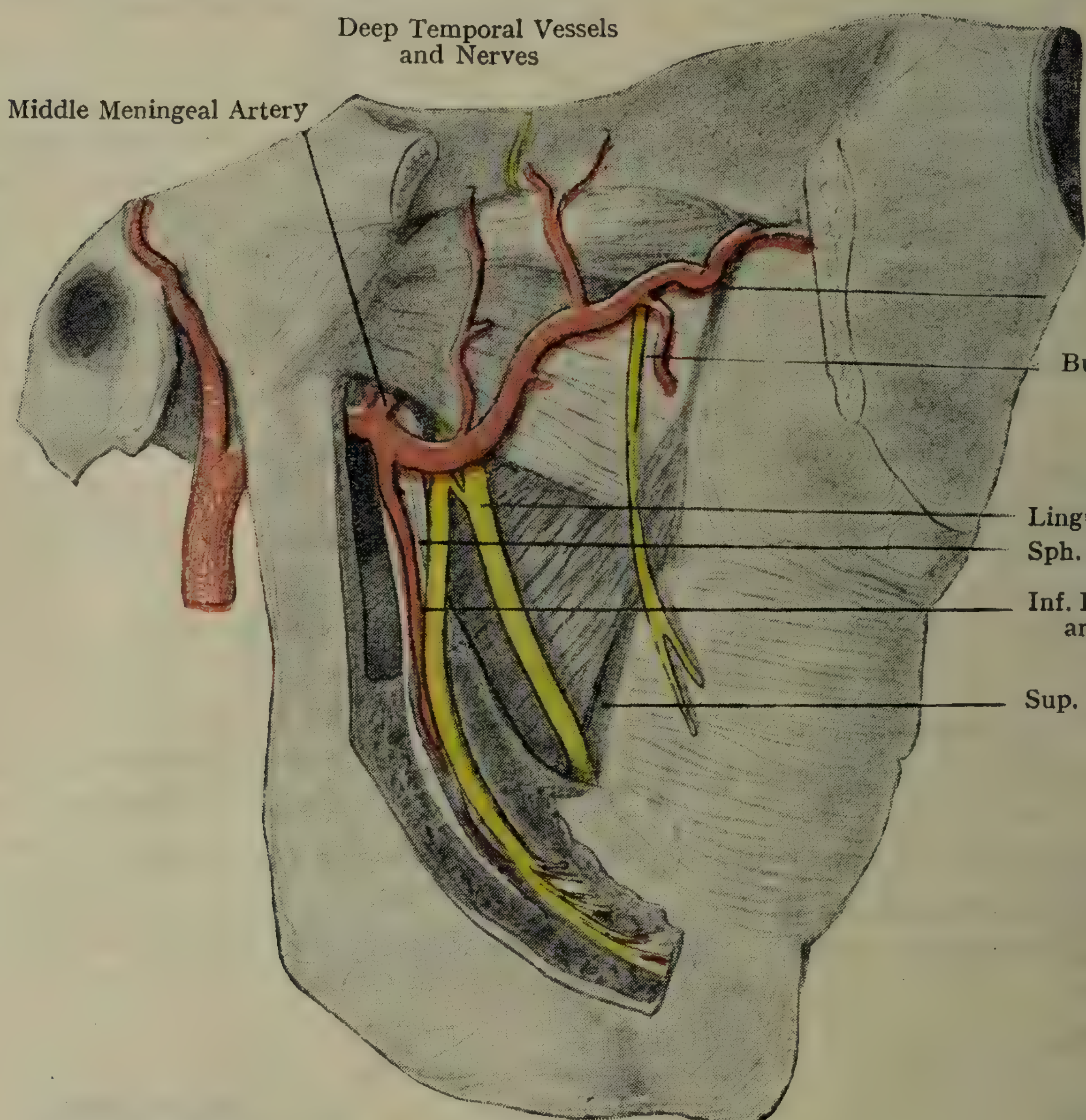


Fig. 792.—Dissection of Right Pterygoid Region.

the foramen spinosum in the sphenoid bone. It then passes upwar and forwards to the inner aspect of the antero-inferior angle of t parietal bone, where it divides into two branches, anterior a posterior, which ramify in the branching grooves on the inner surfa of the parietal bone. The artery is accompanied by a plexus sympathetic nerves, but its vein passes through the foramen ova For the distribution of the vessel within the cranium, see p. 159 Before disappearing through the foramen spinosum the midd meningeal artery usually gives off the *accessory meningeal artery,* whic enters the cranial cavity through the foramen ovale.

The **inferior dental artery** arises nearly opposite the middle meningeal ery, and descends upon the spheno-mandibular ligament in company :h the inferior dental nerve, lying on its posterior and outer side. .ving reached the mandibular foramen, it gives off the small *mylo-oid branch*, and then it passes through the mandibular foramen and ters the mandibular canal, which it traverses as far as the level the mental foramen, where it ends by dividing into its mental and :isor branches. Within the mandibular canal the artery is accom-nied by the inferior dental nerve and inferior dental vein.

Branches.—The *mylo-hyoid branch*, of small size, arises at the vel of the mandibular foramen. In company with the mylo-hyoid rve it pierces the spheno-mandibular ligament, and descends in e mylo-hyoid groove to be distributed to the under surface of the ylo-hyoid muscle. The *molar*, *premolar*, and *canine branches* arise thin the mandibular canal, and supply the pulps of these teeth, iich they reach by passing through the foramina on the extremities their fangs. The *mental branch* leaves the mandibular canal through e mental foramen, and has been already described (see p. 1283). ie *incisor branch* supplies the pulps of the incisor teeth of one side.

Branches of the Second Part.—The branches of this part are muscular their distribution. The **masseteric artery** passes outwards, with the rresponding nerve, over the mandibular notch, and enters the deep rface of the masseter. The **pterygoid branches** are distributed to e corresponding muscles. The **posterior** and **anterior deep temporal teries** pass upwards to the posterior and anterior parts of the temporal ssa beneath the temporalis. They supply the muscle and the bones rming the fossa, and anastomose with the middle temporal artery, iich is a branch of the superficial temporal. The anterior deep mporal artery also anastomoses with the lacrimal artery by twigs hich pass through minute foramina in the outer wall of the orbit. ie **buccal artery** passes downwards and forwards in company with e buccal nerve, and is distributed to the buccinator muscle and the iccal mucous membrane which lines it internally.

Branches of the Third Part.—The **posterior superior dental artery** ises from the maxillary as it is about to pass through the pterygo-axillary fissure into the pterygo-palatine fossa, and is sometimes sociated with the infra-orbital artery at its origin. It descends oon the zygomatic surface of the maxilla posterior to the zygomatic ocess, and its principal branches traverse the posterior dental canals supply the pulps of the upper molar teeth of one side. It also rnishes twigs to the mucous lining of the maxillary sinus and to the im.

The **infra-orbital artery** arises in the pterygo-palatine fossa, some-mes in common with the posterior superior dental. It passes through ie inferior orbital fissure in company with the maxillary nerve, and averses the infra-orbital groove and canal on the floor of the orbit, ie accompanying nerve being now called the infra-orbital nerve. rom this canal it emerges through the infra-orbital foramen on to

the face, where it has been already described (see p. 1282). The arter is accompanied by the infra-orbital vein. As the artery travers the infra-orbital canal it furnishes (1) *orbital branches* to the structur on the floor of the orbit; and (2) the *anterior superior dental branc* which descends in the anterior dental canals in the maxilla, in compan with the corresponding nerves, to supply the pulps of the upper premol incisor and canine teeth, and the mucous lining of the maxillary sinu

The **greater palatine artery (descending palatine artery)** pass downwards in the greater palatine canal, in company with the great palatine nerve, to the hard palate, where it passes forwards and inwar to the incisive fossa. In this situation it furnishes a branch whic ascends through the incisive canal, to anastomose with a branc of the spheno-palatine artery. As the artery traverses the great palatine canal it gives off the *lesser palatine arteries,* which accompan corresponding nerves in the lesser palatine canals, and supply the so palate and tonsil.

The **artery of the pterygoid canal (Vidian artery)** passes backwar through the pterygoid canal in company with the correspondin nerve, and its branches are: (1) to the upper part of the pharyn (2) to the pharyngo-tympanic tube; and (3) to the tympanum.

The **pharyngeal branch (pterygo-palatine artery),** of small siz passes backwards through the pharyngeal canal in company with th pharyngeal branch of the spheno-palatine ganglion, and is distribute to the upper part of the pharynx, the pharyngo-tympanic tube, and th mucous lining of the corresponding sphenoidal sinus.

The **spheno-palatine artery** enters the superior meatus of the nas cavity through the spheno-palatine foramen. Its branches are dis tributed extensively on the outer wall of the nasal cavity, and suppl the mucous membrane of the maxillary, ethmoidal, and frontal sinuse One branch, called the *posterior septal* (*naso-palatine artery*), descend upon the septum to the incisive canal, where it anastomoses with th terminal ascending branch of the greater palatine artery.

Pterygoid Plexus of Veins.—This is a large plexus which surround the lateral pterygoid muscle. Its tributaries correspond for th most part to the branches of the maxillary artery, and are chiefl as follows: the deep auricular, anterior tympanic, two middle menin geal, inferior dental, masseteric, pterygoid, deep temporal, bucca superior dental, infra-orbital, greater palatine, and spheno-palatine The blood is conveyed away from the plexus by two veins—namely the maxillary and the deep facial.

The **maxillary vein (internal maxillary vein)** is a short vessel whic issues from the posterior part of the plexus, and accompanies th first part of the maxillary artery. Opposite the neck of the mandibl it joins the superficial temporal vein within the parotid gland t form the posterior facial vein.

The **deep facial vein** issues from the anterior part of the ptery goid plexus, and, passing downwards and forwards, it emerges dee to the mandibular ramus and masseter muscle, and joins the anterio

ial vein on the buccinator muscle. The pterygoid plexus communicates with the intracranial cavernous sinus by means of emissary ns, which pass through the foramen ovale, the emissary sphenoidal amen, and foramen lacerum; it communicates with the inferior ithalmic vein at the inferior orbital fissure and with the pterygoid xus behind and below. (above?)

Deep Facial Lymph Glands (Internal Maxillary Lymph Glands).—ese glands lie upon the lateral pterygoid muscle. Their *afferent* ssels are derived from (1) the infratemporal and temporal fossæ; the orbit; (3) the palatal mucous membrane; (4) the nasal cavity part; (5) the cerebral dura mater; and (6) the tympanic cavity. eir *efferent* vessels pass to (1) the deep parotid lymph glands, and the superior deep cervical lymph glands.

Mandibular Nerve (Inferior Maxillary Nerve).—This is the **third ision** of the trigeminal nerve. It is a mixed nerve, and consists two roots—sensory and motor. The *sensory root,* which is of large e, arises from the trigeminal ganglion, and the *motor root* represents entire motor root of the trigeminal nerve. Both roots leave the nial cavity through the foramen ovale, and immediately after their it they unite to form a mixed nerve—that is to say, a nerve composed both sensory and motor fibres. This nerve is very short, and lies eply in the infratemporal fossa, under cover of the lateral pterygoid iscle, where it gives off two branches—namely, the nervus spinosus d the nerve to the medial pterygoid muscle. Then it immediately eaks up into two parts, known as the anterior and posterior trunks. e *nervus spinosus* enters the cranial cavity through the foramen inosum, along with the middle meningeal artery, and divides into o branches—anterior and posterior. The anterior branch is stributed to the adjacent dura mater, and the posterior branch sses through the fissure between the petrous and squamous parts the temporal bone, to be distributed to the mucous lining of the istoid air-cells. The *nerve to the medial pterygoid muscle* arises from deep surface of the undivided mandibular nerve, and passes downrds to enter the deep surface of the medial pterygoid muscle. ose to its origin it is intimately related to the otic ganglion.

Anterior Trunk of the Mandibular Nerve.—This division is smaller an the posterior, and is principally motor in function, the only nsory branch furnished by it being the buccal nerve. Its branches e: (1) masseteric, furnishing the posterior deep temporal; (2) middle ep temporal; and (3) buccal, giving off the lateral pterygoid and terior deep temporal, after which it is purely sensory.

The *masseteric nerve* passes upwards deep to the upper head of e lateral pterygoid muscle, where it furnishes the posterior deep mporal nerve. It then passes outwards over the upper border of e lateral pterygoid, and over the mandibular notch behind the mporalis, to enter the upper part of the masseter on its deep surface.

The *deep temporal nerves* are three in number—anterior, middle, id posterior. The *anterior deep temporal nerve* usually arises from

the buccal after it has passed between the two heads of the later pterygoid. It runs upwards superficial to the upper head of th muscle, and enters the anterior part of the temporalis muscle on i deep surface. The *middle deep temporal nerve* is a direct bran of the anterior trunk of the mandibular, and it ascends beneath t lateral pterygoid to enter the middle part of the temporalis on i deep surface. The *posterior deep temporal nerve* springs from t masseteric nerve beneath the upper head of the lateral pterygoi

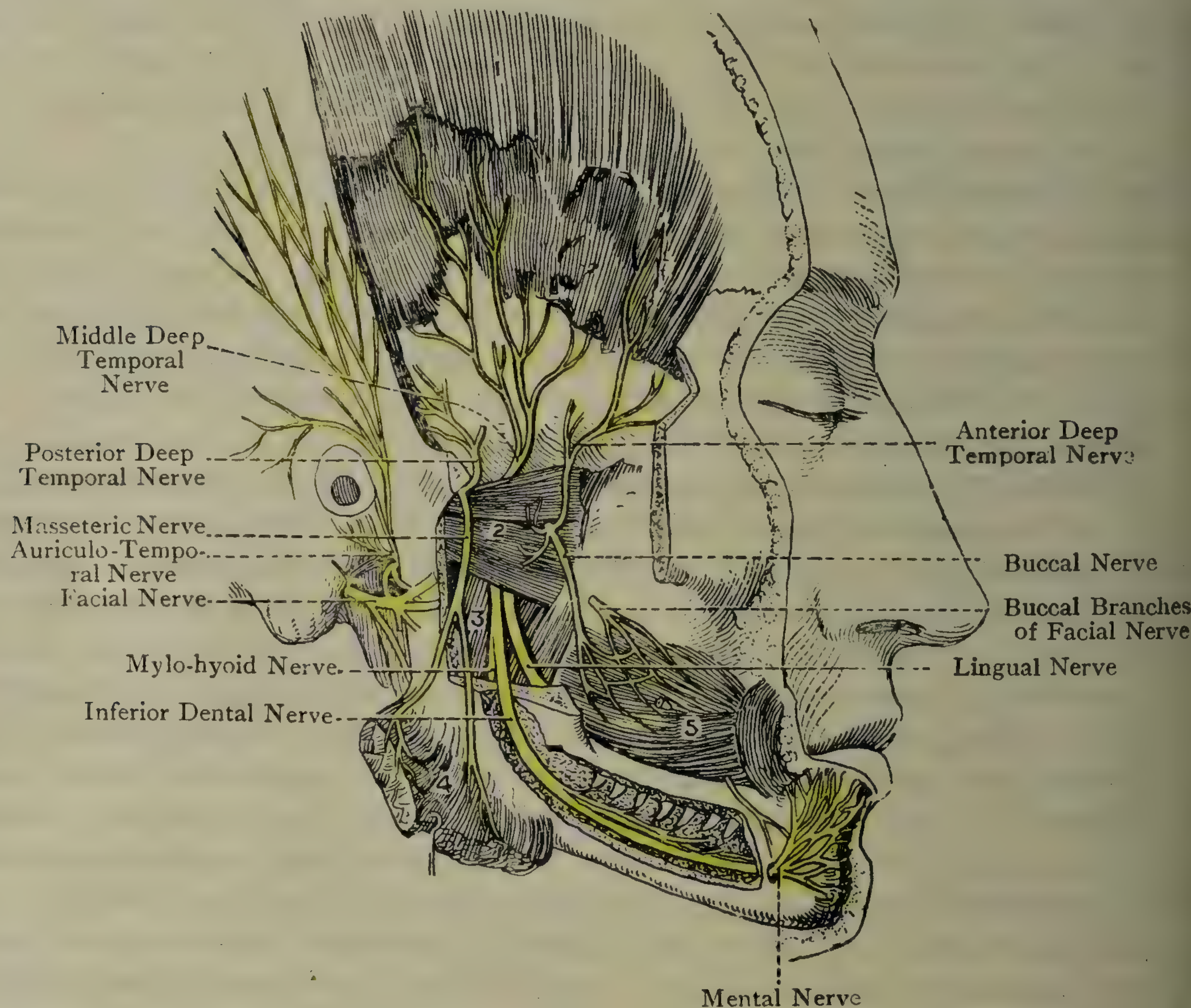


FIG. 793.—THE NERVES OF THE TEMPORAL AND MANDIBULAR REGIONS (HIRSCHFELD AND LEVEILLÉ).

1, temporalis; 2, lateral pterygoid; 3, medial pterygoid; 4, masseter; 5, buccinator.

and, passing upwards, it enters the posterior part of the temporali on its deep surface.

The *buccal nerve* (*long buccal nerve*) passes outwards betwee the two heads of the lateral pterygoid, and then downwards an forwards in contact with the inner surface of the temporalis at it insertion. Having emerged from deep to the mandibular ramus an anterior border of the masseter, it is received upon the outer surfac of the buccinator, where it communicates with the buccal branche of the facial nerve to form the buccal plexus. After this its termin branches are distributed to the skin over the buccinator muscle an

mucous membrane which lines it. The buccal nerve furnishes branches, the lateral pterygoid and the anterior deep temporal ve. The *nerve to the external pterygoid muscle* leaves it near its gin, and enters the lateral pterygoid muscle on its deep surface. *anterior deep temporal nerve* arises from it after it has passed ween the two heads of the lateral pterygoid. These two branches e all the motor fibres from the buccal nerve, which after this is irely sensory.

Posterior Trunk.—This division is larger than the anterior, and ılmost entirely sensory, the only motor fibres which it contains ng destined for the mylo-hyoid branch of the inferior dental nerve. branches are three in number—namely, (1) auriculo-temporal, inferior dental, and (3) lingual.

Auriculo-temporal Nerve.—This nerve, which is sensory, arises two roots, between which the middle meningeal artery ascends the foramen spinosum. Then the two roots join, and the nerve ıs backwards deep to the lateral pterygoid muscle. Having passed se behind the mandibular joint to the interval between that joint l the auricle, it enters the upper part of the parotid gland. It n changes its course and passes upwards, after which it crosses zygoma and descends close behind the superficial temporal artery end in its terminal temporal branches.

Branches of Communication.—(1) Each root of the auriculo-nporal nerve receives a small branch from the otic ganglion. These ınches contain fibres of the glosso-pharyngeal nerve through (*a*) its npanic branch, (*b*) the tympanic plexus, and (*c*) the lesser superficial trosal nerve, which latter is reinforced by a branch from the ganglion the facial nerve. These glosso-pharyngeal fibres are destined for parotid gland. (2) Two communicating branches pass to the ial nerve in the parotid gland.

Branches of Distribution.—(1) *Articular branches* enter the temporo-ındibular joint through the back part of the capsule. (2) *Glandular ınches* are distributed to the parotid gland, to which they conduct res of the glosso-pharyngeal nerve. (3) The *branches to the external ditory meatus*, upper and lower, enter the meatus between its carti-ginous and osseous parts, and supply the skin which lines it, the per branch also giving twigs to the outer layer of the tympanic embrane. (4) *Auricular branches* are distributed to the skin of e tragus and the upper part of the outer surface of the auricle. The stribution of the meatal and auricular branches explains why pain e to affections of the lower teeth may be referred to the ear canal d auricle. (5) The *temporal branches* are terminal. They accom-ıny the branches of the superficial temporal artery, and supply the in of the temporal region as high as the vertex of the skull. They mmunicate with the temporal branches of the facial and the zygo-atico-temporal nerve.

Inferior Dental Nerve.—This nerve, though chiefly sensory, con-ins motor fibres, which, however, leave it in its mylo-hyoid branch.

It passes downwards, being at first under cover of the lateral pteryg muscle. After escaping from beneath that muscle, it descends u the spheno-mandibular ligament and medial pterygoid muscle to mandibular foramen, through which it passes into the mandibular ca after having parted with its mylo-hyoid branch. The lingual ne is anterior and medial to it, and the inferior dental artery is poste and lateral to it. Within the mandibular canal the nerve is acc panied by the inferior dental artery, and, having arrived at the le of the mental foramen, it terminates by dividing into two branch mental and incisive.

Branches.—(1) The **mylo-hyoid nerve** is given off from the par trunk just before it passes through the mandibular foramen. takes all the motor fibres from the parent trunk, and in compa

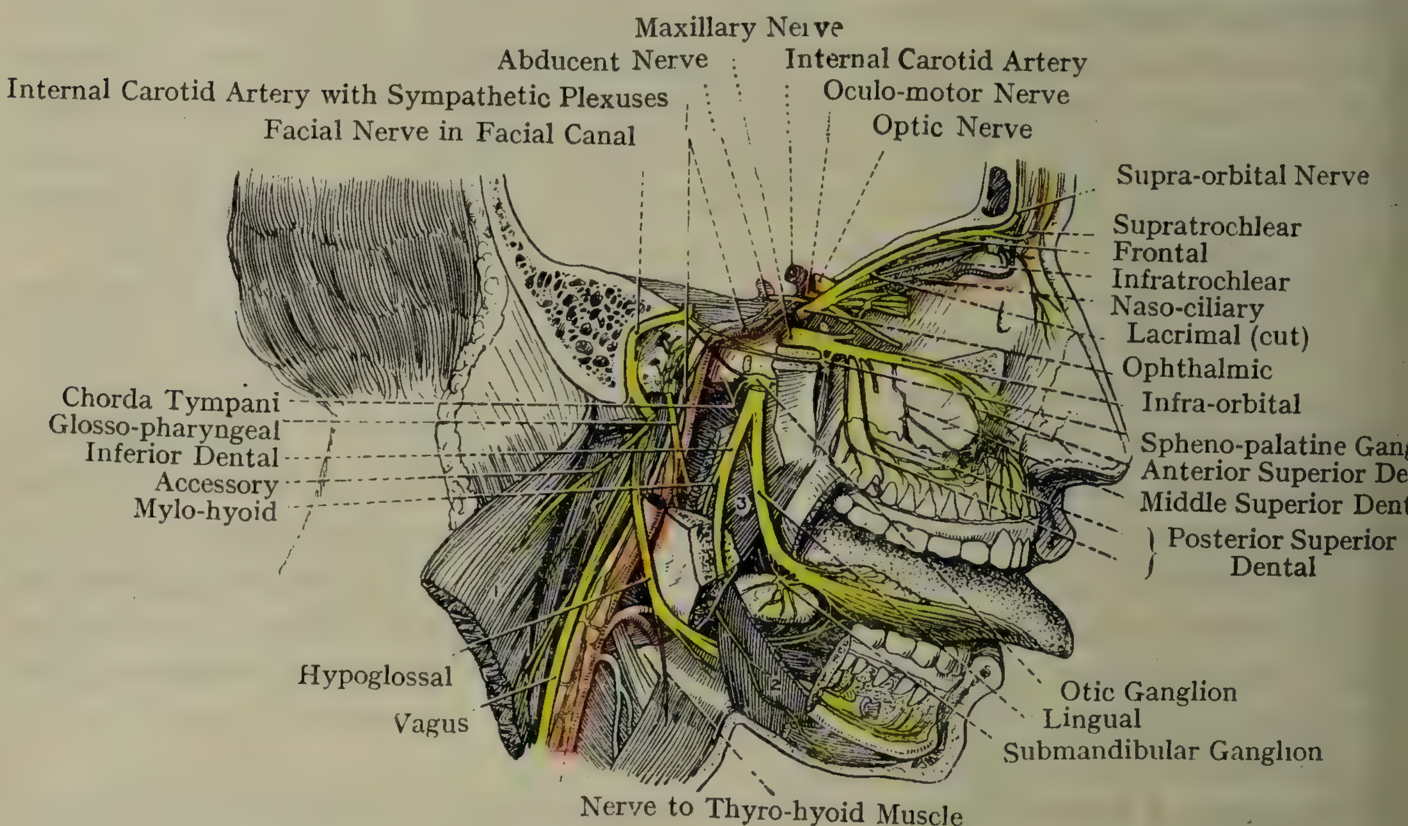


FIG. 794.—GENERAL VIEW OF THE TRIGEMINAL NERVE (HIRSCHFELD AND LEVEILLÉ.

1, sterno-mastoid; 2, mylo-hyoid; 3, medial pterygoid.

with the mylo-hyoid branch of the inferior dental artery pierces t lower part of the spheno-mandibular ligament, and then passes dow wards and forwards in the mylo-hyoid groove of the mandible. T nerve and artery are maintained in position within this groove by expansion from the lower part of the spheno-mandibular ligame which is attached to the lips of the groove. Then the nerve pass forwards on the inferior surface of the mylo-hyoid muscle und cover of the superficial part of the submandibular gland. Havi furnished twigs to the mylo-hyoid muscle, it terminates in the anteri belly of the digastric.

(2) The **dental branches** arise from the parent trunk, whilst traverses the mandibular canal. They communicate with each oth to form a delicate plexus, from which branches are given off to t

s of the lower molar and premolar teeth, as well as to the adjacent of the gum. The pulp branches correspond in number to the s of the teeth, and each enters through a minute opening on the emity of the fang.

3) The **mental nerve** is one of the two terminal branches. It rges from the mandibular canal through the mental foramen. its distribution, see p. 1277.

4) The **incisive branch** is the termination of the inferior dental. egins at the level of the mental foramen, and passes almost ar as the middle line. Its dental branches communicate in a iform manner, and supply the pulps of the lower canine and sor teeth, as well as the adjacent portion of the gum.

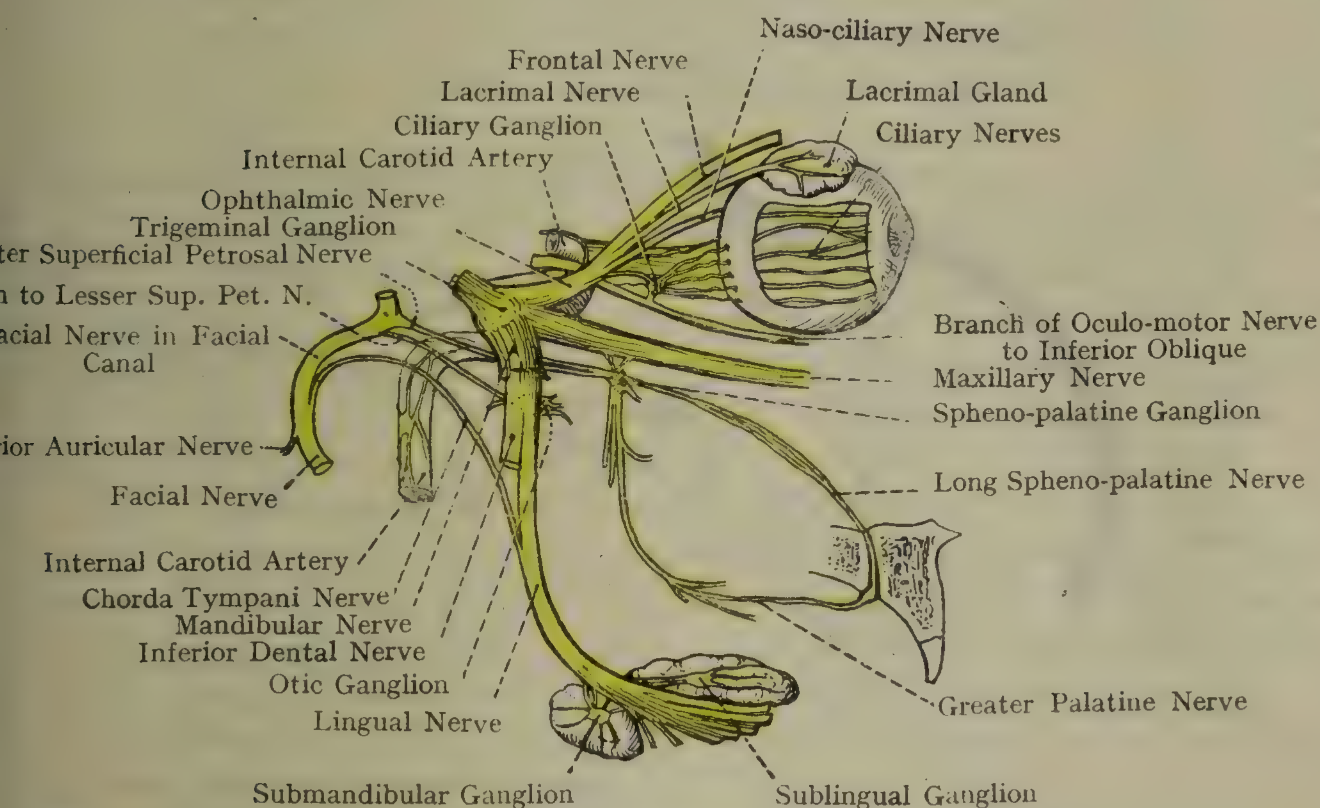


FIG. 795.—SCHEME OF THE TRIGEMINAL NERVE AND ITS GANGLIA (HIRSCHFELD AND LEVEILLÉ.)

Lingual Nerve.—This nerve is sensory. It descends deep to the ral pterygoid muscle, lying anterior and medial to the inferior :al nerve. Whilst under cover of that muscle it receives near its in the chorda tympani nerve, which joins it from behind at an e angle, in a direction downwards and forwards, after leaving tympanic cavity through the anterior canaliculus for the chorda pani nerve. Below the lateral pterygoid muscle the lingual nerve es downwards and forwards between the medial pterygoid muscle the mandibular ramus, and over the mandibular fibres of the rior constrictor muscle. Below the level of the third lower molar h it lies immediately beneath the mucous membrane of the mouth, is here easily reached. It then crosses the stylo-glossus, and es forwards superficial to the hyo-glossus close to the side of the gue. Upon the latter muscle it describes a slight curve with the vexity downwards. It then passes deep to the mylo-hyoid muscle,

where it lies above the deep part of the submandibular gland a the submandibular duct, and has the submandibular ganglion s pended from it. Finally, having looped under the submandibu duct from without inwards, it continues its course as far as the tip the tongue. As it passes along the side of the tongue the nerve immediately beneath the mucous membrane.

Branches of Communication.—(1) *Chorda tympani* (sensory facial); (2) two branches to the submandibular ganglion; and (3) or two filaments to the hypoglossal nerve at the anterior border the hyo-glossus muscle.

Branches of Distribution.—(1) *Buccal,* to the mucous membra of the floor of the mouth and of the gums; (2) *glandular,* to the su

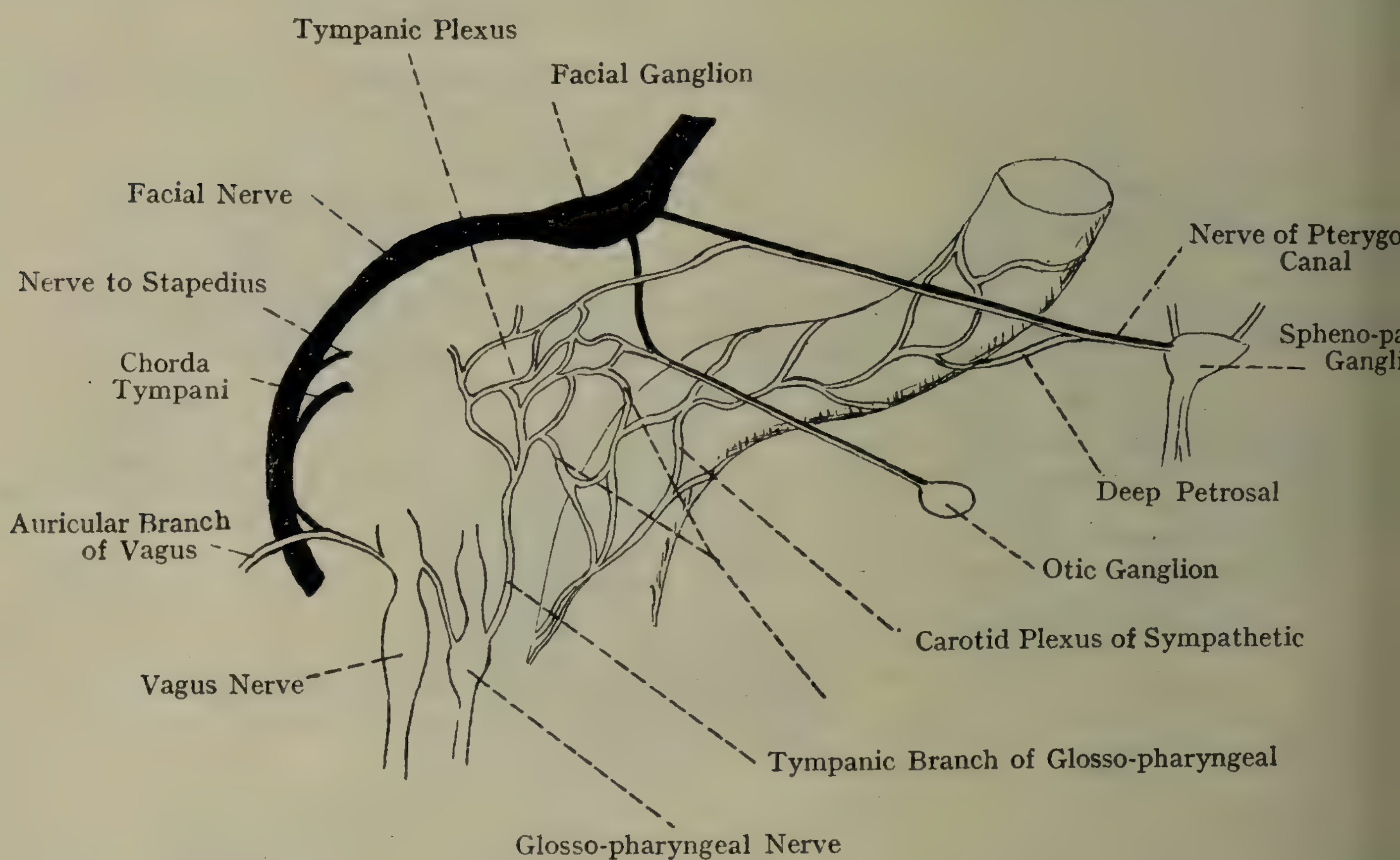


FIG. 796.—RELATIONS OF THE PETROUS PART OF THE INTERNAL CAROTI ARTERY.

lingual gland; and (3) *lingual,* to the mucous membrane of the si and dorsum of the tongue over its *anterior two-thirds.* These lingu branches pierce the muscular tissue of the tongue, and are destin chiefly for the filiform and fungiform papillæ.

Otic Ganglion.—The otic ganglion is a small oval body, of a pink colour, which is situated close to the foramen ovale on the deep surfa of the mandibular nerve at the place of origin of the nerve to t internal pterygoid muscle, with which it is closely connected. It h the middle meningeal artery behind it, and the cartilaginous part the pharyngo-tympanic tube on its inner side. The ganglion h three roots. One root (motor-sensory) is derived from the nerve internal pterygoid (motor and probably sensory fibres). A seco root (sensory-motor) is represented by the lesser superficial petro

ve, which joins the back part of the ganglion. The sensory fibres e from the glosso-pharyngeal by means of (1) the tympanic nerve, the tympanic plexus, and (3) the lesser superficial petrosal. The or fibres conveyed by this root come from the ganglion of the facial ve through the branch which that ganglion gives to join the lesser erficial petrosal nerve. The third root (sympathetic) comes from sympathetic plexus around the middle meningeal artery.

Branches—(1) **Of Communication.**—(*a*) Two branches pass to the iculo-temporal nerve, one to each root. These carry secretory sso-pharyngeal fibres which are destined for the parotid gland. A branch joins the chorda tympani. (*c*) A branch joins the nerve he pterygoid canal.

(2) **Of Distribution.**—Muscular branches are said to be given to tensor tympani and tensor palati, though the modern view is that h these nerves are direct branches of the nerve to the internal rygoid muscle.

Submandibular Ganglion (Submaxillary Ganglion).—This ganglion f small size, and is connected with the lingual nerve in the sub-ndibular region. It is situated upon the upper part of the hyo-ssus muscle, between the lingual nerve and the deep part of the mandibular gland, and under cover of the posterior part of the lo-hyoid muscle. It is suspended from the lingual nerve by two necting branches, posterior and anterior, which stand apart from h other. The **posterior connecting branch,** sometimes broken up two or three twigs, conveys *sensory fibres* from the chorda tympani nsory portion of the facial) and lingual nerves, the latter being a nch of the mandibular nerve. The **anterior connecting branch** resents fibres passing *from the ganglion to the lingual nerve.*

The *posterior branch* consists of fibres which are derived from the rda tympani of the facial, and from the lingual nerve. This terior branch may exist as two twigs. The *anterior branch* is an et from the ganglion to join the lingual. The sympathetic root of ganglion is derived from the plexus on the cervical portion of the al artery.

Roots of the Submandibular Ganglion.

Secretory.	Sensory.	Sympathetic.
m chorda tympani of facial.	From lingual.	From plexus on cervical portion of facial artery.

The submandibular ganglion has three roots—secretory, sensory, l sympathetic. The **secretory root** comes from the chorda tympani ve; the **sensory root** from the lingual nerve; and the **sympathetic t** from the plexus on the cervical portion of the facial artery. The retory and sensory roots are the posterior connecting branch of the nglion.

Branches.—These proceed from the lower and anterior parts of ganglion, and are as follows: (1) glandular, to the submandibular nd; (2) branches to the submandibular duct; (3) buccal, to the

mucous membrane of the floor of the mouth; and (4) an anter connecting branch, which passes to the lingual nerve. The anter connecting branch probably consists of both chorda tympani a lingual fibres, and it accompanies the lingual nerve to the tongue. furnishes twigs to the sublingual gland, and a small ganglion associa with these twigs has been described under the name of the subling ganglion.

Summary of the Mandibular Nerve—1. **Cutaneous Distribution.**—It supp (1) a portion of the dura mater, and the mucous membrane of the mast air-cells; (2) the skin over the greater part of the temporal region; (3) the s of the external auditory meatus, and the outer surface of the tympanic me brane; (4) the skin of the tragus, and of the upper part of the outer surface the auricle; (5) the skin over the body of the mandible, including the skin the chin and lower lip, as well as the mucous membrane of the lower lip; (6) mucous membrane of the floor of the mouth, and the lower gum; and (7) sides and dorsum of the tongue over its anterior two-thirds. 2. **Articular I tribution.**—It supplies the mandibular joint. 3. **Dental Distribution.**—It s plies the pulps of all the lower teeth of one side, and the mucous membr of the outer surface of the lower gum of one side. 4. **Glandular Distribution.**– gives branches to the parotid, submandibular, and sublingual glands. 5. **M cular Distribution.**—It supplies (1) the muscles of mastication—namely, masseter, temporal, lateral pterygoid, and medial pterygoid; (2) the mylo-hy and anterior belly of the digastric; and (3) the tensor palati and tensor tympa

The Mandibular Joint.

The mandibular joint belongs to the class of **synovial joints,** a to the subdivision of **hinge joints.** The articular surfaces are (1) t anterior part of the articular fossa in front of the squamo-tympa fissure, and (2) the head of the mandible.

Ligaments.—The **capsular ligament** consists of scattered fibr which form a thin loose investment to the joint on its anterior, medi and posterior aspects, being completed on the outer aspect by t temporo-mandibular ligament.

The **temporo-mandibular ligament** (**external lateral ligament**) is short strong bundle of fibres, which is attached above to the tuber of root of the zygoma, and below to the condylar tubercle and the out and back part of the neck of the mandible. Its fibres are direct obliquely downwards and backwards. This ligament forms the later portion of the capsular ligament.

The **spheno-mandibular ligament** (**long internal lateral ligament**) a long flat band, which stands off from the joint, and therefore has direct relation to it. It is somewhat triangular, being narrow abo and broad below. Superiorly it is attached to the spine of the spheno bone, and inferiorly to the lingula and the inner margin of the mandibul foramen. Its fibres are directed downwards and slightly forwar The first part of the maxillary artery separates it from the neck the mandible; and inferiorly the inferior dental vessels and ner intervene between it and the ramus of the mandible. At its low attachment it is spread over the upper end of the mylo-hyoid groo and is here pierced by the mylo-hyoid nerve and artery. The maxilla

ery and the auriculo-temporal nerve pass between the temporo-ndibular and spheno-mandibular ligaments.

The spheno-mandibular ligament is formed beside the skeletal bar of the visceral arch.

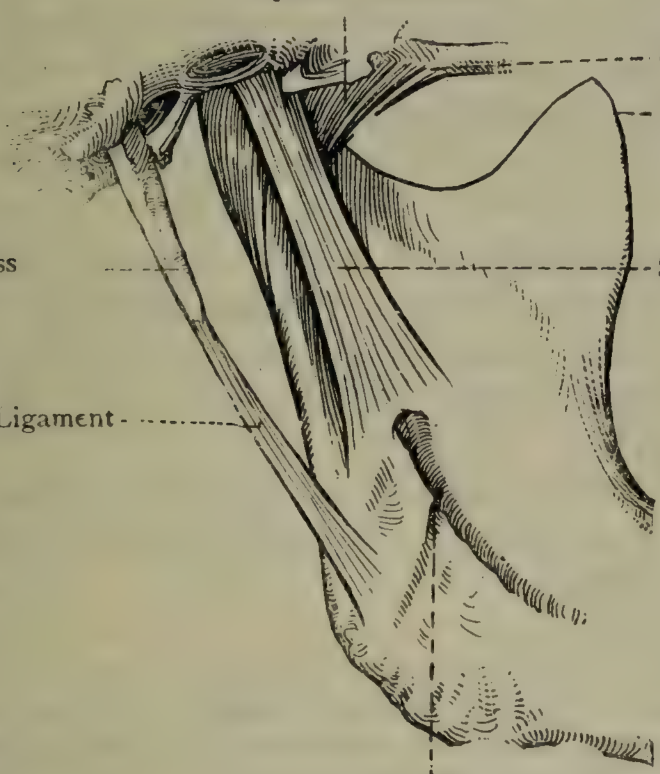


FIG. 797.—THE MANDIBULAR JOINT (MEDIAL ASPECT).

The **stylo-mandibular ligament** is a stout process of the deep cervical cia, which extends from the styloid process of the temporal bone r its tip to the angle and adjacent portion of the posterior border

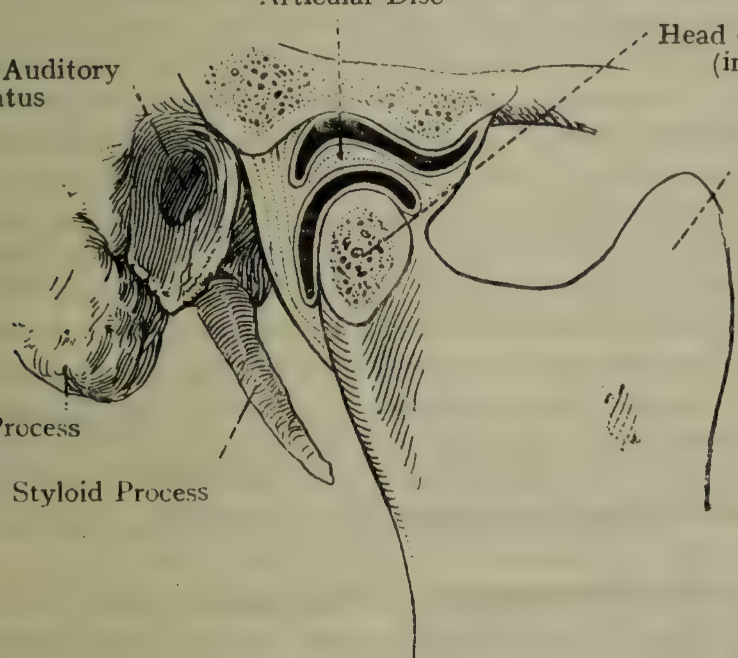


FIG. 798.—THE MANDIBULAR JOINT OPENED (LATERAL ASPECT).

the ramus of the mandible. Superiorly it gives origin to a few res of the stylo-glossus and inferiorly it is implanted between the sseter and medial pterygoid muscles. It separates the submanbular gland from the lower portion of the parotid gland.

The **articular disc** is an oval plate which is interposed between tl two articular surfaces. It is thinnest at the centre, where it is occ sionally perforated, and thickest posteriorly. Its superior surface concavo-convex from before backwards, in adaptation to the co vexity of the articular eminence and the concavity of the articul fossa. Its inferior surface is concave, and fits upon the head of tl mandible. Its circumference is connected with the capsular ligamer and anteriorly it gives partial insertion to the lateral pterygoid muscl It divides the joint into two compartments, upper and lower, whi are usually distinct.

The **synovial membranes** are two in number, upper and lower, o being above and the other below the articular disc. The upper synovi membrane is larger and looser than the lower, and when the articul disc is perforated at the centre, the two synovial cavities are continuo through the perforation.

Arterial Supply.—The superficial temporal artery chiefly.

Nerve-supply.—The auriculo-temporal nerve and offsets from tl masseteric nerve.

Movements.—These are as follows: (1) depression, (2) elevation, (3) protra tion, (4) retraction, and (5) lateral movements. There being two divisions the joint, upper and lower, different movements occur in each. The moveme in the *upper compartment* is of a **gliding** character, whilst in the *lower compartme* it is of a **hinge** character. When the mandible is depressed, as in opening tl mouth, the head and the articular disc move forwards on to the articular eminenc In cases of over-depression, as in violent yawning, or forcing too large a boc into the mouth, the head is apt to slip over the articular eminence into tl infratemporal fossa, and when this takes place dislocation of the mandible the result. The movement of forward gliding on the part of the head ar articular disc during depression takes place in the upper compartment of tl joint. Another movement, however, of a hinge character is taking place in tl lower compartment of the joint between the head and the articular disc. This co sists in the head rotating on the under surface of the plate round a transverse axi

When the mandible is elevated, as in shutting the mouth, the changes whi occur in both compartments of the joint are the reverse of those just describ as taking place in depression. The head and articular disc glide backwar into the articular fossa, and at the same time the head rotates back to its previo position. In protraction, as when the lower incisors are protruded beyond tl upper, and in retraction, the movement mainly takes place in the upper cor partment of the joint, and consists in the head and the articular disc glidi forwards and backwards. When these movements are performed alternate on each side the lateral oblique movements, as in grinding or chewing, take plac and the head and the articular disc of one side move forwards and backward whilst the other head and the articular disc move in the opposite directio During these movements **oblique rotation** is taking place in the lower compar ment of the joint.

Muscles concerned in the Movements.—**Depression** is effected by the platysm mylo-hyoid, anterior belly of the digastric, and genio-hyoid muscles; and **elev tion** by the anterior fibres of the temporal, masseter, and medial pterygo muscles. **Protraction** is produced by the lateral pterygoid, the superficial fibr of the masseter, and slightly by the medial pterygoid; and **retraction** by tl posterior fibres of the temporal and the deep fibres of the masseter. The **grindi movement** is effected by the lateral pterygoid muscles acting alternately. Tl axis of the movement in opening and closing the mouth passes through tl mandibular foramina.

The Maxillary Nerve.

The maxillary nerve is the second division of the trigeminal nerve, l in size is intermediate between the mandibular and the ophthalmic. is entirely sensory, and arises from the trigeminal ganglion. Its irse is forwards to the foramen rotundum, by which it leaves the nial cavity. Then it enters the posterior part of the pterygo-atine fossa, and crosses the upper part of that fossa to the inferior ital fissure, through which it passes on to the floor of the orbit. It v takes the name of the **infra-orbital nerve,** and traverses the infra-ital groove, and then the infra-orbital canal, on the floor of the it. Finally, it leaves this canal through the infra-orbital foramen der cover of the levator labii superioris, and ends in its terminal nches. The course of the maxillary nerve and its continuation, infra-orbital nerve, is almost directly forwards, with a slight lination outwards just before the orbit is entered.

Branches.—These are as follows:

Intracranial.
Meningeal.

In Infra-orbital Canal.
Middle superior dental.
Anterior superior dental.

In the Pterygo-palatine Fossa.
Zygomatic.
Ganglionic.
Posterior superior dental.

On the Face.
Palpebral.
Nasal.
Labial.

The **meningeal branch** supplies the dura mater of the middle anial fossa.

The **zygomatic nerve (temporo-malar nerve)** is the first branch of e maxillary in the pterygo-palatine fossa. It arises from its upper rface, and enters the orbit through the inferior orbital fissure. For further course, see p. 1259.

The **ganglionic branches (spheno-palatine nerves)** are two in number. ey arise from the lower aspect of the parent trunk, and, after a ry short descending course, they end for the most part in the spheno-latine ganglion, to which they convey sensory fibres, and of which ey are the sensory roots. Many of their fibres, however, pass clear the grey matter of the ganglion, and are prolonged into the nasal d palatine branches of the ganglion.

The **posterior superior dental branches** arise from the maxillary as is about to pass through the inferior orbital fissure. They are ually two in number, but sometimes they arise by a single trunk. hey descend in grooves on the posterior surface of the maxilla in mpany with branches of the posterior superior dental artery, and ve off branches to the gum and contiguous parts of the mucous embrane of the cheek. Then they traverse the posterior dental nals, and within the substance of the bone communicate with each her and with the middle superior dental nerve to form a delicate exus, from which branches are given off to the pulps of the three

upper molar teeth. Slender filaments are also furnished to the muc membrane lining the maxillary sinus.

The **middle superior dental branch** arises from the main trunk it lies in the infra-orbital groove near the inferior orbital fissure. descends in the middle dental canal of the maxilla. Its branc communicate with each other, and with the posterior superior a anterior superior dental branches within the substance of the bo to form a delicate plexus, from which branches are given to the pu of the upper two premolar teeth and to the gum. This nerve a furnishes delicate filaments to the mucous membrane lining t maxillary sinus. Two enlargements are described in connection w the middle superior dental branch. One is situated at its communi tion with the posterior superior dental branch, and is known as t *ganglion of Valentin*; and the other at its communication with t anterior superior dental, this one being known as the *ganglion Bochdalek*.

The **anterior superior dental branch** arises from the infra-orbi nerve near the front part of the infra-orbital canal, and descends, company with the anterior superior dental artery, in the anterior den canal. Its branches communicate with each other, and with the mid superior dental branch, to form a delicate plexus, from which branch are given to the pulps of the upper canine and incisor teeth. T nerve also furnishes delicate filaments to the mucous membrane lini the maxillary sinus, and a nasal branch, which enters the nasal cav and supplies the mucous membrane of the anterior part of the infer meatus and adjacent portion of the inferior nasal concha.

The **facial branches** of the infra-orbital nerve—palpebral, nas and labial—have been already described (see p. 1276).

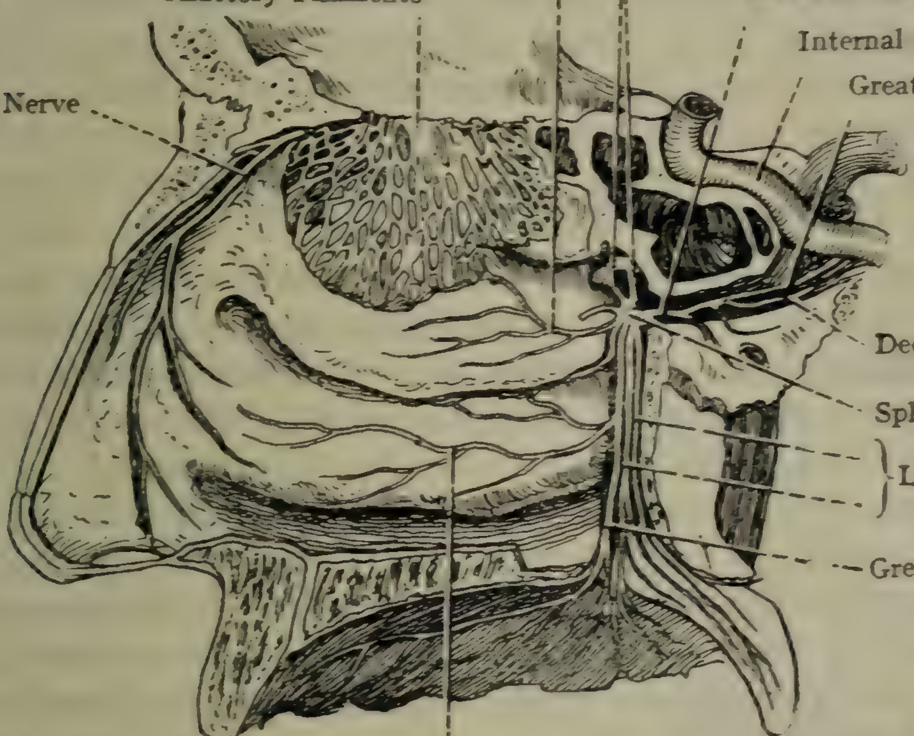
It is to be noted that there are three superior dental branch the *posterior* being a branch of the maxillary, and the *middle* and *anter* being branches of the infra-orbital; whilst there is only one infer dental nerve, which is a branch of the mandibular.

Spheno-palatine Ganglion (Meckel's Ganglion).—It is a sm triangular, somewhat reddish body, situated in the upper part of t pterygo-palatine fossa close to the spheno-palatine foramen, whi leads through the inner wall of the fossa to the superior meatus of t nasal cavity. It is suspended from the maxillary nerve by some the fibres of the two ganglionic branches of that nerve, many fibr of these two branches passing clear of the grey matter of the gangli into its nasal and palatine branches. The fibres conveyed to t grey matter of the ganglion by the two ganglionic branches represe its *sensory root* or *roots*.

The ganglion has sensory and sympathetic roots, but no mot root. The **sensory roots** are derived from *two* sources—maxillary an facial. The **maxillary sensory root-fibres** form two bundles, an represent portions of the *two ganglionic branches*, by which the ganglio is suspended from the trunk of the maxillary nerve in the pteryg palatine fossa. The **facial sensory root-fibres** are represented by th

ater superficial petrosal nerve, which is a branch of the ganglion the facial nerve. The **sympathetic root** is formed by the *deep rosal nerve* from the carotid plexus of the sympathetic.

The facial sensory root (greater superficial petrosal) and the sym-hetic root (deep petrosal) join to form the *nerve of the pterygoid al* in the foramen lacerum. After traversing the pterygoid canal n behind forwards, the nerve enters the pterygo-palatine fossa l joins the back part of the spheno-palatine ganglion. In the rygoid canal the nerve gives off one or two nasal branches, which s through the floor of the canal, and are distributed to the mucous mbrane of the posterior part of the roof of the nasal cavity and acent part of the septum.



. 799.—NERVES OF THE NASAL CAVITY, AND THE SPHENO-PALATINE GANGLION, WITH ITS BRANCHES (MEDIAL ASPECT) (HIRSCHFELD AND LEVEILLÉ).

Branches of the Spheno-palatine Ganglion.—These are arranged in r sets:

scending.	Posterior.	Medial.	Descending.
Orbital.	Pharyngeal. Nerve of ptery-goid canal.	Short spheno-palatine. Long spheno-palatine.	Greater palatine. Lesser palatine.

Ascending Branches.—**Orbital branches** are two or three in number, d enter the orbit through the inferior orbital fissure to be distributed the periosteum. They have been described by Luschka as sending ments through the inner wall of the orbit to supply the mucous mbrane of the posterior ethmoidal and sphenoidal sinuses.

Posterior branches are the pharyngeal nerve and the nerve of the erygoid canal. The **pharyngeal nerve** passes backwards in the

palato-vaginal canal along with the pharyngeal branch of the maxillar artery, and is distributed to the mucous membrane of the upp part of the pharynx in the region of the orifice of the pharyng tympanic tube.

Medial branches are the long and short spheno-palatine nerve The **short spheno-palatine nerves** (**superior nasal nerves**) are of sma size, and derive some of their fibres from the ganglionic branches the maxillary nerve. They are about six in number, and, springin from the inner part of the ganglion, they enter the superior meatus the nose through the spheno-palatine foramen. They supply th mucous membrane of the superior and middle conchæ, the superi meatus, the posterior ethmoidal sinus, the middle meatus, and th upper and back part of the septum.

The **long spheno-palatine nerve** (**naso-palatine nerve**) enters th nasal cavity along with the short spheno-palatine nerves. It cross the roof of the cavity, and then passes downwards and forwards upo the septum, lying in the groove on the lateral surface of the vome Having arrived at the incisor crest, the left long spheno-palatin nerve descends through the anterior incisive canal, and the righ descends through the posterior. Having reached the incisive foss in this manner, the two nerves communicate in a plexiform manne and delicate filaments are furnished to the mucous membrane of th hard palate behind the incisor teeth. In this situation communica tions are established with the greater palatine nerve of each sid As the long spheno-palatine nerve traverses the groove on the later surface of the vomer, it furnishes twigs to the mucous membrane the nasal septum, and in this part of its course it is accompanied b the posterior septal branch of the spheno-palatine artery; but th artery does not accompany it through the median incisive canal.

Descending branches are the greater and lesser palatine nerve They arise from the lower part of the ganglion, usually by a commo trunk, and they derive some of their fibres from the ganglionic branch of the maxillary nerve.

The **greater palatine nerve** descends in the greater palatine cana and escapes from it through the greater palatine foramen. Then divides into branches which pass forwards and inwards, occupyin grooves on the hard palate, to the mucous membrane and glands which, as well as to the mucous membrane of the upper gum on i inner aspect, they are distributed. In the region of the incisive foss this nerve communicates with the long spheno-palatine nerve. A it descends in the greater palatine canal it furnishes **nasal branche** which enter the nasal cavity, and are distributed to the muco membrane over the inferior concha, except anteriorly, and to that the adjacent portion of the inferior meatus. The **lesser palatine nerv** descend in the lesser palatine canal, after emerging from which the are distributed to the mucous membrane of the soft palate and tonsi They have been said to furnish branches to the levator palati an musculus uvulæ, the fibres of these branches being derived from th

iiculate ganglion of the facial through the great superficial petrosal, ich contributes to the formation of the nerve of the pterysoid canal, d conveys motor fibres to the ganglion. The two muscles in question, wever, are supplied by the bulbar part of the accessory nerve through the pharyngeal plexus.

Summary of the Maxillary Nerve and the Spheno-palatine Ganglion.—1. Cuieous Distribution.—(1) The skin of the anterior part of the temporal region, d over the zygomatic bone; (2) the skin from the lower eyelid down to the per lip, including the skin of the side of the nose; (3) the mucous membrane the naso-pharynx in the vicinity of the orifice of the pharyngo-tympanic; the mucous membrane of the nasal cavity; (5) the mucous membrane of the xillary sinus; (6) the mucous membrane of the soft palate and tonsil; and the mucous membrane of the hard palate, with its glands, and that of the ier surface of the upper gum. 2. **Dental Distribution.**—The pulps of all the per teeth of one side, as well as the mucous membrane of the outer surface of upper gum.

In addition to the foregoing, the maxillary nerve supplies the periosteum of orbit, and the dura mater of the middle cranial fossa.

Deep Dissection of the Neck.

Stylo-pharyngeus—*Origin.*—The base of the styloid process of the mporal bone on its inner aspect.

Insertion.—(1) The posterior border of the lamina of the thyroid rtilage, and (2) the lateral wall of the pharynx, its fibres blending th those of the palato-iaryngeus and middle con-rictor muscles.

Nerve-supply.—The glosso-iaryngeal nerve.

The muscle is directed wnwards and inwards.

Action.—To elevate the iarynx and larynx.

The muscle passes between e superior and middle con-rictor muscles. The glosso-iaryngeal nerve lies at first ong its posterior border, and ien becomes lateral, on its ay to the posterior part of e tongue.

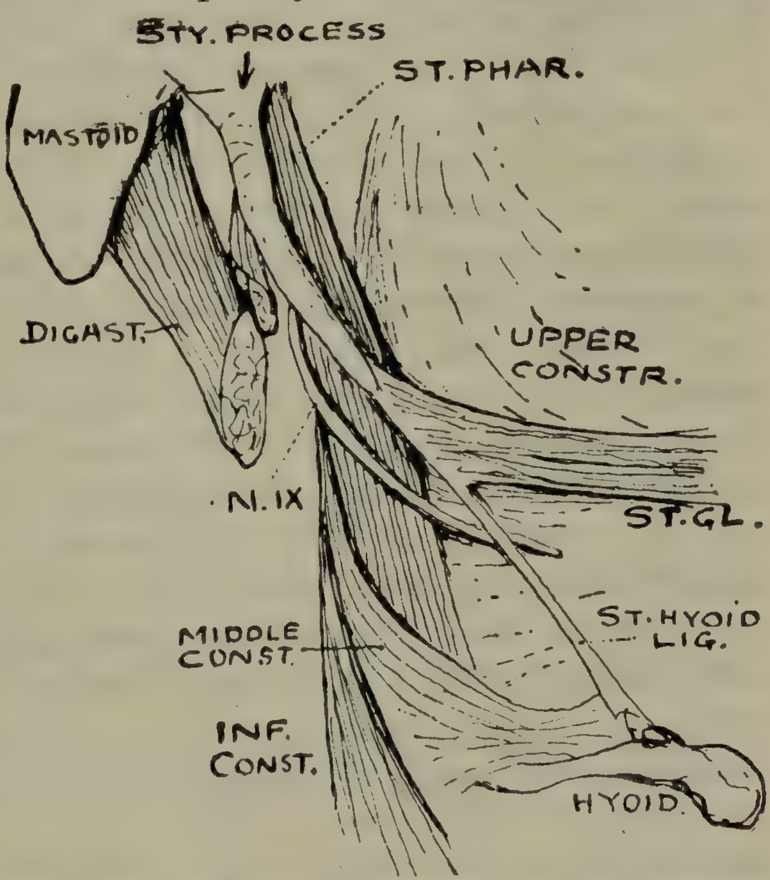


FIG. 800.—THE GROUP OF MUSCLES ASSOCIATED WITH THE STYLOID PROCESS AND LIGAMENT (RIGHT SIDE).

Internal Carotid Artery.—he internal carotid artery is ie of the terminal branches the common carotid. It gins on a level with the pper border of the thyroid cartilage, and passes upwards to the nder surface of the petrous part of the temporal bone. Here it nters the carotid canal within the petrous portion of the temporal

bone, and, after traversing this canal, it enters the cranial cavit The vessel is divided into three parts—cervical, petrous, and cavernou

The Cervical Part.—This part of the vessel extends from the level the upper border of the thyroid cartilage to the carotid canal on t inferior surface of the petrous part of the temporal bone. Its cour is upwards, and at first it lies in the carotid triangle, where it is plac lateral to and behind the external carotid artery.

Relations—*Superficial.*—This part of the vessel is comparative superficial, being covered by the integument, platysma, and stern mastoid, the latter overlapping it. After leaving the carotid trian the artery becomes deeply placed, and passes deep to the posteri belly of the digastric and stylo-hyoid muscles, parotid gland, stylo process, and stylo-pharyngeus muscle. In this part of its cour the vessel is crossed by the hypoglossal, accessory, and glosso-phary geal nerves, and the pharyngeal branch of the vagus, and by t occipital and posterior auricular arteries. The relation of the arte to the external carotid here undergoes a change. The level where t change takes place is as the internal carotid passes deep to the stylo process of the temporal bone, and the change consists in the extern carotid taking up a position directly anterior to the internal caroti The two arteries are, however, separated from each other by the follo ing structures: (1) the styloid process or stylo-hyoid ligament; (2) t stylo-pharyngeus muscle; (3) the glosso-pharyngeal nerve; (4) t pharyngeal branch of the vagus; and (5) the parotid gland.

Posterior.—The longus capitis, the superior cervical ganglion the sympathetic, and the superior laryngeal branch of the vagus.

Lateral.—The internal jugular vein and vagus nerve, the ner being on a plane posterior to both artery and vein. These thr structures are still surrounded by a sheath which is an upward e tension of the carotid sheath previously described. Close to t base of the skull the glosso-pharyngeal, accessory, and hypogloss nerves lie between the internal artery and the internal jugular vei The glosso-pharyngeal nerve soon passes forwards superficial to t artery, the accessory nerve passes backwards superficial to the vei and the hypoglossal nerve passes forwards superficial to the arte at the lower border of the posterior belly of the digastric muscle.

Medial.—The ascending pharyngeal artery, the lateral wall the pharynx, the tonsil, and the superior laryngeal nerve.

Development.—The internal carotid artery is developed from the thi aortic arch and the part of the dorsal aorta in front of this arch.

The Glosso-pharyngeal Nerve.

The glosso-pharyngeal or ninth cranial nerve is a mixed nerv consisting of both afferent or sensory and efferent or motor fibre It leaves the cranial cavity through the middle compartment of t jugular foramen, along with the vagus and accessory nerves, b enclosed in a separate sheath of the dura mater, and lying anteri

these two nerves. In passing through the jugular foramen the ve has two ganglia, the upper one, which is small and situated the upper part of the foramen, being called the *superior ganglion gular ganglion*); and the lower one, which is rather larger, being led the *inferior ganglion* (*petrous ganglion*). The latter is about ich in length, and lies in the lower part of the foramen, where it upies a groove on the petrous portion of temporal bone. After leaving the jugular amen, the nerve at first descends between internal carotid artery and internal jugular n, being lateral to the vagus nerve. It n passes downwards and forwards in front the internal carotid artery, and under er of the styloid process, stylo-pharyngeus scle, and external carotid artery. It next ves round the hinder border of the stylo-aryngeus, and crosses it (Fig. 800) super-ally in a forward direction. Finally, it sses deep to the hyo-glossus muscle, and reaches the posterior third of the tongue, ere it divides into its terminal branches.

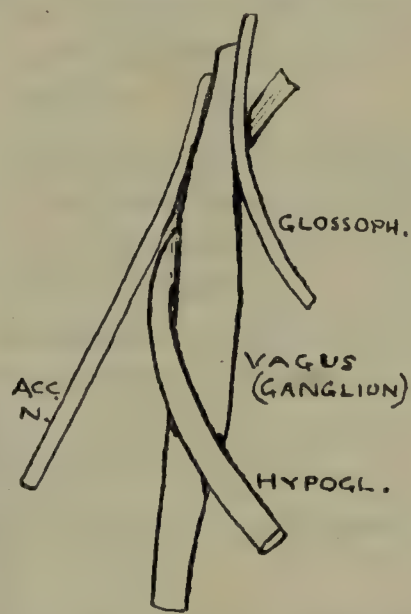


FIG. 801.—SKETCH SHOWING THE RELATIONS BETWEEN NINTH, TENTH, ELEVENTH, AND TWELFTH NERVES, IN CAROTID SHEATH JUST BELOW SKULL.

The **superior ganglion (jugular ganglion)**, as ted, is very small, and involves only a few the fibres of the nerve, the other fibres ssing clear of, but close to, the ganglion, d being continued into the nerve beyond it. is ganglion neither gives nor receives any branches, and is some-ies absent.

The **inferior ganglion (petrous ganglion)**, unlike the jugular, in-ves all the fibres of the nerve, and it furnishes connecting branches d the tympanic nerve.

Branches of the Glosso-pharyngeal Nerve—1. **From the Inferior nglion**—(*a*) *Branches of Communication.*—One to the superior cervical iglion of the sympathetic; one to the auricular branch of the superior iglion of the vagus; and one to the superior of the vagus.

(*b*) *Branch of Distribution.*—This is called the *tympanic nerve rve of Jacobson*). After leaving the inferior ganglion it ascends, company with the tympanic branch of the ascending pharyngeal ery, through the canaliculus for the tympanic nerve. In this y it enters the tympanic cavity at the junction of the inner wall and or, and ascends upon the inner wall. Being joined by the carotico-npanic branch of the carotid plexus of the sympathetic, it breaks into branches which occupy grooves upon the promontory and m the *tympanic plexus*. From this plexus the tympanic nerve erges under the name of the lesser superficial petrosal nerve, which ves the tympanic cavity and traverses a minute canal in the petrous ne, passing in its course beneath the upper portion of the canal ich lodges the tensor tympani muscle. Whilst in this canal it is

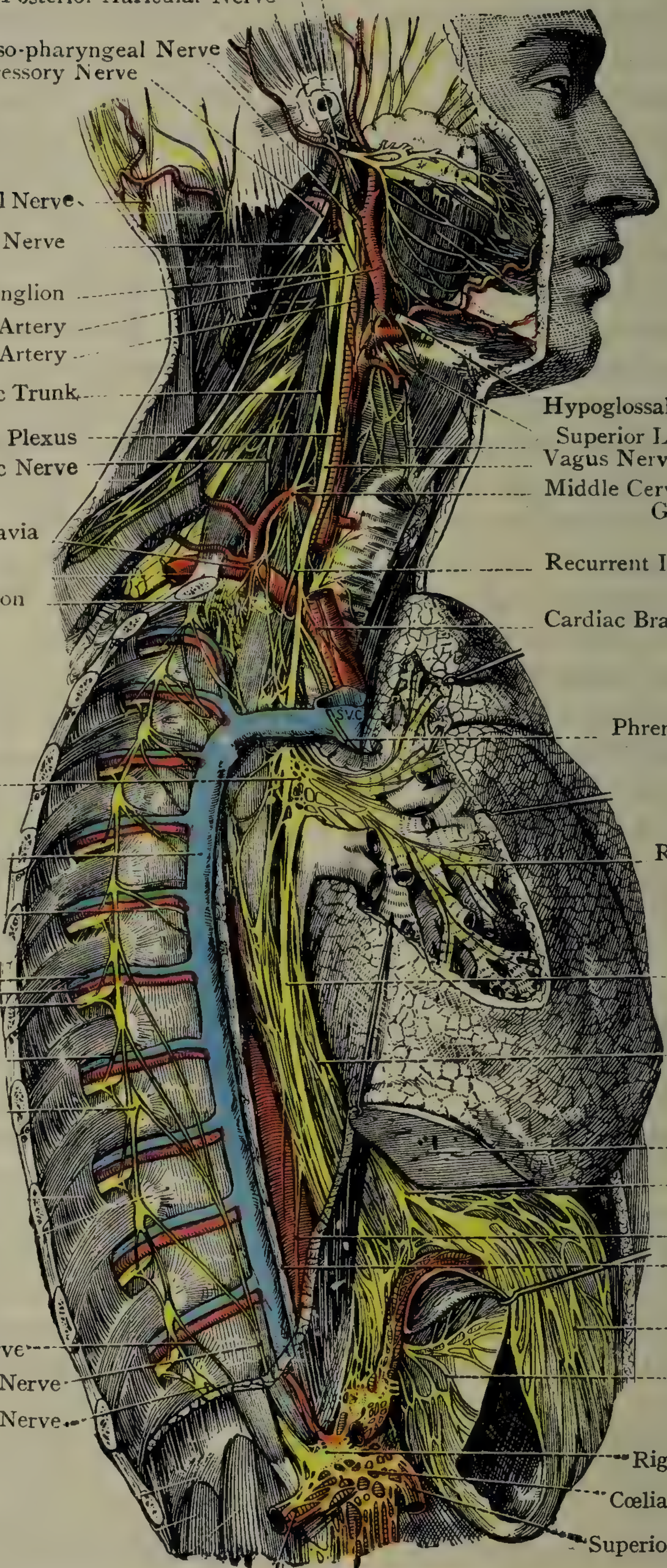


Fig. 802.—Nerves of the Right Side of the Face, Neck, and Thorax (Hirschfeld and Leveille).

ied by a communicating branch from the ganglion of the facial ve. It leaves the canal through the hiatus for the lesser superal petrosal nerve on the surface of the petrous bone, and then ses forwards and inwards beneath the dura mater. After this asses through the canaliculus innominatus, when present, or through fissure between the petrous temporal and greater wings of the ienoid, or sometimes through the foramen ovale, into the infraiporal fossa, where it joins the otic ganglion, to which it conducts sso-pharyngeal and facial fibres.

2. **From the Trunk of the Nerve.**—(1) A *communicating branch* netimes passes from the nerve a little below the inferior ganglion join the digastric branch of the facial nerve. (2) A *carotid branch* sses to the sympathetic plexus on the internal carotid artery. *Pharyngeal Branches.*—These are about four in number. Three of em unite, over the middle constrictor of the pharynx, with the subrisions of the pharyngeal branch of the vagus, and with branches the superior cervical ganglion of the sympathetic, to form the aryngeal plexus. The other pharyngeal branch pierces the superior istrictor, and is distributed to the mucous membrane of the upper rt of the pharynx. (4) A *muscular branch* to the stylo-pharyngeus iscle, some of the fibres of which pierce the muscle to supply the icous membrane of the pharynx. (5) *Tonsillar branches* form a cular plexus round the tonsil, known as the circulus tonsillaris; om it branches supply the tonsil and region of the oro-pharyngeal hmus. (6) *Lingual Branches.*—Under cover of the hyo-glossus iscle, the terminal part of the nerve divides into two branches, rsal and lateral. The *dorsal branch* passes to the vallate papillæ d the mucous membrane over the posterior third of the tongue, tending as far back as the front of the epiglottis. The *lateral branch* distributed to the mucous membrane of the side of the tongue 'er about its posterior half.

Summary of the Glosso-pharyngeal Nerve—1. **Cutaneous Distribution.**—It pplies (*a*) the mucous membrane of the tympanic cavity, the posterior third the tongue, the region of the oro-pharyngeal isthmus, and the pharynx; and the tonsil. 2. **Muscular Distribution.**—The stylo-pharyngeus. 3. **Glandular stribution.**—Through (1) its tympanic, subsequently lesser superficial petrosal, anch, (2) the otic ganglion, and (3) the auriculo-temporal nerve, it furnishes cretory branches to the parotid gland.

The Vagus Nerve in the Neck.

The vagus, or tenth cranial, is a mixed nerve, consisting of both ferent and efferent fibres. It leaves the cranial cavity through the iddle compartment of the jugular foramen, being enclosed in the me sheath of dura mater as the accessory, and, with that nerve, ing posterior to the glosso-pharyngeal. In the foramen it presents small enlargement called the superior ganglion. After emerging from e foramen it is joined by the cranial root of the accessory nerve, id here there is another enlargement, called the inferior ganglion.

This ganglion is larger and longer than the superior ganglion, full $\frac{3}{4}$ inch in length, and presenting a somewhat plexiform appearanc In this part of its course the nerve lies between the internal caroti artery and the internal jugular vein, the glosso-pharyngeal nerve bein in front of it and the accessory behind it. The hypoglossal nerv lies at first deeply behind it, but subsequently turns round the oute side of the inferior ganglion. The vagus then descends within th carotid sheath, lying at first between the internal carotid artery an the internal jugular vein, and then between the common carotid arter and the internal jugular vein, being on a plane posterior to both vessel Within the sheath the nerve occupies a special compartment, situate in the back part of the septum which separates the artery from th vein. Below the root of the neck the right and left nerves have impor tant differences in their course and relations.

Branches—A. **The Superior Ganglion (Ganglion of the Root)**—1. **Branches of Communication.**—(*a*) It receives two filaments from th cranial root of the accessory nerve. (*b*) It communicates by a smal twig with the inferior ganglion of the glosso-pharyngeal nerve. (*c*) I communicates with the facial, and with the posterior auricular branc of the facial, through its auricular branch of distribution. (*d*) I receives a twig from the superior cervical ganglion of the sym pathetic.

2. **Branches of Distribution.**—(*a*) The *meningeal branch* takes a recurrent course, and, after entering the cranial cavity, supplies th dura mater which lines the cerebellar fossa of the occipital bone (*b*) The *auricular branch* is of small size, and is soon reinforced by a twi from the inferior ganglion of the glosso-pharyngeal. It enters th mastoid canaliculus through an aperture on the outer wall of th jugular fossa. In this canaliculus it traverses the petrous portion o the temporal bone, crossing in its course the inner aspect of th descending portion of the facial canal a little above the stylo-mastoi foramen, where it forms its first communication with the facial nerve It then leaves the petrous temporal through the tympano-mastoi fissure, between the mastoid process and the tympanic plate, an then divides into two branches. One of these joins the posterio auricular branch of the facial nerve, and the other is distributed t (*a*) the skin of the inner surface of the auricle, and (*b*) the skin of th lower and back part of the external auditory meatus.

B. **The Inferior Ganglion (Ganglion of the Trunk)**—1. **Branches of Communication.**—(*a*) The most important branch of communication is the *cranial root of the accessory nerve,* which passes over the surface of the ganglion in intimate contact with it. Most of the cranial fibres are continued into the pharyngeal and superior laryngeal nerves, but some of them descend in the main trunk of the vagus, and pass into its cardiac and inferior laryngeal branches. The cranial fibres are to be regarded as of two kinds—namely, *motor,* for the muscles of the soft palate, pharynx, and larynx; and *cardiac inhibitory.* (*b*) Branches pass between the inferior ganglion and the hypoglossal nerve. (*c*) A

municating branch is received from the superior cervical ganglion
ie sympathetic.

. **Branches of Distribution.**—These are pharyngeal and superior
ngeal.

The **pharyngeal branch** arises from the upper part of the inferior
glion, its fibres being chiefly derived from the cranial root of the
ssory nerve. It passes forwards and downwards between the
rnal and external carotid arteries, and divides into branches opposite
middle constrictor muscle, which join the pharyngeal branches of
glosso-pharyngeal and superior cervical ganglion of the sympathetic
orm the pharyngeal plexus.

The **pharyngeal plexus** is situated upon the middle constrictor
cle opposite the greater horn of the hyoid bone. It is formed by
the pharyngeal branch of the inferior ganglion of the vagus, derived
inally from the accessory; (2) the pharyngeal branches of the glosso-
ryngeal; and (3) the pharyngeal branches of the superior cervical
glion of the sympathetic.

Branches are distributed to (1) the constrictor muscles of the pharynx;
the mucous membrane of the pharynx; and (3) the palato-glossus,
ato-pharyngeus, levator palati, and musculus uvulæ. In this way
the muscles of the soft palate except the tensor palati are supplied
the accessory nerve. Branches of communication pass between
plexus and the superior laryngeal and external laryngeal nerves,
another branch, known as the *lingual branch of the vagus*, passes
the hypoglossal nerve.

Superior Laryngeal Nerve.—This nerve, which is principally sensory,
es from the inferior ganglion of the vagus near its centre, and contains
es of the cranial root of the accessory nerve. It passes downwards
l forwards behind the internal carotid artery, having received com-
nicating branches from the superior cervical ganglion of the sym-
hetic and from the pharyngeal plexus. As it passes behind the in-
nal carotid artery it divides into two branches, internal and external.
e **internal laryngeal nerve,** which is sensory, passes forwards, in
npany with the superior laryngeal branch of the superior thyroid
ery, to the thyro-hyoid membrane, which it pierces under cover of
posterior border of the thyro-hyoid muscle. Having reached the
erior of the larynx, it divides into branches which supply the mucous
mbrane of the epiglottis with its folds, a little of the back of the
igue, the mucous membrane of the larynx as low as the vocal folds,
d that covering the lateral and posterior portions of the cricoid carti-
e. One branch descends over the inner surface of the lamina of the
yroid cartilage, and joins a branch of the recurrent laryngeal. The
ernal laryngeal nerve, of small size, descends deep to the sterno-
yroid muscle to the crico-thyroid muscle, which it supplies. It
nishes some twigs to the inferior constrictor, and a filament which
ns the superior cardiac branch of the sympathetic. It receives
communicating branch from the superior cervical ganglion of the
mpathetic, and one or two branches from the pharyngeal plexus.

Recurrent Laryngeal Nerve.—This nerve is mainly motor, and the principal motor nerve of the intrinsic muscles of the larynx. contains fibres of the cranial root of the accessory nerve. The *ri* nerve arises from the vagus at the root of the neck in front of t first part of the subclavian artery, round the lower border of which bends, and then ascends behind it. Then it passes upwards a inwards behind the carotid sheath and inferior thyroid artery to t groove between the trachea and the œsophagus. The *left* nerve aris in the thorax from the vagus in front of the arch of the aorta on a le with its lower border. It passes backwards below the arch and to t left of the ligamentum arteriosum, and then it turns upwards behi the arch. Having reached the groove between the trachea and t œsophagus, it ascends therein to the neck. The right and left nerv pass upwards in the groove between the trachea and the œsophag on each side, lying usually behind the corresponding inferior thyro artery and in close relation with the lobes of the thyroid gland. the level of the cricoid cartilage each nerve passes beneath the low border of the inferior constrictor muscle, and enters the larynx behi the crico-thyroid joint.

Extralaryngeal Branches.—(1) *Communicating twigs* pass betwe the recurrent laryngeal nerve and the inferior cervical ganglion of t sympathetic; (2) *cardiac branches*, which contain cranial fibres fro the accessory, are furnished to the deep cardiac plexus; (3) *trache* and *œsophageal branches* are supplied to these tubes; and (4) *muscul offsets* pass to the lower part of the inferior constrictor.

Intralaryngeal Branches.—These are chiefly *muscular*, and supp the intrinsic muscles of the larynx, except the crico-thyroid, whi is supplied by the external laryngeal nerve. *Sensory branches*, howeve are given to the laryngeal mucous membrane below the vocal fold except over the lateral and posterior portions of the cricoid cartilag Within the larynx the nerve communicates with a branch of t internal laryngeal nerve under cover of the lower part of the lami of the thyroid cartilage.

For the explanation of the recurrent course of each recurre laryngeal nerve, see p. 1121.

Cardiac Branches.—These are subject to variation as regar numbers. As a rule there are two, upper and lower, both of whi contain cranial fibres from the accessory. Those of the right si pass behind the first part of the subclavian artery, and end in t *deep* cardiac plexus. On the left side the **upper** nerve passes to t *deep* cardiac plexus, but the **lower** nerve ends in the *superficial* cardi plexus.

Summary of the Vagus Nerve in the Neck—1. **Motor Distribution.**—(1) T muscles of the soft palate by accessory fibres, except the tensor palati; (2) t constrictor muscles of the pharynx; (3) the intrinsic muscles of the larynx; a (4) the muscular tissue of the œsophagus and trachea. 2. **Sensory Distribution.** It supplies (1) the pharynx, œsophagus, and trachea; (2) a limited portion of t dura mater; and (3) a small portion of the skin on the inner surface of the auric as well as of the lower and back part of the external auditory meatus. 3. **Co**

cations.—Each vagus nerve forms connections with the facial, glosso-yngeal, accessory, hypoglossal, and sympathetic nerves. It is also con-ed with the loop between the first and second cervical spinal nerves. Its important connection is that which is established with the cranial root of ccessory nerve. The bulbar fibres of the nerve are probably chiefly con-ed in the innervation of the muscles of the soft palate (except the tensor i), pharynx, and larynx, but also to a certain extent in the innervation of eart.

Accessory Nerve.

The accessory or eleventh cranial nerve consists of two roots—ial and spinal. In the jugular foramen these two parts either e to form one trunk or freely intermingle, and a communication stablished between the cranial root and the superior ganglion of vagus by means of two twigs. The nerve passes through the lar foramen, being enclosed he same sheath of dura mater he vagus, behind which it lies. nediately beneath the jugular men the two parts of the nerve rate from each other.

The **cranial root** passes over, in intimate contact with, the rior ganglion of the vagus, its fibres are continued partly the pharyngeal and superior ngeal branches of the inferior glion, and partly into the k of the vagus below the glion. These latter fibres are mately prolonged into the liac and recurrent laryngeal nches of the nerve. The nial fibres of the accessory regarded as (1) the motor nerves of (*a*) the muscles of the soft ate, except the tensor palati, (*b*) the constrictor muscles of the rynx, and (*c*) the intrinsic muscles of the larynx; and (2) the ibitory fibres of the heart.

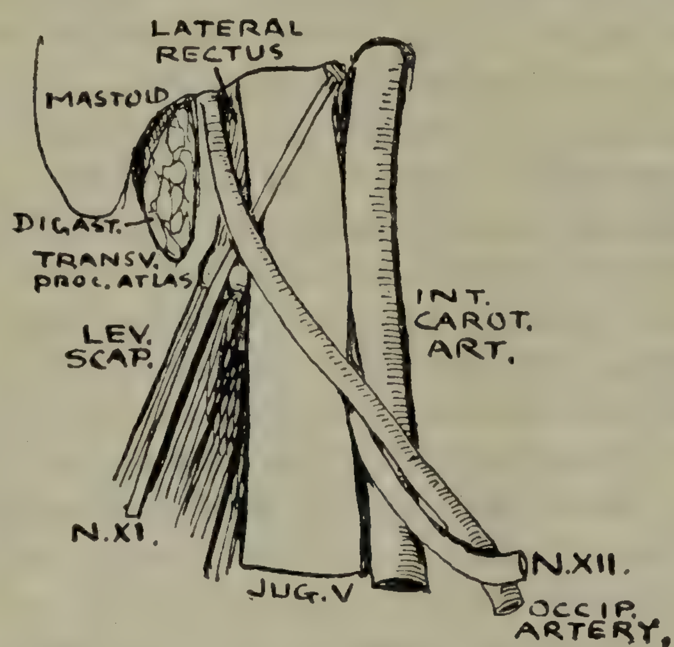


FIG. 803.—SHOWING RELATIONS BETWEEN ACCESSORY NERVE, HYPOGLOSSAL NERVE, AND OCCIPITAL ARTERY A LITTLE BELOW SKULL BASE.

The **spinal root** of the accessory nerve passes backwards and down-ds either behind or in front of the internal jugular vein. It then ces the deep surface of the sterno-mastoid, which it supplies along h a branch of the second cervical nerve. Then it crosses the terior triangle of the neck obliquely downwards and backwards to anterior border of the trapezius, beneath which it passes, supplying muscle, in company with branches from the third and fourth vical nerves.

Summary.—The **spinal root** of the accessory nerve supplies the trapezius and sterno-mastoid. The **cranial root,** through its connection with the vagus ve and its branches, supplies (1) the muscles of the soft palate, except the

tensor palati; (2) the constrictor muscles of the pharynx; and (3) the intrin muscles of the larynx. It also furnishes the *inhibitory fibres* of the heart, wh reach that organ through the cardiac branches of the vagus.

Hypoglossal Nerve.

The hypoglossal or twelfth cranial nerve consists at first of t bundles, which pierce the dura mater separately. In passing throu the anterior condylar canal these two bundles unite to form one trur After leaving that canal the nerve lies deeply under cover of the intern carotid artery and internal jugular vein. It then turns round t outer side of the inferior ganglion of the vagus, with which it is close connected, and passes forwards between the internal carotid arte and internal jugular vein. Then it descends to the lower border the posterior belly of the digastric, at which level it hooks round t occipital artery from without inwards, and crosses in front of t external carotid artery and its lingual branch. In this part of i course the nerve lies in the superior carotid triangle. It next ru forwards above the hyoid bone, passing deep to the tendon of t digastric and the lower part of the stylo-hyoid muscle, and superfic to the hyo-glossus. After this it disappears deep to the mylo-hyoi still resting upon the hyo-glossus, where it is accompanied by t vena comitans hypoglossi, and is covered by the deep part of t submandibular gland. At the anterior border of the hyo-glossus is connected with the lingual nerve, and then enters the genio-glossu

Branches—1. **Of Communication.**—After leaving the anterior co dylar canal, the hypoglossal nerve communicates with the inferi ganglion of the vagus. It then receives a branch from the superi cervical ganglion of the sympathetic, and one from the first cervic nerve, or the loop between the first and second. As it hooks rour the occipital artery it receives the lingual branch of the vagus fro the pharyngeal plexus; and at the anterior border of the hyo-gloss it is connected with the lingual nerve.

2. **Of Distribution.**—One or two *meningeal branches* arise from t nerve in the anterior condylar canal, which take a recurrent cours and enter the cranial cavity to supply the dura mater near the canal

The *ramus descendens hypoglossi* nerve has been already describe (see p. 1205).

The *nerve to thyro-hyoid* will be found described on p. 1206.

The *muscular branches* are given off from the nerve as it lies upo the hyo-glossus under cover of the mylo-hyoid. These supply t stylo-glossus, hyo-glossus, genio-glossus, and genio-hyoid. The ner to the genio-hyoid is composed of spinal fibres derived from the fir and second cervical nerves.

The *terminal branches* pierce the under surface of the tongue, an are distributed to its muscular tissue.

The hypoglossal nerve receives many spinal fibres. Those derive from the first cervical nerve, or the loop between the first and secon soon become applied to it, and most of them pass off to form the ramu

:endens hypoglossi. A few of these, however, still pass along the n trunk. The spinal fibres derived from the second and third vical nerves in part ascend in the ramus descendens hypoglossi, then pass off from it to be applied to the main trunk in its onward rse.

Summary.—1. **Distribution.**—The hypoglossal fibres of the nerve supply stylo-glossus, hyo-glossus, genio-glossus, and intrinsic muscles of the tongue. spinal fibres supply both bellies of the omo-hyoid, the sterno-hyoid, sterno-roid, thyro-hyoid, and genio-hyoid muscles. The hypoglossal nerve also plies the dura mater near the anterior condylar canal. 2. **Connections.**—It blishes connections with (1) the inferior ganglion of the vagus; (2) the superior vical ganglion of the sympathetic; (3) the first two cervical nerves; (4) the ryngeal plexus, through the lingual branch of the vagus; and (5) the lingual ve from the mandibular division of the trigeminal nerve.

The Sympathetic Trunk.

Cervical Portion.—This portion of the sympathetic trunk extends m the base of the skull, at the carotid canal on the under surface the petrous part of the temporal bone, to the root of the neck, ere it enters the thorax, passing on the right side behind the sub-vian artery. It lies directly behind the carotid sheath, and in nt of the transverse processes of the cervical vertebræ, resting upon longus capitis and longus cervicis muscles. The cord presents ee ganglia—superior, middle, and inferior.

Superior Cervical Ganglion.—This ganglion is fusiform and more in an inch long. It represents four ganglia united into one, and responding to the first four cervical nerves. It is situated in front the transverse processes of the second and third cervical vertebræ, d lies upon the longus capitis, the vagus nerve being lateral to it. either end it tapers, being continued superiorly into its ascending inch, and inferiorly into the descending trunk.

Branches.—These may be conveniently arranged into internal rotid, lateral, medial.

The **internal carotid nerve** enters the carotid canal in the petrous rt of the temporal bone in company with the internal carotid artery, d divides into two parts. The *lateral branch* lies upon the outer le of the artery, and its subdivisions form by their interlacement the **ernal carotid plexus.** From this plexus several communicating anches are given off. (1) The carotico-tympanic nerve enters the mpanic cavity, and joins the tympanic branch of the glosso-pharyn-al, to take part in the tympanic plexus. (2) The deep petrosal rve joins the greater superficial petrosal from the ganglion of the cial nerve in the upper part of the foramen lacerum, to form the rve of the pterygoid canal, which passes through the latter to join e spheno-palatine ganglion. (3) A branch (or branches) passes to in the abducent nerve. (4) One or more branches pass to join the igeminal ganglion. The internal carotid plexus furnishes filaments the coats of the internal carotid artery, and it receives a branch om the tympanic plexus.

The *medial branch* of the internal carotid nerve lies upon the in side of the internal carotid artery, to which it furnishes twigs, and subdivisions form by their interlacement the **medial part** of the inter carotid plexus (**cavernous plexus**). This plexus lies in contact with internal carotid artery as it traverses the cavernous sinus. Its co municating branches pass to join the oculo-motor, trochlear, a ophthalmic nerves, and the ciliary ganglion. The last-named bran forms the sympathetic root of the ciliary ganglion, and enters the or through the superior orbital fissure. It is the source of the motor sup of the dilator pupillæ muscle. The medial part of the internal caro plexus furnishes filaments to the coats of the internal carotid arte and offsets which accompany the branches of that artery, around wh they are disposed as plexuses.

The **lateral branches** are communicating, and pass to (1) each the upper four cervical nerves; (2) the inferior ganglion of the glos pharyngeal; (3) the superior ganglion of the vagus; and (4) the hyp glossal nerve.

The **medial branches** are laryngo-pharyngeal and cardiac. T **laryngo-pharyngeal branches,** two or three in number, unite with t pharyngeal branches of the glosso-pharyngeal and vagus to form t pharyngeal plexus (see p. 1329).

The **cardiac branch** arises by two roots from the lower part of t superior cervical ganglion, and descends behind the carotid sheath, lyi medial to the main sympathetic trunk. The nerve of the right si passes in front of or behind the first part of the subclavian artery, a then along the innominate artery, to end in the *deep* cardiac plex In its course down the neck it receives twigs from the external larynge nerve, and is joined by the superior cervical cardiac branch of t vagus nerve. As it enters the thorax it receives a filament from t recurrent laryngeal nerve. The nerve of the left side within the thor accompanies the left common carotid artery, and passes in front the arch of the aorta to end in the *superficial* cardiac plexus.

The **anterior branches** are vascular, and pass to the external carot artery, upon which and its branches they form delicate plexuses.

Middle Cervical Ganglion.—This ganglion is situated opposite t sixth cervical vertebra, and usually lies in front of the inferior thyro artery. It is the smallest of the three, and is connected by gr rami communicantes with the fifth and sixth cervical nerves, th representing two fused ganglia. Its branches of distribution a thyroid and cardiac. The **thyroid branches** accompany the inferi thyroid artery to the thyroid gland, and communicate with the extern and recurrent laryngeal nerves. The **cardiac branch** of each side en in the *deep* cardiac plexus. The nerve of the right side passes eith in front of or behind the first part of the right subclavian artery. then descends in front of the trachea, and joins the right half of th deep cardiac plexus. The nerve of the left side enters the thora between the left common carotid and left subclavian arteries, and joins the left half of the deep cardiac plexus.

Inferior Cervical Ganglion.—This ganglion is situated between the nsverse process of the seventh cervical vertebra and the neck of first rib, where it lies behind the subclavian near the root of the tebral artery. It is intermediate in size between the superior and ddle ganglia, and, like the middle, it probably represents two ganglia ited into one. It is frequently fused with the first thoracic ganglion. e connection between the middle and inferior cervical ganglia passes hind the subclavian artery, but sometimes a cord or cords in front the vessel form a loop around it, called the **ansa subclavia** (**ansa ussenii**). The inferior cervical ganglion is connected by grey ni communicantes with the seventh and eighth cervical nerves, and branches of distribution are vascular and cardiac. The **vascular anches** accompany the vertebral artery in the form of the *vertebral xus*, which gives filaments to the vessel and offshoots along its rious branches. The plexus is continued along the basilar artery d its branches, and on to the posterior cerebral arteries. The **rdiac branch** on each side joins the *deep* cardiac plexus. The nerve the right side passes behind the first part of the right subclavian tery, and then in front of the trachea. It is connected with the rdiac branch of the middle cervical ganglion and recurrent laryngeal rves. The nerve of the left side in many cases joins the cardiac anch of the middle cervical ganglion, and so reaches the deep cardiac xus.

Constitution of the Cervical Sympathetic Trunk.

The sympathetic trunk in the neck contains the following important groups of res: (1) dilator pupillæ, (2) vaso-constrictor and vaso-dilator, (3) secretory, d (4) accelerator.

The **dilator pupillæ fibres** are derived from the *upper three thoracic nerves*, d ascend in the sympathetic trunk to the superior cervical ganglion, in which ey end. From this ganglion they are continued as sympathetic fibres to medial part of the internal carotid plexus, through this plexus to the ciliary nglion, and thence to the dilator pupillæ muscle.

The **vaso-constrictor fibres** are derived from a variable number of thoracic rves, beginning at the second and ending at the eighth. The origin of the **so-dilator fibres** is not definitely known. The vaso-constrictor fibres ascend the superior cervical ganglion, in which they end. From this ganglion they continued as sympathetic fibres into the plexus around the external carotid tery, and thence along the branches of that vessel.

The **secretory fibres** are destined for the submandibular gland, and are derived iefly from the second and third thoracic nerves. They also ascend to the perior cervical ganglion, in which they end. They are thence continued as mpathetic fibres into the external carotid plexus, from that into the facial exus, and thence into the submandibular ganglion, from which they pass into e submandibular and sublingual glands.

The **accelerator fibres of the heart** are chiefly derived from the second and ird thoracic nerves, but some also spring from the first, fourth, and fifth nerves. ie spinal fibres pass to the middle and lower cervical ganglia, from each of which ey are continued as sympathetic fibres.

The Mouth Cavity.

The cavity of the mouth extends from the *oral fissure* in front, here it opens externally on the face, to the oropharyngeal isthmus hind, where it opens into the pharynx. It is divided by the upper

and lower alveolar arches into two compartments, the anterior of wh
is called the vestibule and the posterior the mouth cavity proper.

The **vestibule of the mouth** is bounded anteriorly and externa
by the lips and cheeks, and internally by the alveolar arches and gur
Superiorly and inferiorly it is bounded by the reflection of the muc
membrane from the lips and cheeks on to the gums. In the medi
line, above and below, the mucous membrane forms a small vertical f
called the *frenulum*. On the inner surface of each cheek the vestibu
mucous membrane presents a small papilla opposite the second up
molar tooth, and on this is the minute opening of the parotid duct.

The **mouth cavity proper** lies within the alveolar arches. It co
municates with the vestibule by the interval between the upper a
lower teeth, and also by an opening at either side situated behind t
last molar tooth. Anteriorly and externally it is bounded by t
alveolar arches and gums, and posteriorly it opens into the phary
by means of the oropharyngeal isthmus. The *roof*, which is arched,
formed by the hard palate and the soft palate. The *floor* is form
by the tongue, and the reflection of mucous membrane from the inn
surface of the lower alveolar arch on to its under surface. In t
region of the tip of the tongue the lateral reflections of mucous me
brane from the two sides of the lower alveolar arch are continuo
across the median line. In the median line the mucous membra
forms a prominent fold, called the *frenulum linguæ*, which is co
nected above with the under surface of the tongue a little distan
from the tip. In some children it may extend quite to the tip, impa
ing the utility of the organ, and giving rise to the condition known
'tongue-tied.' Close to each side of the frenulum there is a sm
papilla, on which is the opening of the submandibular duct. A litt
posterior to this is a fold of the mucous membrane at either sid
produced by the upper border of the subjacent sublingual glan
This fold is known as the *plica sublingualis*, and it extends from t
side of the tongue to the alveolar arch. It is upon this plica that t
majority of the sublingual ducts open.

The **lips** are covered by skin externally, and mucous membra
internally. Between these two layers are the muscular fibres of t
orbicularis oris, blended with which are the fibres of the buccinat
and in the case of the upper lip fibres of the depressor anguli or
whilst in the case of the lower lip there are the fibres of the levat
anguli oris. Between the mucous membrane and the muscul
element there are a number of small racemose glands, called the labi
glands, the ducts of which open on the inner surface of each lip. T
tortuous labial arteries are embedded in each lip, and those of opposi
sides anastomose at the median line.

Between the upper lip and the columna nasi there is a groov
called the *philtrum*.

The **lymphatic vessels** of the **upper lip** pass on either side to t
submandibular, to the submental, or to the superficial parotid lym
glands. The lymphatic vessels of the *lateral portion* of the **lower l**

so pass on either side to the submandibular lymph glands, and ose of the *medial portion* pass to the submental lymph glands of the rresponding side.

The **cheeks** are covered externally by skin, and internally are lined ith mucous membrane. The muscular element consists of the ccinator, which is covered by the buccal fascia. Posteriorly this scia is continuous with the pharyngeal fascia, which is derived from e deep cervical fascia, the two being known as the bucco-pharyngeal scia. Superiorly and inferiorly it is attached to the alveolar arches.

The lymphatic vessels of the cheek pass to the superficial parotid lymph glands and the submandibular glands, the buccal lymph ands being a gland-station in the path of the latter.

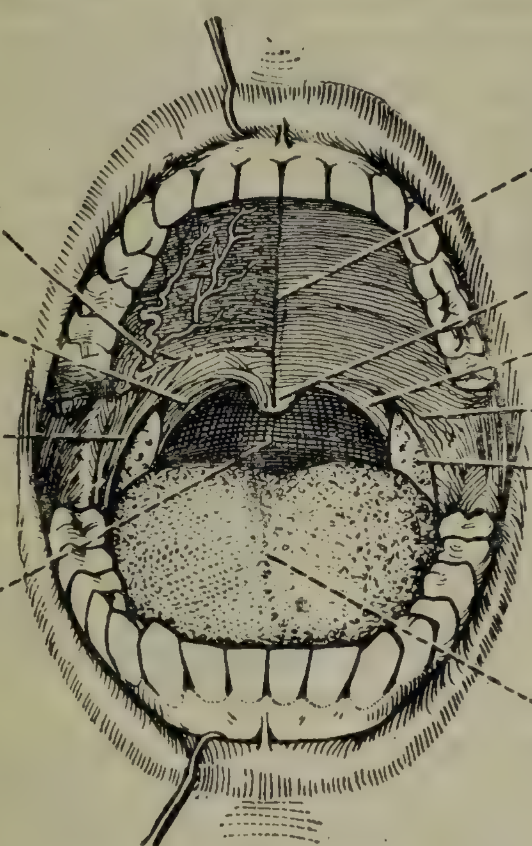


FIG. 804.—THE CAVITY OF THE MOUTH AND OROPHARYNGEAL ISTHMUS. The jaws are widely separated.

The **suctorial pad of fat** is situated upon the buccal fascia, and is ell developed in young children. It is continuous with the fat in e pterygoid region.

The buccal fascia, buccinator, and lining mucous membrane are ierced by the parotid duct. Between the buccinator and the mucous embrane there are several racemose buccal glands. In addition to ese there are three or four molar glands, mucous in character, which re situated superficial to the buccal fascia in the angle between the asseter and buccinator.

The **masseteric fascia** is an upward prolongation of the deep cervical scia. It is attached superiorly to the zygoma, and externally is ontinuous with the parotid fascia.

The **alveolar arches** are formed by the alveolar borders of the axillæ and mandible, the teeth, and the gums.

The **gums** (**gingivæ**) consist of dense fibrous tissue, which is covere by mucous membrane and is closely connected with the periosteum c the alveolar borders of the mandible and maxillæ. The mucou membrane, which is very vascular, is continuous with the labial an buccal mucous membrane on the one hand, and with that of the floo of the mouth on the other. Close to the necks of the teeth it is bese with vascular papillæ.

The **lymphatic vessels** of the **upper gum** pass on either side t the submandibular lymph glands. The lymphatic vessels of th *lateral portion* of the **lower gum** also pass on either side to the sub mandibular lymph glands; and those of the *medial portion* pass to th submental lymph glands of the corresponding side.

The **mucous membrane of the gums** is separated from the subjacen periosteum by dense connective tissue, which connects the two i such a close manner that the mucous membrane is immovable. Clos to the necks of the teeth it is beset with papillæ. The **mucous mem brane of the hard palate,** like that of the gums, is separated from th periosteum by a thick layer of dense connective tissue, which bind the two so closely that the mucous membrane is immovable. Ther is a median raphé, which is continued over the soft palate, and end in front at the incisive fossa in a small papillary elevation, known a the *incisor papilla.* On either side of the raphé anteriorly there ar a few transverse rugæ. Each lateral half of the hard palate is traverse by the ramifications of the greater palatine artery, the branches o which extend forwards and inwards from either lateral angle posteriorly The mucous membrane of the hard palate is provided with racemos palatal glands of a serous character, which are arranged in tw symmetrical groups laterally disposed.

Occasionally a hard swelling, lying antero-posteriorly in the mid line of the hard palate, is seen, and must not be mistaken for a bon tumour or exostosis. It is known as the *torus palatinus.*

The **lymphatic vessels** of the mucous membrane of the hard palat pass to (1) the deep facial lymph glands, and (2) the superior dee cervical lymph glands.

Nerves.—The **greater palatine nerve** descends in the greate palatine canal, which it leaves through the greater palatine foramen Then it divides into branches which pass forwards in groove on the hard palate, and supply the mucous membrane, glands and inner aspect of the upper gum. The **long spheno-palatine** i distributed to the mucous membrane behind the incisor teeth, wher it communicates with twigs of the greater palatine nerve. To reach the hard palate the nerve of the right side passes through the *posterio incisive foramen,* whilst the left nerve passes through the *anterio foramen.* The mucous membrane of the cheek is supplied by the buccal nerve, which is a branch of the mandibular division of the trigeminal nerve. The mucous membrane of the floor of the mouth derives its nerves from the submandibular ganglion.

Arteries.—These are the right and left greater palatine branches of

e third part of the maxillary. Each greater palatine artery takes e same course as, and has a similar distribution to, the greater palatine erve. At the incisive fossa it terminates in a small branch which cends through the lateral incisive canal, and anastomoses at the pper end of that canal with the posterior septal branch of the spheno-alatine artery.

Development of the Mouth, Lips, and Gums (pp. 70 & 85).

In the early stages of formation of the embryo, a transversely directed ink or furrow exists between the overhanging fore-brain and the prominent ricardium. This is known as the **oral fossa** or **stomodæum,** and is frequently

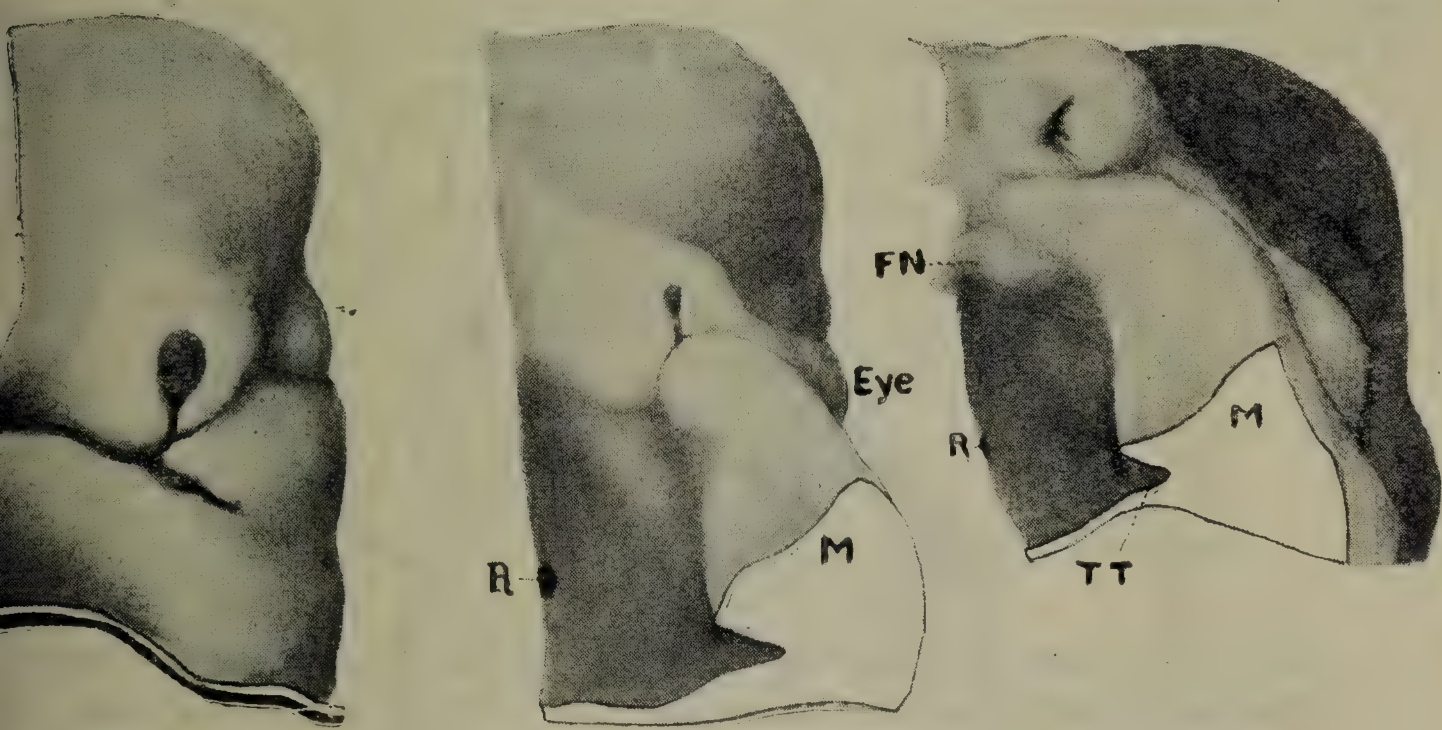


FIG. 805.—EMBRYOS OF 10 MM., 12 MM., AND 13·5 MM.

ne first gives the facial aspect, the mandible being *in situ.* The maxillary process has not yet come against the fronto-nasal process. The 12 mm. specimen, seen from below after the mandible has been removed, shows the maxillary process meeting the fronto-nasal. The 13·5 mm. specimen, seen from below and somewhat from behind, shows the beginning of the extension of maxillary mesoderm over the fronto-nasal process. The primitive posterior naris can be seen in this embryo, in which the bucco-nasal plug has been destroyed, as a small point behind the maxillary extension and to the outer side of the globular or fronto-nasal process. The corresponding point in the previous stage can be seen, but there is no aperture. The early palate folds are recognizable. FN, fronto-nasal process; M, maxillary process, cut at its base; R, opening of Rathke's pouch; TT, anterior margin of passage into tubo-tympanic recess.

ferred to as an early stage in the developing mouth; it is, however, nearly, not altogether, replaced by forward growths from the wall of the pharynx, closing between them the cavity of the adult mouth. The **stomodæum** shut off from the pharynx by the *bucco-pharyngeal membrane,* formed by e meeting of the *ectoderm* lining the stomodæum with the *entoderm* lining the arynx. The membrane is attached to the mandibular and maxillary pro-sses, is carried forward by these as they begin to grow, and is quickly broken d lost.

The mandibular arch grows forward above the pericardium and mak a new **floor** for the mouth. The *maxillary processes* grow forward on each sid

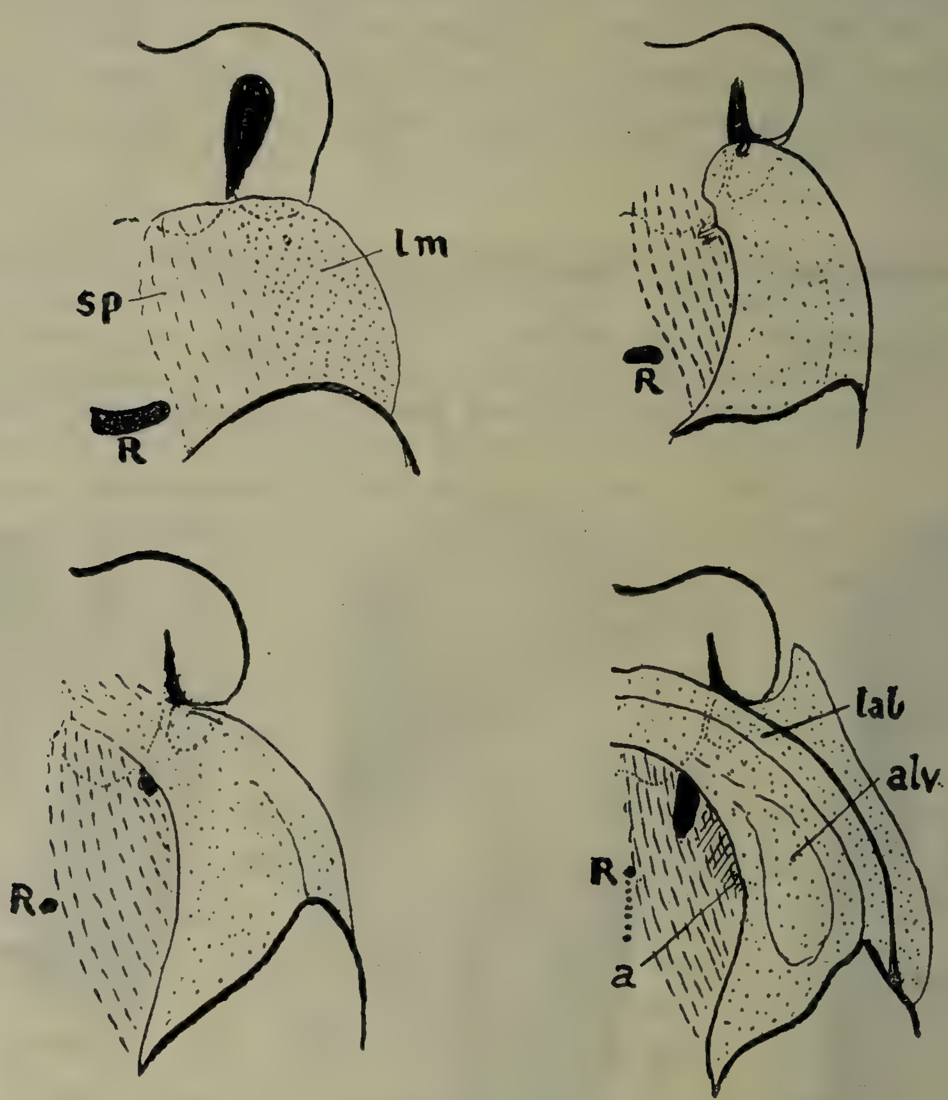


FIG. 806.—PLANS SHOWING DISTRIBUTION OF MAXILLARY MESENCHYME.

I. The early simple process reaches and just overlaps the hinder ends of t nasal folds. Its outer and thicker part (*lm*, lateral mass, dotted) thi away internally, covering the paraxial mesoderm, and its inner part (*s* septal process, interrupted lines) comes against the inner fold; it do not reach the middle line, and Rathke's pouch (R) is widely open.

II. The palate fold is a definite but blunt inner edge to the lateral mass, whi has thickened greatly and is fusing in front with the inner nasal fol The septal process has reached the middle line in front and has sprea over the neighbouring area of the fronto-nasal process. The opening is smaller, being compressed by deeper paraxial growth.

III. The extremity of the lateral part (having broken down the epithelial septu at their junction) has invaded the fronto-nasal region and is spreadi over it in front of the area covered by *sp*; this extension is going to for the alveolus and lip in this part. The septal process is coming into r lation with R, and reaches the middle line in front of this.

IV. Shows modifications in the lateral mass, which presents a labial edge (*la* and an alveolar eminence (*alv*) as well as a definite palate fold. T primitive posterior naris is represented as having extended to some degre showing that the septal process is forming the back part of the septu between the nares, thus explaining its name. The opening R, now on a point, has been caught between the process and its fellow, and has bee displaced slightly forwards, as indicated by the dotted line.

forming a **side wall** and **lateral roof,** and come up against the *outer nasal fold* cross these, and come into contact with the **fronto-nasal process.** Thus t mouth has the mandibular arch and growing tongue as its floor, while its ro

limited laterally by the deep maxillary processes, and in front by the fronto-sal process, with which the maxillary processes are joined.

Associated with the mouth are (1) the pouch of Rathke, (2) the tongue, the salivary glands, (4) the tonsils, and (5) the teeth.

The **pouch of Rathke** is a diverticulum of the roof of the ectodermic stomo-um, ventral to the bucco-pharyngeal membrane. Its development is given p. 87. It gives rise to the *anterior lobe* of the **hypophysis cerebri,** the *posterior e* of which is developed from a diverticulum of the floor of the *third ventricle* the cerebrum.

The development of the tongue, salivary glands, tonsils, and teeth will be ind after the description of each of these organs.

Each early **nasal cavity** lies above and behind the fronto-nasal process, and opening into the mouth, very small, and closed at first by the *bucco-nasal mbrane,* is placed just above the junction of the maxillary with that process. ie opening extends in an *upward* direction (see p. 85), and at the same time **late folds** make their appearance on the inner side of the maxillary processes se to the outer edges of these openings. These folds are turned down and lie side the tongue, which occupies the cavity and is in contact with its roof. ie folds run into the outer edges of the fronto-nasal process in front.

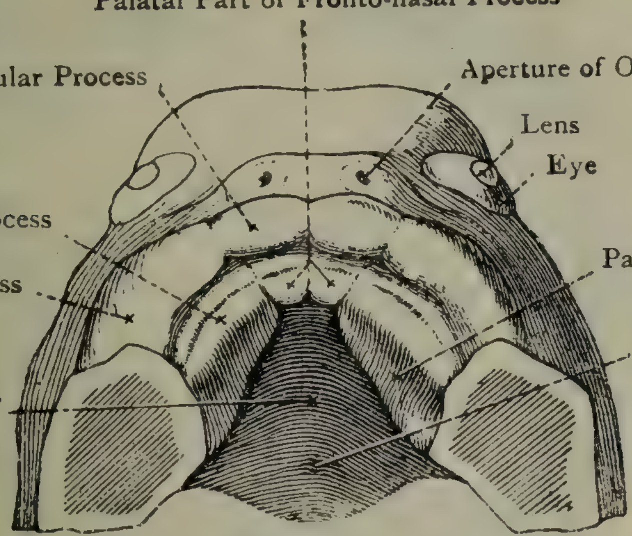


FIG. 807.—ROOF OF MOUTH (MARSHALL, AFTER HIS).

About the end of the ninth week—by which time the nasal openings have tended up to the highest level of the roof of the cavity—the palate folds me on to the *dorsal* surface of the tongue, *as a result of this being carried below fronto-nasal process by the growing mandible.* They are now pressed against e 'edge' of the septum between the two openings, to which they adhere, us shutting off the lower parts of these openings from the mouth and making e **hard palate.** The folds meet behind the fronto-nasal process, which forms e **incisive papilla.** The **incisive canals** are in the angles between folds and ocess.

Lips (Labia Oris) and Gums (Gingivæ).—Shortly after the fusion of the max-ary and globular processes to form the maxilla, a groove appears along each these processes on either side. The margins of this groove, which form rallel ridges, are external and internal relatively to the oral cavity. The *ternal* or *labial ridge* gives rise to the **upper lip,** the globular portion of the dge representing the premaxillary part of the lip, and the maxillary portion rming the remainder. The *internal* or *gingival ridge* is the rudiment of the **pper gum.**

The **philtrum** is probably developed from the mesodermic investment of the ited globular processes.

A similar groove and similar ridges (*labial* and *gingival*) appear along each andibular arch, and from the ridges the **lower lip** and **lower gum** are developed.

The **angles of the mouth** correspond to the union between the two lips on either side, and each originally represents the angle between a mandibular arch and maxillary process.

The Tongue.

The tongue is a muscular and very sensitive organ, covered by the buccal mucous membrane, and situated on the floor of the mouth. It is concerned in the sense of taste, mastication, deglutition, and speech, and it consists of a root or base, a body, and a tip. The root is attached to the hyoid bone. The tip is the anterior free extremity

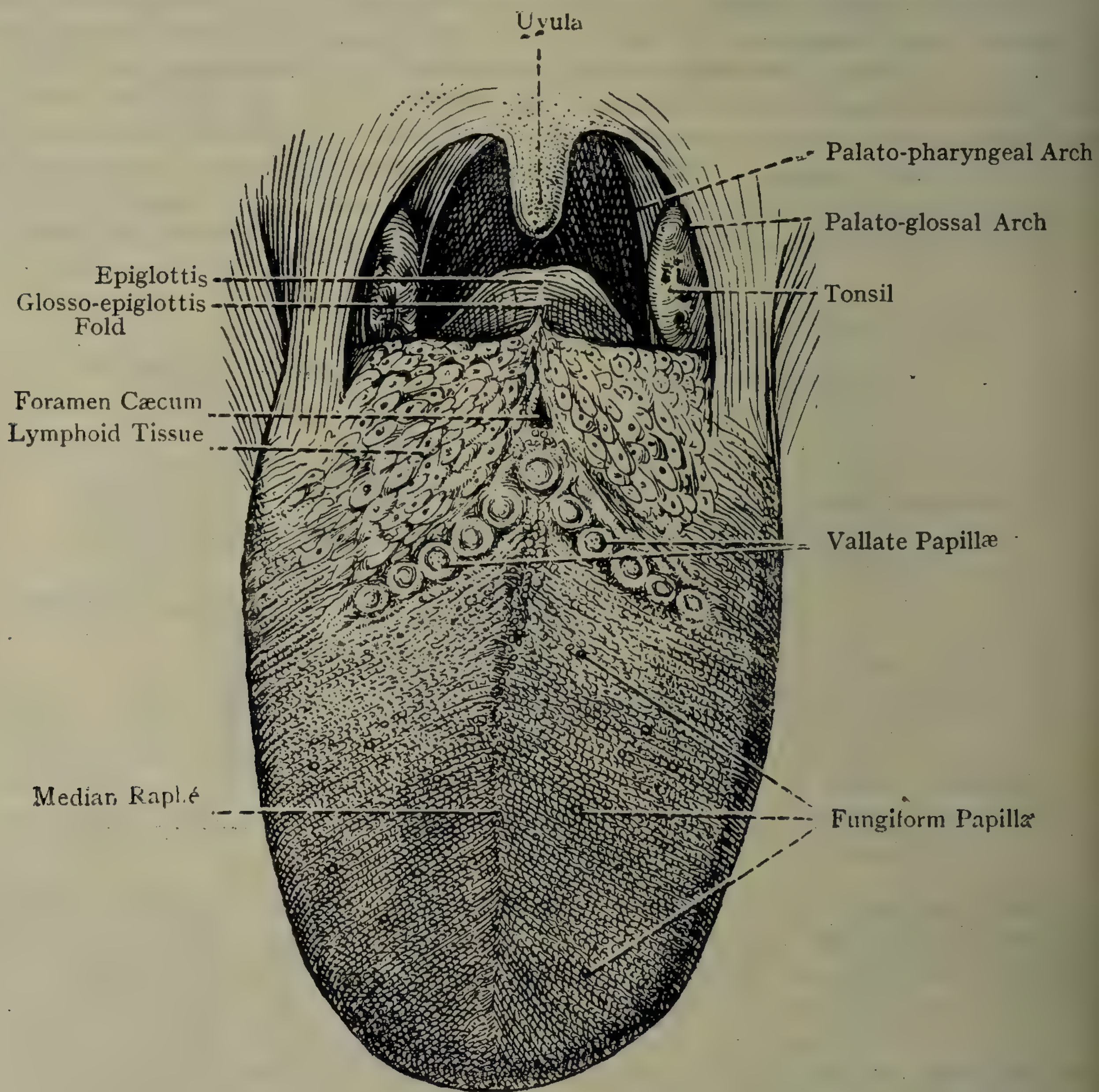


Fig. 808.—The Dorsum of the Tongue.

which, in the quiescent state, lies behind the upper incisor teeth. The body has an upper surface or dorsum, an under surface, and two lateral borders, right and left. The dorsum is convex from before backwards, and on its anterior two-thirds is a median depression or raphé, on either side of which the surface is convex from side to side. This ends posteriorly in the *foramen cæcum*. In this region the dorsum has a V-shaped groove, known as the *sulcus terminalis*. The joint of the V is at the foramen cæcum, and the two limbs pass outwards and forwards to the sides of the tongue, where the palato-glossal arches are connected with it. The sulcus terminalis marks the union of the

o parts from which the tongue is developed. The part behind it, presenting one-third, is the basal, lymphoid, or **pharyngeal portion.** occupies the buccal part of the pharynx, and overhangs the epi- ottis. The portion in front of the sulcus terminalis, representing two- irds, is known as the **buccal** or **papillary portion.**

Mucous Membrane.—The mucous membrane covering the basal pharyngeal portion of the tongue is destitute of proper papillæ, but freely provided with lymphoid follicles like those of the tonsils, d with mucous glands. The follicles are ranged upon the walls crypts, the mouths of which open upon the surface. The mucous embrane in this region forms the **glosso-epiglottic fold,** which is edially placed. On either side of this fold, between it and each

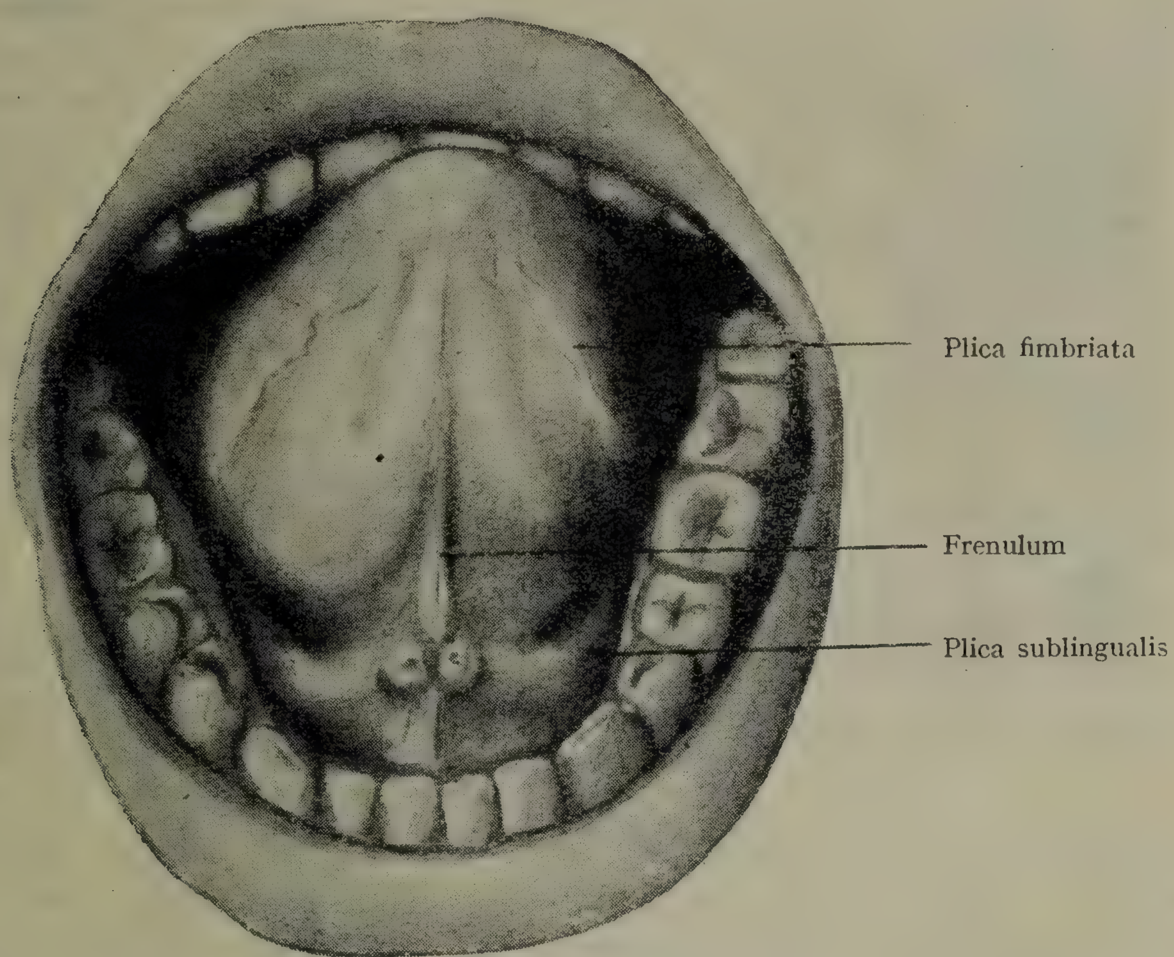


FIG. 809.—UNDER SURFACE OF TONGUE, WITH SUBLINGUAL REGION.

aryngo-epiglottic fold, there is a pouch or depression, called the **llecula.** In front of the sulcus terminalis the mucous membrane the dorsum, borders, and tip of the tongue is freely covered by aracteristic papillæ, which, being visible to the naked eye, impart this part its distinctive appearance. These papillæ bear secondary pillæ, which, however, are concealed by the epithelial covering. ne mucous membrane on the under surface of the tongue in the median ne forms near the tip a vertical fold, called the *frenulum linguæ.* little lateral to the frenum on either side is an indistinct fringed ld, called the *plica fimbriata.* The two plicæ converge as they pass rwards towards the tip, and inside each the outline of the vena mitans hypoglossi may be visible. They represent the under tongue *sublingua* of lemurs and marmoset monkeys. On either side of

the tongue, in the region of the limbs of the sulcus terminalis, the mucous membrane presents a few ridges which represent the *papillæ foliata* of such animals as the rabbit.

Papillæ.—These are of four kinds—filiform, fungiform, circumvallate, and foliate—and they are confined to the anterior two-thirds of the organ. The **filiform papillæ** are the most numerous, and are arranged in more or less parallel, closely-set rows, directed forwards and outwards from the median line except towards the tip, where the rows tend to become transverse. On the sides of the tongue they are arranged in vertical parallel rows.

FIG. 810.—THE FILIFORM PAPILLÆ OF THE TONGUE.

The **fungiform papillæ** are scattered amongst the filiform, and are most numerous at the sides and tip, being rather sparse over the dorsum. Each is round and enlarged at the surface, but tapers at its deep end like a button mushroom, and it bears secondary papillæ, but there is no thread-like processes on the epithelial caps.

The **vallate papillæ** are conspicuous, and vary in number from seven to thirteen. They are arranged in two diverging rows which lie anterior to, and parallel with, the limbs of the sulcus terminalis. The two rows converge backwards and inwards, and so form a capital V. In the median line, at the point of the V, there is a single vallate papilla, behind which is the foramen cæcum. The free surface of each papilla is broad and flat, and bears secondary papillæ, whilst the deep end is somewhat constricted, and is received into a circular pit of the mucosa. In this manner each papilla is surrounded by a space known as the trench. The outer wall of the trench projects slightly beyond the level of the free surface of the papilla, thus forming a circular elevation around it, called the *vallum* (rampart). It is from this circumstance that the papillæ have received the name 'vallate.' Their sides, as well as the wall of the vallum, contain the taste-buds.

The tongue contains a number of acinous glands. Some of them open into the trenches around the vallate papillæ, where taste-buds are present, and are serous in character (**Ebner's glands**). Others open into the foramen cæcum, into the crypts on the posterior third of the dorsum, and along the sides of the organ, these being mucous in character (**Weber's glands**). Beneath the apex of the tongue, on either side of the median line, there is a small group of glands, partly

ous and partly mucous. These two groups are known as the erior lingual glands (glands of Blandin or of Nuhn).

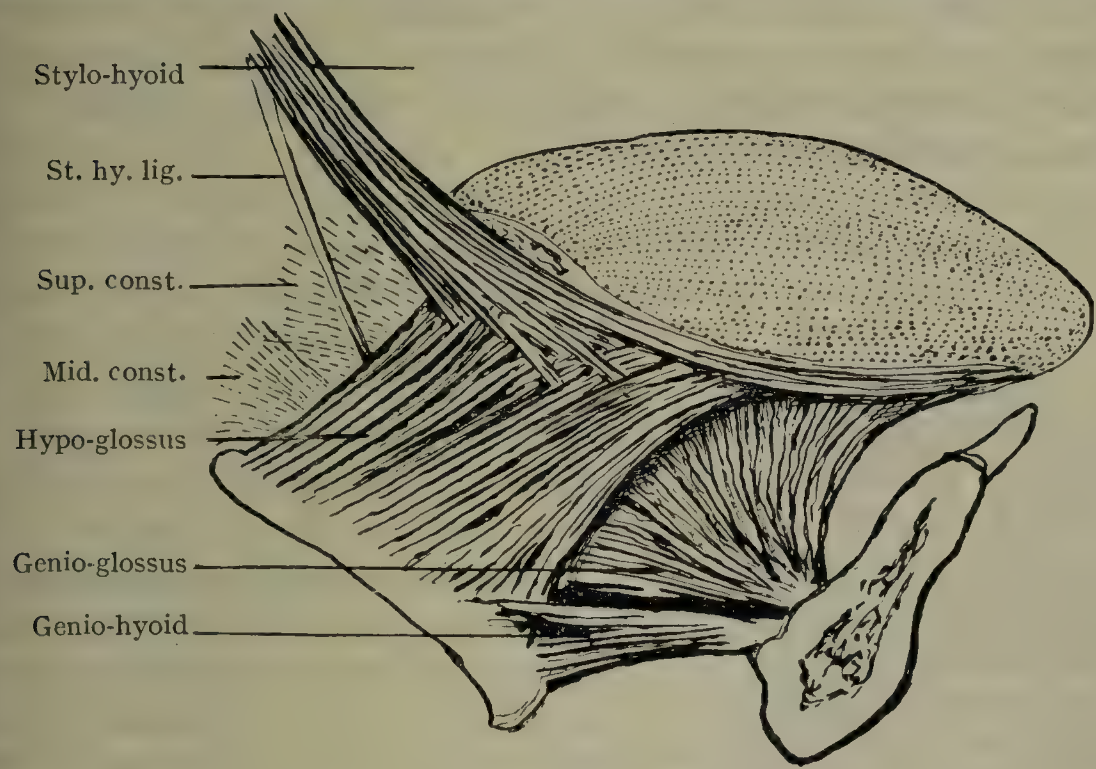


FIG. 811.—EXTRINSIC MUSCLES OF TONGUE.

The **muscular tissue of the tongue** is of the striped variety. It ms two sets of muscles—namely, extrinsic and intrinsic. The

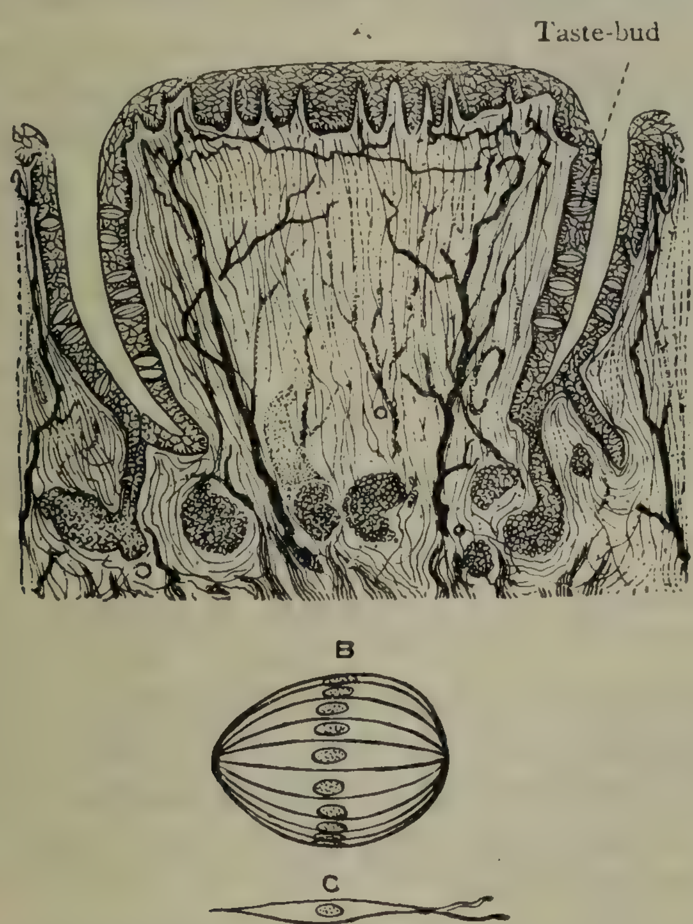


FIG. 812.—VERTICAL SECTION OF A VALLATE PAPILLA OF THE TONGUE.
A, vallate papilla, beset with secondary papillæ; B, taste-bud; C, gustatory cell.

trinsic muscles are those which have their origins outside the tongue, d their insertions into it. They are: (1) the genio-glossus, (2) the

hyo-glossus (including the chondro-glossus), (3) the stylo-glossus, a (4) the palato-glossus, all of which have been already described. T *intrinsic muscles* are those which are contained entirely within t tongue, and are: (1) the longitudinalis superior, (2) the longitudina inferior, (3) the transverse linguæ, and (4) the verticalis linguæ.

The **longitudinalis linguæ superior** is an expanded sheet placed the dorsum immediately beneath the mucous membrane. Its fibr are disposed longitudinally, and the muscle extends from the t backwards to the body of the hyoid bone. Posteriorly it is ove lapped by fibres of the hyo-glossu Its fibres do not extend over t whole length of the tongue, b take attachment at short interva to the mucous membrane.

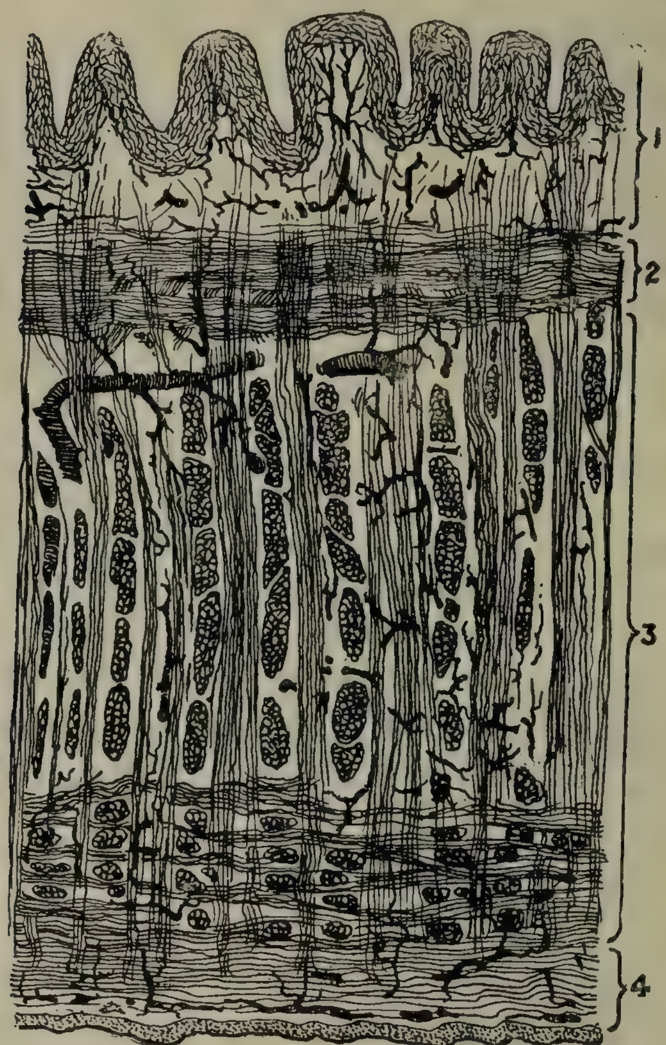


FIG. 813.—LONGITUDINAL SECTION OF THE TONGUE OF A CAT (INJECTED).

1. Muscosa.
2. Longitudinal Superior
3. Transversus et Verticalis Linguæ
4. Longitudinalis Inferior

The **longitudinalis linguæ inferi** is disposed as a round bundle the inferior surface of the tongu Posteriorly it lies between the i sertions of the genio-glossus med ally and the hyo-glossus laterall and anteriorly fuses with the styl glossus laterally. The muscle e tends from the tip of the tong to the body of the hyoid bone, wi which it is connected.

The **transversus linguæ** const tutes a layer of considerable thick ness which is placed between t longitudinales superior et inferio It arises from the median septun and extends outwards, the upp fibres curving upwards, to be i serted into the mucous membrar of the side of the tongue an adjacent portion of the dorsun This muscular stratum is inte spersed with fat, and is muc broken up by fibres of the verticalis linguæ and genio-hyo-glossus.

The **verticalis linguæ** extends from the mucosa of the dorsum t that of the inferior surface. Its fibres describe curves, having th convexities directed inwards, and they decussate freely with th fibres of the transversus linguæ.

Septum Linguæ.—The septum of the tongue is a fibrous partitio which extends in the median line from the tip of the organ to th body of the hyoid bone. It divides the tongue into two symmetrica halves, and the transversus linguæ muscle arises from it on eithe side.

Arteries.—(1) The **arteria profunda linguæ (ranine artery)**, which i

:anch of the lingual, and is situated on the inferior surface immedi-
y lateral to the line of insertion of the genio-glossus muscle. It stomoses with its fellow beneath the tip, but elsewhere there is no stomosis across the septum linguæ. (2) The **dorsalis linguæ,** ally several branches. (3) The **tonsillar branch** of the *cervical ion of the facial* artery. (4) **Pharyngeal branches** of the *ascending ryngeal* artery.

The **veins** pass to the internal jugular vein.

Lymphatics.—The lymphatic vessels of the tongue are disposed in *' groups*—apical, marginal, basal, and central.

The **apical lymphatics** pass to the submental lymph glands of the ıe side, and to one of the medial chain of deep cervical lymph glands a level with the cricoid cartilage of the larynx.

The **marginal lymphatics** carry lymph from the anterior two- ·ds of the lateral border and marginal part of the dorsum. The *erior* lymphatics of this set turn round the mylo-hyoid muscle, . end in the anterior submandibular lymph glands. The *posterior* s to the superior deep cervical lymph glands, and more particularly one lying deep to the angle of the mandible. The small lingual ıds, which lie upon the outer surface of the hyo-glossus muscle, ve as gland-stations in their path.

The **basal lymphatics** return lymph from the posterior third of the gue, and end in the same way as the posterior marginal lymphatics t stated.

The **central lymphatics** return lymph from the median part of the gue, and pass to the deep cervical lymph glands, which extend from posterior belly of the digastric muscle to the level of the cricoid tilage of the larynx.

Nerves.—The *sensory nerves* are: (1) the **lingual branch** of the *ndibular nerve,* which is distributed to the mucous membrane over *anterior two-thirds* of the tongue, including the *filiform* and *fungi- n papillæ,* upon which it confers common sensibility; (2) the **rda tympani** nerve, which accompanies the lingual nerve to the erior two-thirds of the tongue, of which it is usually regarded as nerve of taste; (3) the **lingual branch** of the *glosso-pharyngeal ve,* which is distributed to the mucous membrane of the *posterior d* and to the *vallate papillæ,* of which it is the nerve of taste; (4) the **ernal branch** of the *superior laryngeal nerve,* which furnishes a few gs to the mucous membrane of the *root of the tongue* in the region the epiglottis; and (5) the **hypoglossal nerve,** which supplies the gual muscles.

Sympathetic filaments are also conducted to the tongue by the ious arteries.

Taste-buds.—These *gustatory organs* are modified epithelial cells, l are present in the following situations: (1) The sides of the vallate pillæ and the opposed surface of each vallum; (2) the sides of the erior two-thirds of the tongue, partly in connection with the fungi- m papillæ, and partly embedded in the stratified epithelium; (3) the

folds which form the *papillæ foliatæ*; (4) the buccal surface of the s palate; and (5) the posterior surface of the epiglottis.

Each taste-bud is a flask-shaped body. The *base* rests upon t corium of the mucosa, and gives passage to nerve-fibres. The *ap* or narrow end lies between the surface-cells of the epithelium, a it is perforated by a minute opening called the *gustatory pore*, throu which the peripheral processes of the gustatory cells in the inter of the bud project as gustatory hairs.

Structure.—The *wall* of a taste-bud is composed of flatten nucleated, epithelial walls, called the **supporting cells.** These ce are elongated in the direction of the bud, they taper at either en and their margins are closely applied to each other. The *interior* the bud consists of a bundle of **gustatory cells.** Each gustatory c is nucleated and spindle-shaped. The body of the cell is prolong at either end into a process, peripheral and central respectively. T *peripheral process* passes to the gustatory pore at the apex of the bu

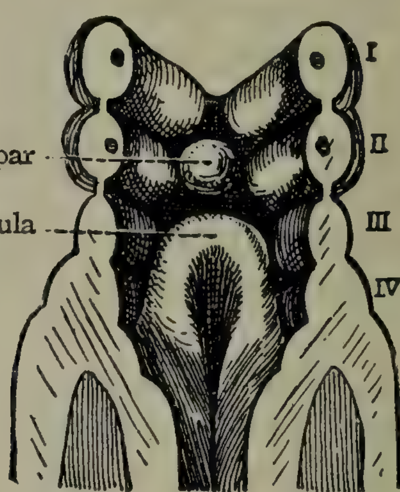


FIG. 814.—THE VISCERAL ARCHES OF THE EMBRYO (POSTERIOR VIEW) (Hi

I. Mandibular Arch
II. Hyoid Arch
III. Thyro-hyoid Arch
IV. Fourth Arch

through which it projects as a gustatory hair. The *central proce* passes towards the base of the bud, which rests upon the corium o the mucosa. It is usually branched, and ends in free extremitie It does not therefore become continuous with nerve-fibres, and therei it differs from the corresponding process of an olfactory cell.

It has been seen that the base of each taste-bud gives passage t nerve-fibres. These, as they enter the bud, lose their medullar sheaths, and their axons end within the bud in arborizations aroun the constituent gustatory cells. Nerve-fibrils also enter the ep thelial wall of the bud, and ramify between the supporting cells.

Development.—The tongue is developed in the floor of the pharynx in tw parts—buccal and pharyngeal—which are separated from each other by th foramen cæcum and **V**-shaped sulcus terminalis (see p. 72).

The *buccal* or *papillary part*, which represents the anterior two-thirds, i developed from the tuberculum impar of the first or mandibular visceral arch This eminence may give rise to the portion of the buccal part directly in fron of the foramen cæcum.

This, which appears very early, is a small rounded and well-defined swelling he middle line of the pharyngeal floor; it is in the line of the first pharyngeal ove, but appears to belong really to the mandibular arch. It enlarges slowly

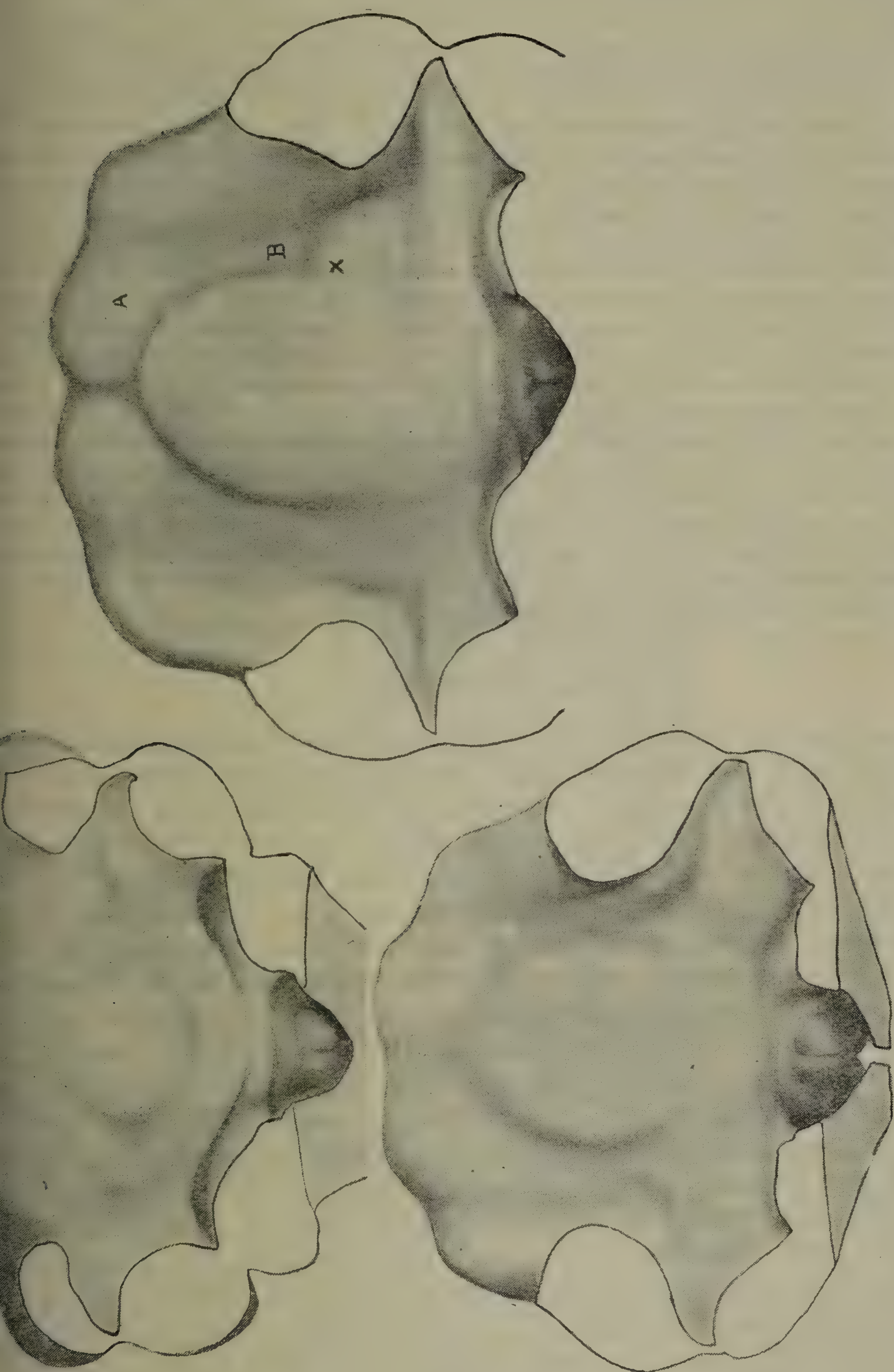


FIG. 815.—FLOOR OF MOUTH IN EMBRYOS OF 10, 12, AND 13·5 MM. LENGTH, TO SHOW DEVELOPMENT OF FRONT PART OF TONGUE.

A, A, paired swellings on mandibular arch; B, portion of arch in which growth is most marked, keeping pace with tongue; X marks approximately the site of the submaxillary outgrowth.

g. 815) but clearly as a separate formation, into which extend, from below l behind, the paired anterior ends of the ventral down-growths from post- c (occipital) myotomes; with these the hypoglossal nerves and lingual vessels ch the tongue.

This account is in keeping with the observations made on embryo material of all the stages involved. The usual description, that pai swellings on the mandibular arch envelop and in this way obliter the tubercle as a separate structure, appears to have little support in f (Fig. 815).

The pharyngeal or basal part of the tongue, the portion lying behind foramen cæcum and sulcus terminalis, is made from forward extension of anterior end of the hypobranchial eminence coming against the back of the gro ing tuberculum impar and extending behind it and postero-laterally. actual mass which comes forward in this way is probably a third arch derivati the mesoderm of this arch extending into and covering the anterior end of hypobranchial eminence; the second arch, which at one time seems to rea the eminence also, is overpowered by the third arch growth, which covers it a comes forward above it. This is a part of the general movement in the pharyng floor in which the second arch drops completely out of the floor, except in t tympanum, the third arch passing forward over it and coming against the fi arch in front of it. In the middle, the third arch masses apply themselves the back of the tuberculum impar, and in doing so enclose temporarily a sm entoderm-lined space which opens by a relatively wide aperture, the futu *foramen cæcum.* This space would have the thyroglossal duct inserted into floor, if the duct had not separated (apparently) from it long before. The spa gradually fills up, as a rule, and the ' opening ' becomes the definitive foram cæcum. Thus the foramen cæcum is not the actual impression of the thyro outgrowth, but, owing to the way in which it comes into existence, it is behind t tuberculum impar, and thus marks *on the surface* the spot from which—b at a deeper level—the thyroid growth took place.

The Soft Palate.

The soft palate is a movable musculo-aponeurotic curtain situat at the back part of the hard palate, where it projects downwards ar backwards into the pharynx. Anteriorly it is attached to the posteri border of the hard palate, laterally it is connected with the side the tongue and the wall of the pharynx, and postero-inferiorly it h a free border. Its surfaces, which occupy an oblique plane, a antero-inferior or buccal, which is concave, and postero-superior pharyngeal, which is convex and looks towards the naso-pharyn The postero-inferior border at its centre has a conical proces called the **uvula.** On either side of the base of the uvula the are two prominent folds of mucous membrane, which extend ou wards and downwards in a diverging manner. These constitu the **palato-glossal** and **palato-pharyngeal arches** (**anterior and posteri pillars of the fauces**). Each palato-pharyngeal arch belongs to th postero-inferior border of the soft palate, and it sweeps outward downwards, and backwards to the lateral wall of the pharynx. is due to the palato-pharyngeus muscle. Each palato-glossal arc belongs to the buccal surface of the soft palate, and it sweeps ou wards, downwards, and forwards to the back part of the side of th tongue. It is produced by the palato-glossus muscle. Between th diverging palato-glossal and palato-pharyngeal arches on either sid there is a triangular interval, which is occupied by the tonsil. Th passage which leads from the buccal cavity into the pharynx is calle the **oropharyngeal isthmus** (**isthmus of the fauces**). It is somewha

istricted, and is bounded above by the soft palate, below by the :k part of the dorsum of the tongue, and on either side by the lato-glossal arch.

Structure.—The soft palate is composed of a double fold of mucous embrane, which contains between its two layers an aponeurosis, iscles, and many racemose glands, with bloodvessels and nerves. e **mucous membrane** on the buccal surface has a median raphé, iich is continuous with that on the mucous membrane of the hard late, and along which the originally separate halves of the soft late unite. On the buccal surface and along the postero-inferior rder it is covered by stratified squamous epithelium, but on the aryngeal surface by ciliated columnar epithelium. The **glands,**

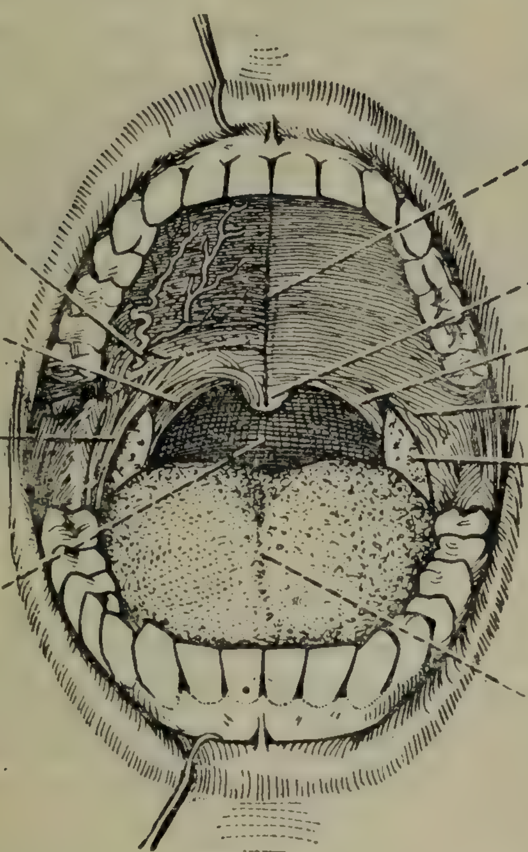


FIG. 816.—THE CAVITY OF THE MOUTH AND OROPHARYNGEAL ISTHMUS. The jaws are widely separated.

hich are racemose or acinous, are especially abundant on the buccal urface beneath the mucous membrane, where they are closely packed gether. The **palatine aponeurosis** is attached anteriorly to the osterior border of the hard palate, and laterally it becomes continuus with the aponeurosis of the pharynx. It affords attachment to ortions of the palatal muscles.

Muscles.—These are arranged in pairs, and are palato-glossus, alato-pharyngeus, musculus uvulæ, levator palati, and tensor palati.

Palato-glossus—*Origin.*—The surface of the palatine aponeurosis, s fibres being continuous across the middle line with those of the pposite muscle.

Insertion.—The back part of the side of the tongue, where its bres blend with the fibres of the transversus linguæ.

Nerve-supply.—The pharyngeal plexus.

The direction of the muscle is outwards, downwards, and forward

Action.—(1) To depress the side of the soft palate, and (2) draw the tongue upwards and backwards. The two muscles al approximate the palato-glossal arches. By means of these combine actions, aided by the tongue, the oropharyngeal isthmus is close and the anterior part of the buccal cavity is shut off from the pharyn at the beginning of the second stage of deglutition.

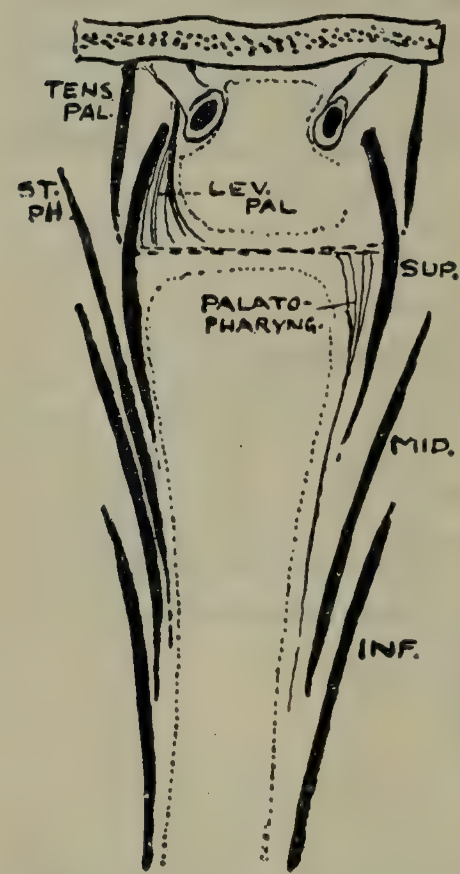


FIG. 817.—SCHEME TO SHOW PLANES IN COMPOSITION OF PHARYNGEAL WALL, WITH RELATION OF MUSCLES TO MUCOUS MEMBRANE (DOTTED LINE).

SUP., MID., INF., upper, middle, and lower constrictors. Sinus of Morgagni is the interval between upper constrictor and skull base; the tube is seen coming through this.

The muscle forms the lowest layer in th soft palate, and it gives rise to the mucou fold, called the palato-glossal arch.

Palato - pharyngeus — *Origin.* — By tw layers, upper and lower. The **posterior (uppe small layer** arises from the palatine aponeu rosis of the back of the soft palate abov the musculus uvulæ, its fibres decussatin with those of the opposite side; and th **anterior (lower) large layer** arises from th posterior margin of the hard palate, as we as from the palatine aponeurosis, decussatin with its fellow of the opposite side.

Insertion.—(1) The superior and posterio borders of the lamina of the thyroid cartilage and (2) the lateral and posterior wall of th pharynx, its fibres blending with those o the stylo-pharyngeus.

The muscle receives an accessory sli from the lower part of the cartilage of th pharyngo-tympanic tube, which is known a the *salpingo-pharyngeus muscle.*

Nerve-supply.—The pharyngeal plexus.

The muscle is directed downwards and backwards.

Action.—(1) To approximate the palato-pharyngeal arch to its fellow at the commencement of the second act of deglutition, and (2) to elevate the pharynx.

The muscle gives rise to the mucous fold called the palato-pharyngeal arch.

Musculus Uvulæ (Azygos Uvulæ)—*Origin.*—The side of the posterior nasal spine and the adjacent palatine aponeurosis.

Insertion.—The submucous tissue of the uvula, having previously united with its fellow of the opposite side.

Nerve-supply.—The pharyngeal plexus. The direction of the muscle is backwards and downwards.

Action.—To elevate and shorten the uvula.

The muscle is double at its origin, but single at its insertion. It

s above the levator palati, and beneath the upper layer of the lato-pharyngeus.

Levator Palati—*Origin.*—(1) The rough surface on the inferior pect of the petrous part of the temporal bone between the apex d the carotid canal, and (2) the lower and posterior part of the rtilage of the pharyngo-tympanic tube.

Insertion.—The aponeurosis of the soft palate, its posterior fibres coming continuous across the middle line with the corresponding res of the opposite muscle.

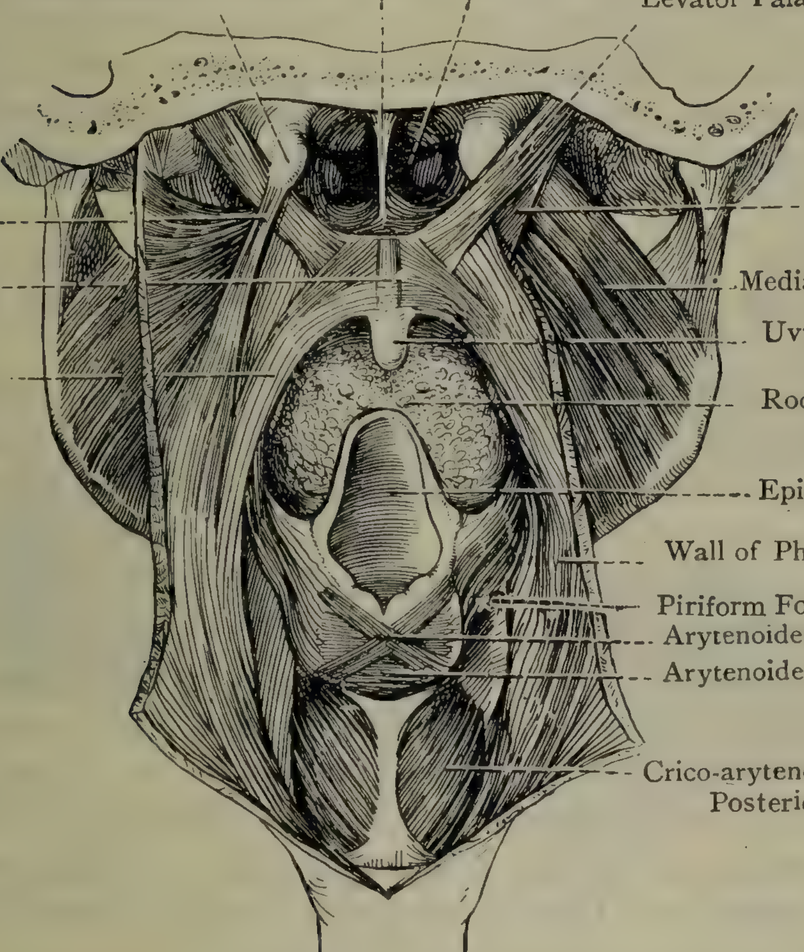


FIG. 818.—THE PHARYNX OPENED FROM BEHIND.

Nerve-supply.—The pharyngeal plexus.

The muscle is directed downwards, forwards, and inwards.

Action.—To raise the soft palate, and probably to open the pharyngo-npanic tube.

The muscle, which is round and fleshy, passes over the upper rder of the superior constrictor and through the pharyngeal apon-rosis. At its origin it is closely related to the membranous portion the pharyngo-tympanic tube.

Tensor Palati—*Origin.*—The scaphoid fossa at the root of the dial pterygoid plate of the sphenoid; and the ridge running back far as the spine; and the lateral lamina of the cartilage of the aryngo-tympanic tube.

Insertion.—(1) The transverse ridge on the under surface of th horizontal plate of the palatine bone near the posterior border; an (2) the aponeurosis of the soft palate.

Nerve-supply.—A branch from the nerve to the medial pterygoi muscle.

The muscle at first descends vertically as a flat fleshy band betwee the medial pterygoid plate and the medial pterygoid muscle, bein in close contact with the medial surface of the latter. As it approache the pterygoid hamulus it ends in a tendon, which turns round th process, a synovial bursa intervening, and then passes horizontall inwards, expanding as it does so. From the fact that the muscle i bent around the pterygoid hamulus it has been called the **circum flexus palati.**

Action.—(1) To make tense the soft palate, and (2) to draw dowr wards and backwards the margins of the cartilage of the pharyngo tympanic tube, and so open the tube during deglutition. (See actio of levator palati.)

Sensory Nerves.—These are the greater and lesser palatine nerve from the spheno-palatine ganglion, and the tonsillitic branches of th glosso-pharyngeal.

Arteries.—The soft palate is supplied by the following arteries (1) the ascending palatine of the cervical portion of the facial; (2) th palatine branch of the ascending pharyngeal; and (3) the lesse palatine branches of the greater palatine artery from the maxillary which descends in the greater and lesser palatine canals.

Relation of Structures in the Soft Palate.—Supposing the sof palate to be transfixed from its buccal to its pharyngeal surface, th following structures would be pierced: (1) the mucous membran covering the buccal surface, (2) the layer of closely-set racemos glands, (3) the palato-glossus, (4) tensor palati, (5) the lower laye of palato-pharyngeus, (6) the levator palati, (7) the musculus uvulæ (8) the upper layer of the palato-pharyngeus, and (9) the mucou membrane covering the pharyngeal surface.

Development.—The soft palate is developed from a differentiated portio of the palatal shelf or plate of the maxillary process of either side. This differenti ated portion does not undergo ossification, but acquires muscular tissue. Lik the hard palate, the soft palate and the uvula are developed in two symmetrica halves. The muscular tissue is derived from an upward growth from the wal of the pharynx invading the posterior part of the (maxillary) palate fold. Thi upgrowth makes the 'posterior pillar of the fauces.'

The Tonsils.

The tonsils are two in number, right and left. Each is situatec in the triangular depression between the palato-glossal and palato pharyngeal arches on either side, and above it is a small recess, knowr as the **intratonsillar cleft (supratonsillar fossa),** which is the remain of the inner portion of the second visceral cleft. The tonsil stands ou as an oval enlargement covered by mucous membrane, and it lie

posite the angle of the mandible, being under cover of it and the jacent portion of the ramus. The organ varies much in size, but an average it measures about 1 inch in length, about $\frac{3}{4}$ inch from fore backwards, and about $\frac{1}{2}$ inch from within outwards. The edial surface is pitted with a number of orifices which lead into crypts the interior. The outer surface, which has a fibrous covering, is ated to the superior constrictor of the pharynx, some loose tissue tervening, and lateral to the superior constrictor is the medial erygoid muscle. Two of the tonsillar arteries, the tonsillar and cending palatine, lie between the superior constrictor and medial erygoid. The cervical portion of the facial artery in its course lies little below the outer aspect of the tonsil. The internal carotid tery is situated about 1 inch from it on its outer and posterior aspect.

Arteries.—(1) The tonsillar and ascending palatine branches of e facial; (2) the ascending pharyngeal branch from the external rotid; (3) the dorsalis linguæ branches from the lingual; (4) the

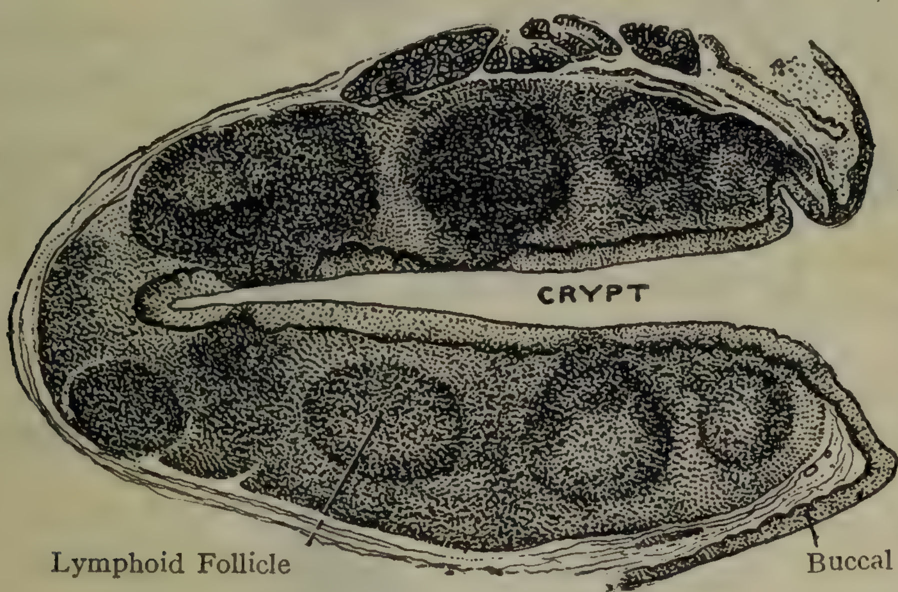


FIG. 819.—SECTION THROUGH A CRYPT OF THE TONSIL.

ser palatine offsets of the greater palatine artery from the third rt of the maxillary; (5) tonsillar twigs from the internal carotid.

The **veins** form a plexus on the outer surface of the tonsil, from ich the blood passes into the pharyngeal plexus.

Lymphatics.—These pass to the superior deep cervical lymph ands.

Nerves.—The nerves are derived from (1) the glosso-pharyngeal,) the lesser palatine branches of the spheno-palatine ganglion, and) the sympathetic.

Structure.—The tonsils are composed of lymphoid follicles. The follicles e ranged upon the sides of the crypts, which penetrate into the organ, these ypts being lined with mucous membrane covered by stratified squamous ithelium. Lymph corpuscles migrate from the follicles into the crypts, and come salivary corpuscles.

Development.—The tonsil of either side is developed from the epithelium the ventral part of the corresponding *second visceral cleft.* About the *fourth nth* a depression, known as the *sinus tonsillaris,* makes its appearance. Solid

epithelial outgrowths or buds then extend from this sinus into the surroundin mesoderm. These buds subsequently become hollow, the surface of the sinu becomes pitted, and so the **crypts** on the tonsil are formed. The mesoderm i relation to the buds and crypts becomes pervaded with lymphoid cells, and i this manner is formed the **lymphoid tissue** which constitutes the bulk of the tonsil

The **intratonsillar cleft** indicates the position of the ventral angle of th second lateral pouch.

The Nasal Cavity.

The nasal cavity extends from the anterior to the posterior aperture of the nose. Anteriorly it opens upon the face, and posteriorly int the nasal part of the pharynx. The cavity is narrow above, bu

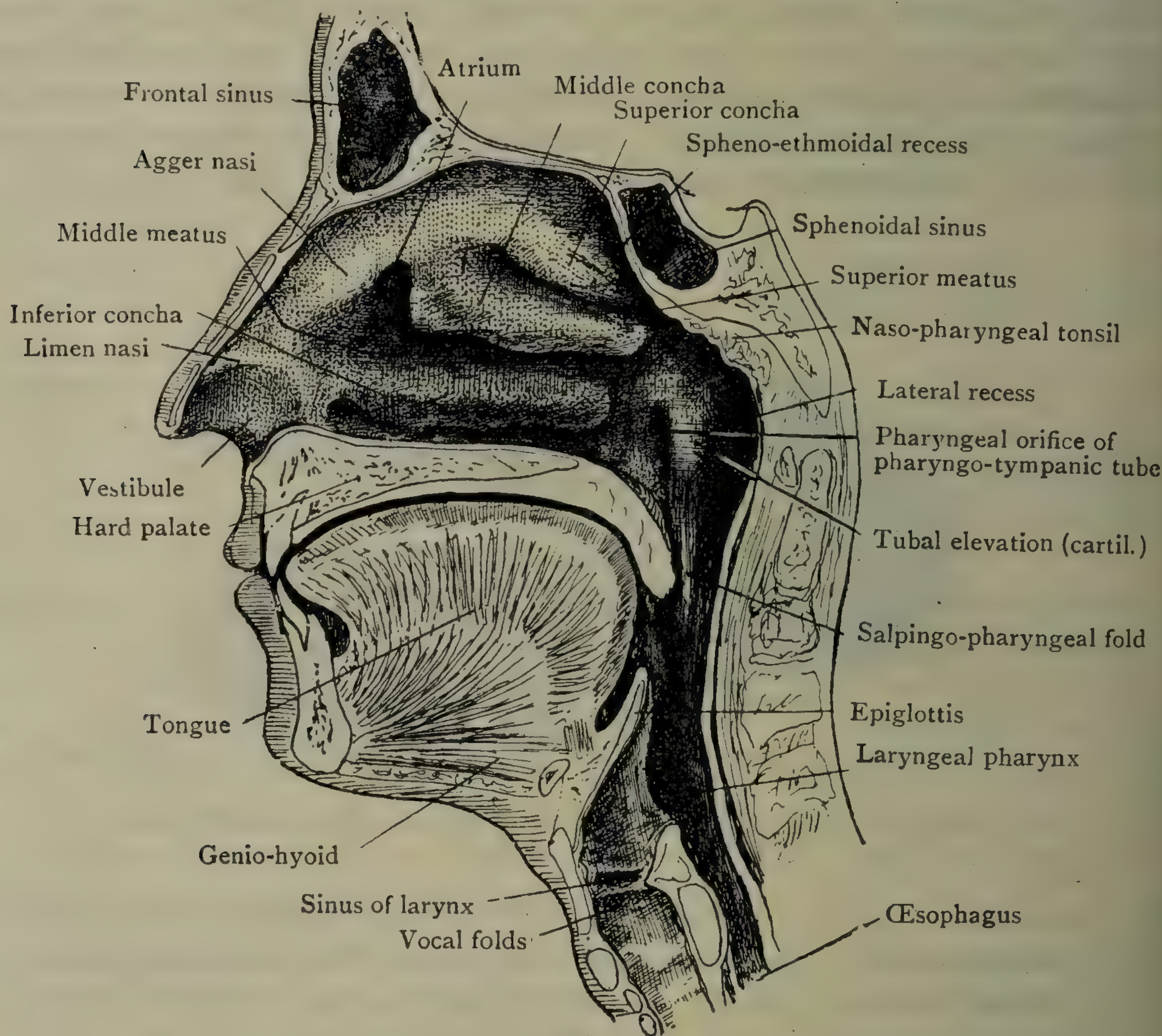


FIG. 820.—SAGITTAL SECTION THROUGH THE NASAL CAVITY, MOUTH, PHARYNX, ŒSOPHAGUS, AND LARYNX.

The outer wall of the right nasal cavity is shown.

expanded below. It is divided into right and left halves by the nasal septum, and each half has two walls (outer and inner), a roof, and a floor. The **lateral wall** is rendered very irregular by three bony scrolls, disposed antero-posteriorly, which bulge into the fossa. These are the superior, middle, and inferior nasal conchæ. They overhang deep channels, which are known as the **meatus**—superior, middle, and inferior respectively.

The **superior meatus** is confined to the back part of the outer wall,

ıd lies between the superior and middle conchæ. It is short and blique, and opening into it there are the spheno-palatine foramen, hich leads from the pterygo-palatine fossa, and the posterior eth-oidal sinus, by one or more openings. Above and behind the iperior concha is a depression, called the *spheno-ethmoidal recess*, to which the sphenoidal sinus opens.

The **middle meatus** is situated between the middle and inferior nchæ, is directed from behind forwards, and is overhung by the iddle concha. Anteriorly it describes a bend, and passes upwards ıder cover of the front part of the middle concha, to be continued to the *infundibulum*, which leads from the frontal sinus of the corre-onding side. The openings into the middle meatus are (1) the fundibulum, leading from the frontal sinus, with the opening of the ıterior ethmoidal sinus; (2) the opening of the maxillary sinus;

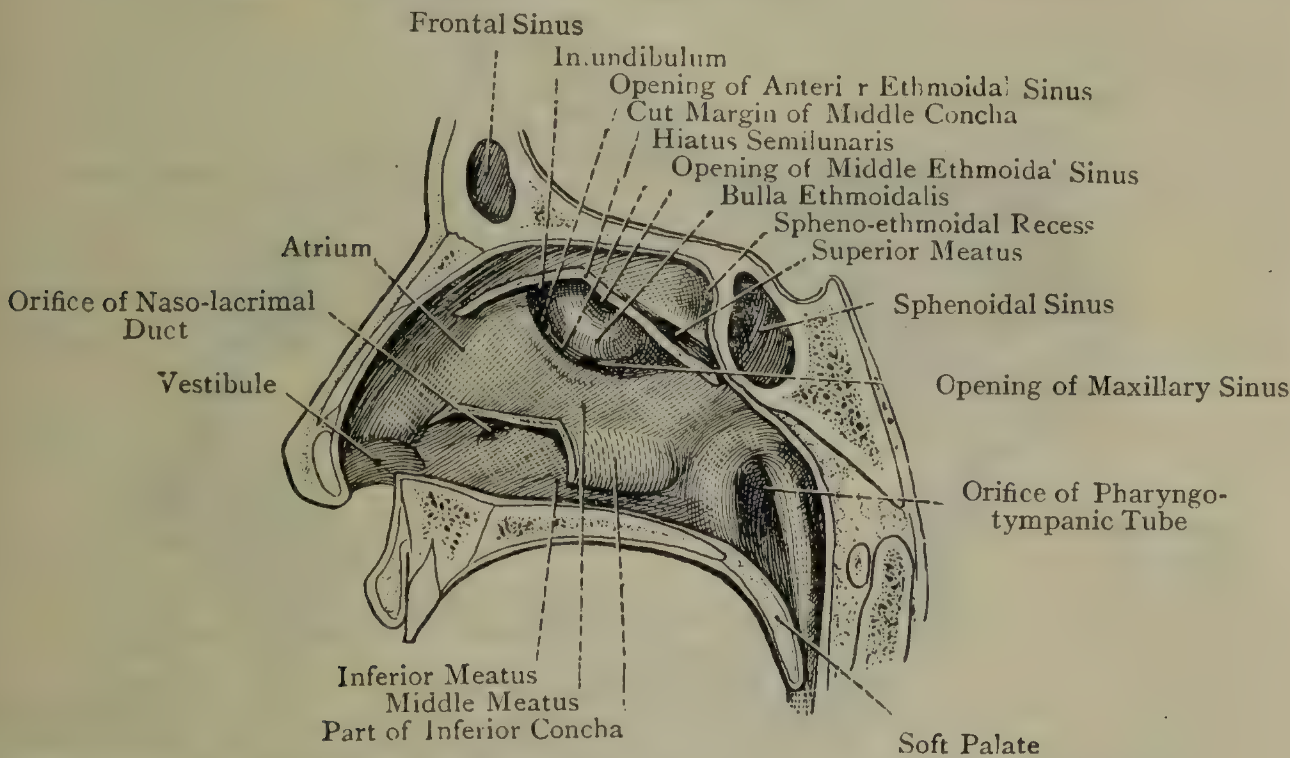


FIG. 821.—THE LATERAL WALL OF THE RIGHT NASAL CAVITY.
The superior and middle conchæ and part of the inferior concha have been removed.

ıd (3) one or two openings of the middle ethmoidal sinus. These ırious openings are concealed by the middle concha. When this is moved a deep curved groove, called the **hiatus semilunaris,** is seen rected downwards and backwards from the lower end of the in-ndibulum. Behind and above this hiatus there is a round promi-nce, called the **bulla ethmoidalis** (see Fig. 821). The opening of e anterior ethmoidal sinus is situated in the vertical portion of the atus semilunaris, and the opening of the maxillary sinus, which is small size, is placed in its horizontal portion, whilst the middle hmoidal sinus opens above the bulla ethmoidalis. In front of the iddle meatus is the region known as the **atrium,** which communicates teriorly with the **vestibule,** situated just within the ala of the nostril.

The **inferior meatus** is situated below the inferior concha. Open-g into its anterior part, under cover of the inferior concha, is the

lower orifice of the naso-lacrimal duct, which is provided with an im perfect mucous fold, called the **lacrimal fold.** The orifice is abou $1\frac{1}{4}$ inches from the anterior nasal aperture. Quite often the superio nasal concha bifurcates posteriorly, and thus encloses a fourth o highest meatus.

The **inner wall** forms the *nasal septum.*

The **roof,** which is narrow, is horizontal in its central part, th anterior portion being sloped downwards and forwards, and th posterior portion downwards and backwards.

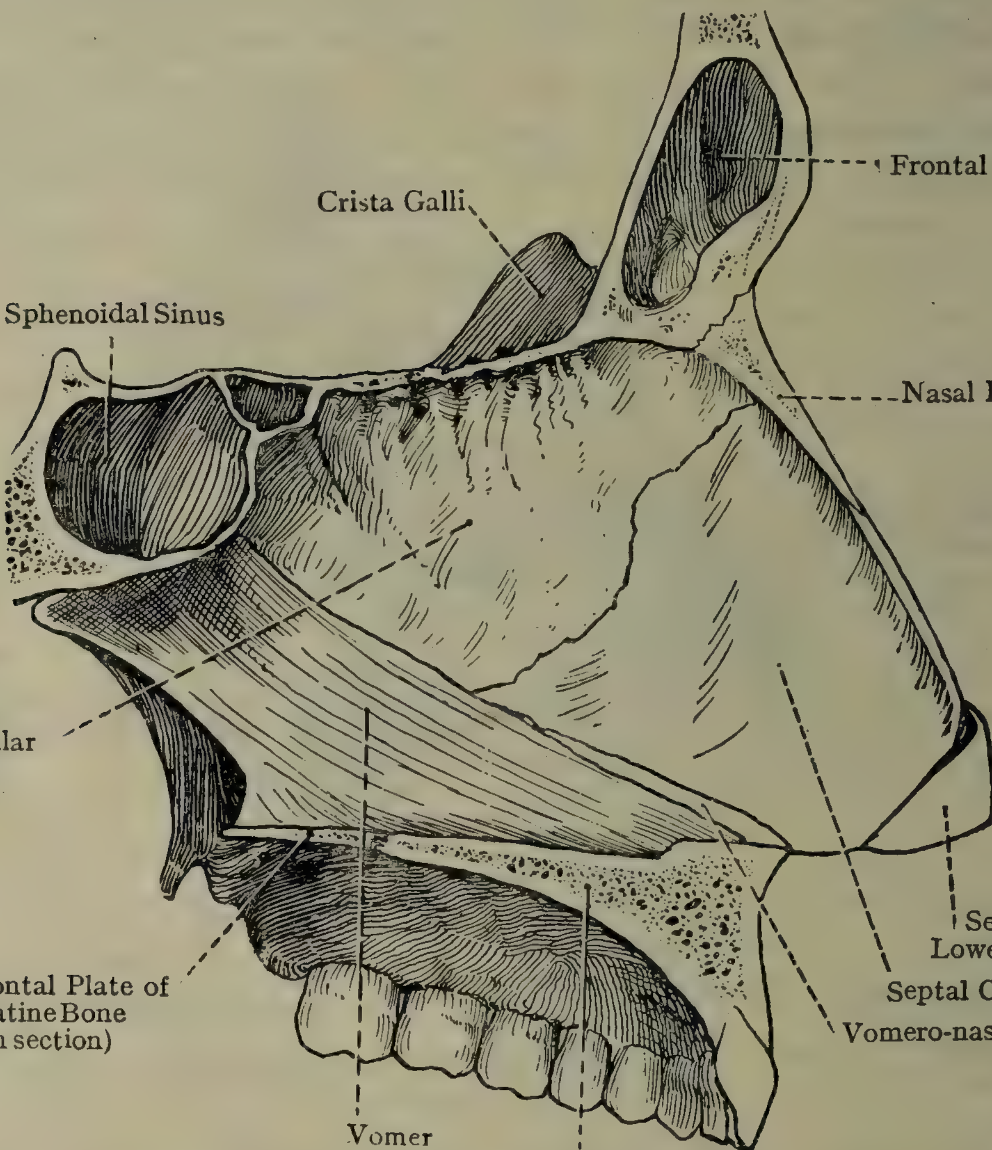


FIG. 822.—THE OSSEOUS AND CARTILAGINOUS NASAL SEPTUM (RIGHT LATERAL VIEW).

The **floor** is smooth, and at its anterior and inner part is the inciso foramen, into which a funnel-shaped portion of the mucous membran extends. This region represents the wide communication which existed in early life between the nasal and buccal cavities.

Each nasal cavity is divided into three regions—vestibular, ol factory, and respiratory. The **vestibular region,** or **vestibule,** form the anterior and lower part near the nostril. It is covered by skin which is provided with hairs or *vibrissæ.* The **olfactory region** i situated superiorly, and corresponds to the superior concha and th

er third of the nasal septum. The **respiratory region** comprises middle and inferior conchæ, the middle and inferior meatus, and corresponding part of the septum.

The Nasal Mucous Membrane.—With the exception of the vestibule, ch is lined with skin, the nasal cavity is provided with a highly cular and sensitive mucous membrane. It is continuous through the terior nasal apertures with the mucous membrane of the nasal part the pharynx; with that of the naso-lacrimal duct, lacrimal sac, lacrimal canaliculi, and thence with the conjunctiva; and with t of the various air-sinuses which communicate with the nasal ity. It is thick and spongy over the conchæ, especially along the er borders of the middle and inferior conchæ, and also on the nasal tum, but over the floor, atrium, and meatus it is comparatively

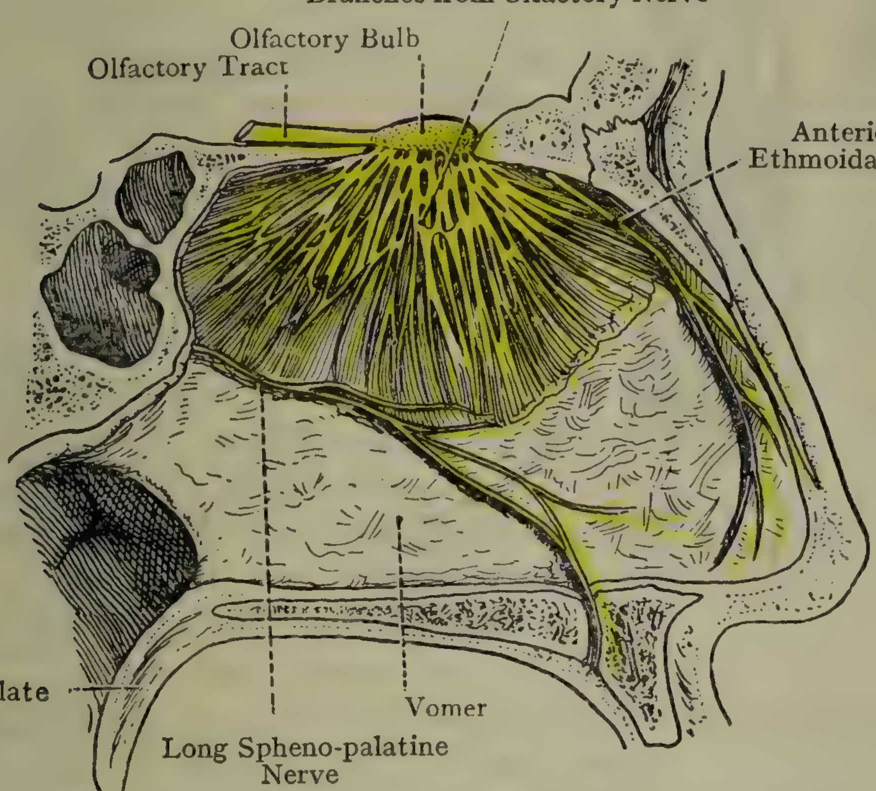


FIG. 823.—THE NERVES OF THE NASAL SEPTUM (HIRSCHFELD AND LEVEILLÉ).

n. It is freely provided with acinous glands, and contains a certain ount of lymphoid tissue.

The epithelium varies in different regions. In the vestibular ion, where the lining membrane is skin, it is of the stratified squamous iety; in the respiratory region, as well as in the air-sinuses, it is atified, columnar, ciliated epithelium; and in the olfactory region s non-ciliated columnar epithelium.

Olfactory Mucous Membrane.—In the olfactory region the mucous mbrane is thick and pulpy, and has a yellowish-brown colour, e to pigment in the epithelial cells. It contains a copious plexus olfactory nerve-fibres, and many serous glands, which are known the **nasal glands (Bowman's glands)**. The **epithelium** is thick, and, as s been shown, is of the non-ciliated columnar variety, its free surface ng covered by a delicate limiting membrane. The cells of which

it is composed are of three kinds: (1) Long columnar nucleated cel called the **supporting cells,** the deep end of each of which is prolong into a branched process. (2) Between these supporting cells the are the olfactory cells, which are elongated and spindle-shaped. Ea contains an almost spherical nucleus, and has a superficial and a de process or pole. The *superficial pole* extends through the limiti membrance to the free surface, and pı jects slightly in the form of a tuft delicate hair-like filaments called t **olfactory hairs.** The *deep pole,* which a delicate varicose filament, exten towards the mucosa, where it becom continuous with one of the nerve-fibr of the olfactory plexus. (3) In the de part of the epithelium there are in sor places **conical cells,** the broad ends which rest upon the basement membra (see Fig. 824).

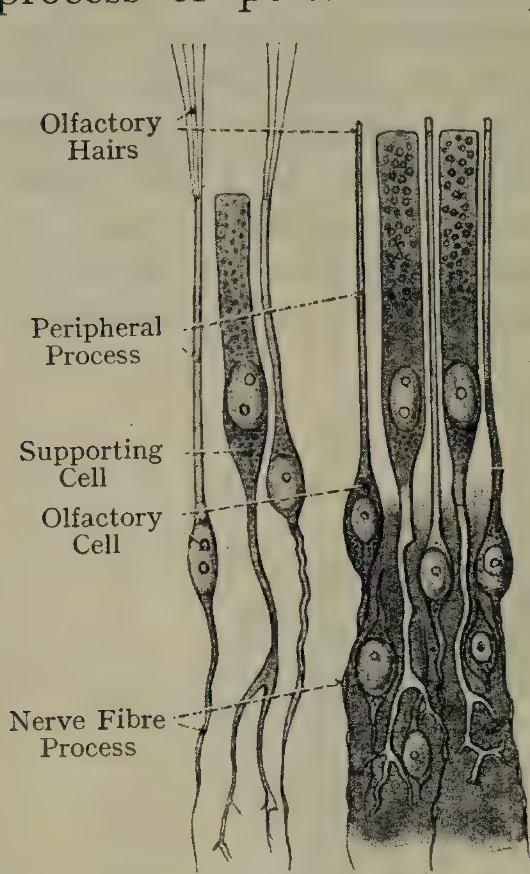


FIG. 824.—CELLS OF OLFACTORY MUCOUS MEMBRANE (SCHULTZE, FROM QUAIN'S 'ANATOMY').

Olfactory Nerves.—These are from f teen to twenty in number on each sic After leaving the inferior surface of t olfactory bulb, they pass through t foramina in the corresponding half of t cribriform plate of the ethmoid bor and so reach the upper part of the nas cavity invested by prolongations of t membranes of the brain. Within t nasal cavity they are arranged in tv groups, inner and outer. The nerves the *inner group* are distributed to the mucous membrane of the nas septum over about its upper third. The nerves of the *outer group* a distributed to the mucous membrane in the region of the superi concha and olfactory sulcus. The nerves form a copious plexus the mucous membrane, and the filaments which issue from this plex become continuous, as has been shown, with the deep poles of t olfactory cells. The olfactory nerves have no medullary sheath.

Nerves of Ordinary Sensation:

1. Upper nasal branches of the spheno-palatine ganglion.
2. Nasal branches of the nerve of the pterygoid canal.
3. Lower nasal branches of the greater palatine nerve.
4. Anterior ethmoidal nerve.
5. Branches of the anterior superi dental nerve.
6. Long spheno-palatine nerve.
7. Infra-orbital nerve.

The **upper nasal branches** of the spheno-palatine ganglion enter the superi meatus through the spheno-palatine foramen, and are distributed to the muco membrane (1) over the superior and middle conchæ, (2) over the upper a back part of the nasal septum, and (3) within the posterior ethmoidal sinus.

Branches from the nerve of the pterygoid canal pierce the floor of that can and are distributed to the mucous membrane over the back part of the roof the nasal cavity and the adjacent part of the septum.

Lower nasal branches arise from the greater palatine branch of the spheno-latine ganglion as that nerve traverses the greater palatine canal. They ter the nasal cavity through foramina in the perpendicular plate of the latine bone, and are distributed to the mucous membrane over the greater rt of the inferior concha, and the corresponding parts of the middle and ferior meatus.

The branches from the **anterior ethmoidal nerve** are two, septal and lateral. ie *septal branch* is distributed to the mucous membrane over the anterior and per part of the septum, and the *lateral branch* to that over the anterior rtions of the middle and inferior conchæ, and over the outer wall in front these.

Upper nasal branches of the anterior superior dental nerve are distributed to e mucous membrane over the anterior part of the inferior meatus and the jacent part of the floor of the nasal cavity.

The **infra-orbital branch of the trigeminal** supplies the vestibule.

FIG. 825.—THE ARTERIES OF THE NASAL SEPTUM (HIRSCHFELD AND LEVEILLÉ).

It will be noticed that, with the exception of the anterior ethmoidal branch of ie naso-ciliary, all the nerves of the nasal cavity are derived from the maxillary vision of the trigeminal nerve.

The **long spheno-palatine nerve** arises from the spheno-palatine ganglion, id enters the nasal cavity through the spheno-palatine foramen. It then osses the roof, and so reaches the septum, upon which it descends with a rward inclination, occupying the groove on the outer surface of the vomer. then passes downwards to the anterior part of the hard palate, the *left* nerve aversing the anterior incisive canal, and the *right* nerve the posterior incisive nal. As the long spheno-palatine nerve lies upon the nasal septum it furnishes anches to its mucous membrane.

Arteries of the Nasal Cavity.—These are derived from the following sources:

1. The spheno-palatine.
2. The greater palatine.
3. The artery of the pterygoid canal.
4. The anterior ethmoidal.
5. The posterior ethmoidal.
6. The superior labial.

The **spheno-palatine artery** is the principal artery of the nasal cavity. Arising om the third part of the maxillary, it enters the cavity through the spheno-latine foramen. Most of its branches are distributed to the outer wall; but

one, called the *posterior septal branch*, accompanies the long spheno-palati nerve. This branch gives offsets to the septum, and enters the incisive forame where it anastomoses with a branch of the greater palatine artery, which ascen from the palate in the incisive canal.

The **greater palatine artery** arises from the third part of the maxillary. it traverses the greater palatine canal it gives off two or three branches whi accompany the lower nasal branches of the greater palatine nerve throu foramina in the perpendicular plate of the palate bone, to be distributed to t back part of the inferior concha and the adjacent parts of the middle and i ferior meatus.

The **artery of the pterygoid canal,** arising from the third part of the maxillar traverses the pterygoid canal, and furnishes a few twigs which accompany t branches of the corresponding nerve, and supply the back part of the roof the nasal cavity and the adjacent part of the septum.

The **anterior** and **posterior ethmoidal arteries** are branches of the ophthalm The *anterior ethmoidal* enters the nasal cavity along with the anterior ethmoid

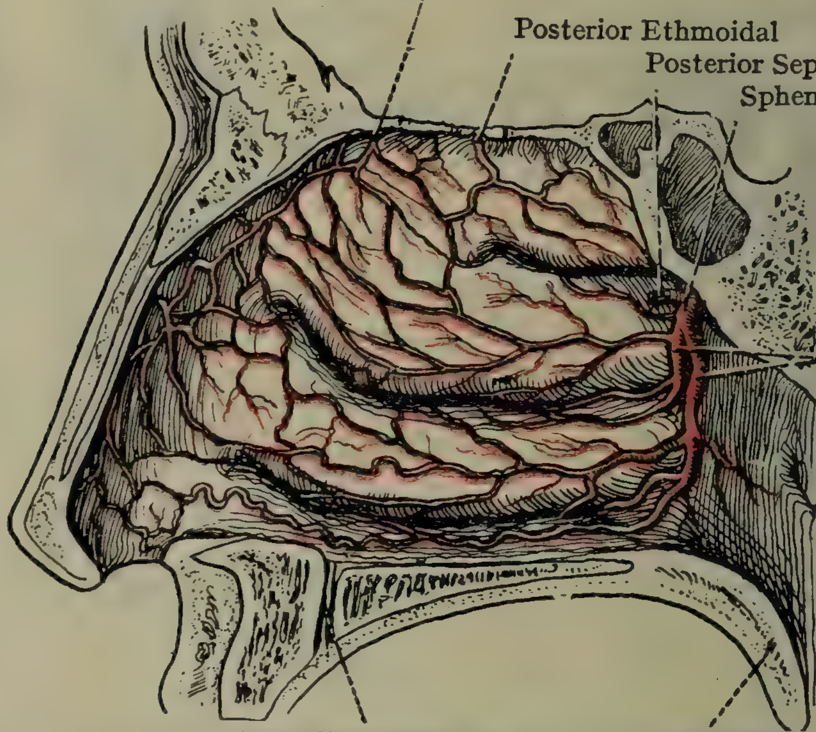


Fig. 826.—The Arteries of the Lateral Wall of the Right Nasal Cavity, (after Hirschfeld and Leveillé).

nerve, and furnishes branches to the anterior and upper part of the septur the front part of the outer wall, and the anterior portions of the middle ar inferior conchæ. The *posterior ethmoidal* gives nasal branches which enter tl nasal cavity through some of the foramina in the cribriform plate of the ethmoi and are distributed to the roof and upper part of the septum.

The **superior labial artery,** a branch of the facial, gives off a *septal branc* which supplies the anterior part of the septum and the columna nasi.

The **veins** form a free plexus, especially over the inferior concha and tl lower margin and back part of the middle concha. The vessels which carr away the blood from the plexus correspond to the various arteries, and the principal destination is threefold—namely, (1) the pterygoid plexus, (2) th superior ophthalmic vein, and (3) the anterior facial vein. The ethmoidal vein which open into the superior ophthalmic vein, communicate with the intracrani anterior meningeal veins and with the commencement of the anterior faci vein by means of twigs which pass through minute apertures in the front process of the maxilla, and, it may be, through a small foramen in the nas bone. In those cases where the foramen cæcum is pervious it transmits a

issary vein which passes between the intracranial superior sagittal sinus l the veins of the roof of the nasal cavity.

The **lymphatics** of the **atrium** and **vestibule** pass to the submandibular lymph nds. The principal lymphatics pass to (1) the retropharyngeal glands; (2) the ɛp facial lymph glands; and (3) the superior deep cervical lymph glands. e lymphatics of the air-sinuses end in a similar manner.

The lymphatics of the nasal fossæ communicate with lymphatic spaces ich are related to the olfactory nerve-filaments; and these lymphatic spaces turn communicate with the intracranial, subdural, and subarachnoid spaces.

Development of the Nose (pp. 83-88).

The cavity of the mouth in the embryo is separated from the lower surface the fore-brain and its derivatives by a layer of mesoderm which thickens ntinuously. The **nasal cavities** are developed in this mesodermal layer, and us *are not parts of the common mouth cavity*; they open into this cavity by ertures which lengthen as the mesoderm thickens, and of which the greater rtions are secondarily closed by the palate folds, the unclosed parts forming e definite **posterior nasal apertures.**

The first indications of the olfactory organ are the two **olfactory areas.** ɪey consist of thickened ectoderm, and are placed on the ventral aspect of e anterior cerebral vesicle, on either side of the mesial nasal process of the ɔnto-nasal process, and on the cephalic side of the orifice of the stomodæum ig. 54).

Each olfactory area soon becomes depressed and forms the **olfactory pit.** ɪe depression is due to the growth of mesoderm; on the inner and outer sides is forms **inner** and **outer nasal folds** respectively, continuous in front but open hind. The outer fold is the longer, and the maxillary process, growing in-ards across this, comes into contact with the *inner* fold, with which it fuses. hus the *pit* becomes a shallow *fossa.* Its posterior end is closed by the junction maxillary and inner nasal processes, and the epithelial fusion between these akes the *bucco-nasal membrane,* separating it from the mouth. The membrane oses what is, potentially, a *primitive posterior naris*; it is stretched as this ows, and finally breaks and disappears.

The subsequent development of the proportionately full-sized cavity from is small beginning has been described on p. 85, etc., to which the reader is ferred.

The *lower conchal* mass is present at an early stage, being made by the in-ɛrnal projection of the lower edge of the outer nasal fold. It is added to by ldition of maxillary mesoderm as the fossa increases in length backwards. he *middle* and *upper nasal conchæ* become evident later as the cavity grows; ɪey are present by the end of the second month. The upper mass is described s derived from the upper part of the inner wall, migrating across the roof, but ɪe ontogenetic evidence of this is very doubtful. The cartilaginous bases of ɪe masses are derived from the cartilaginous capsule. In fœtal life there is marked tendency for the two upper masses to show longitudinal subdivisions, iving the appearance of the presence of half a dozen or more conchæ, but the ppearance is deceptive, as these are only surface formations, and are usually ɔst by the time of birth.

The maxillary sinus can be recognized in the third month as a depression 1 the outer wall. It extends very slowly, so that at birth it only makes a avity a few millimetres wide in the inner part of the maxilla.

A **cartilaginous nasal capsule** is built up round the two cavities as they xtend up. It is deficient below, where the elongated aperture is placed; here ts lateral plate has its lower edge turned in to make the cartilaginous basis of he *lower nasal concha.* The other nasal conchæ are based on ingrowths from ts inner aspect. It presents the **septal cartilage** centrally, formed in the thick ıesoderm between the two cavities. The **vomer** develops as a paired ossifica-ion in the mesoderm along the lower or free edge of the septal cartilage. The

palatine bone ossifies on the deep surface of the capsule, and the maxilla structures superficially. The premaxilla and incisive part of the palate devel in the region of the primitive palate. The capsule is in contact with the bo of the sphenoid above and behind, and a wing-like process here, the **orbi sphenoidal process,** is related with the lesser wing.

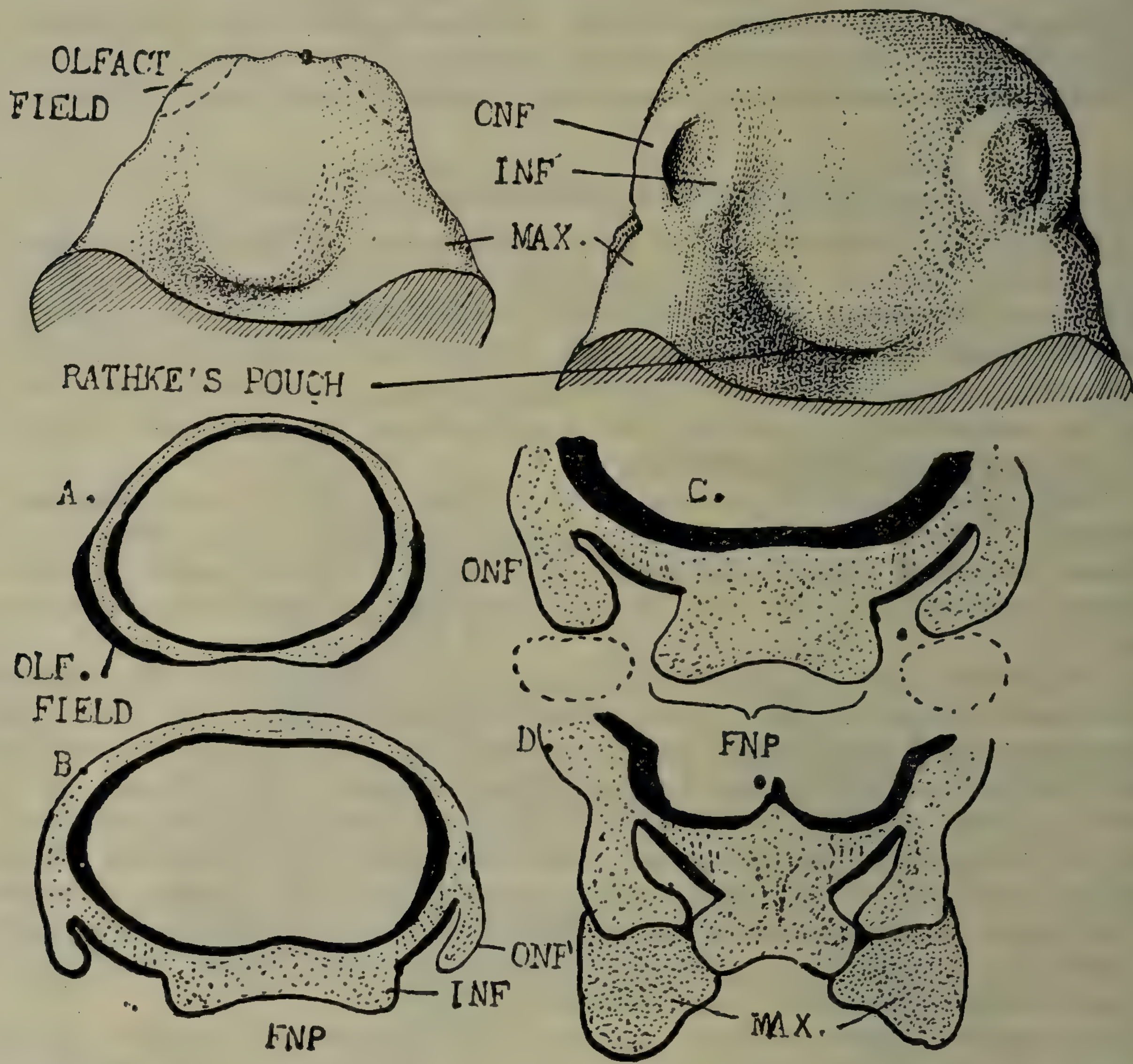


FIG. 827.

The two upper figures show the lower aspects of the projecting heads of embry of 4 mm. and 7 mm. (From reconstruction models.) The change position of the olfactory region is due to the growth of the telencephal in the 7 mm. specimen. This not only advances the front of the he beyond the site of the olfactory fields, but also, as a result of increase breadth, turns them more on to the lower aspect. A and B in the low figures are sections through the olfactory fields of the two embryos, showi formation of olfactory pits and fronto-nasal process. C and D are diagra matic sections to illustrate the further changes. The maxillary process are indicated by interrupted lines to show where they will come into po tion, as in D. ONF, INF, lateral and medial nasal folds; FNP, fronto-nas process.

The **Paranasal Sinuses.**—The frontal, ethmoidal, sphenoidal, and maxilla sinuses are developed as evaginations of the *nasal mucous membrane,* whi extend into spaces formed by absorption within the respective bones. The ma toid air-cells are developed as evaginations of the *tympanic mucous membra* which is continuous with the nasal mucous membrane through the pharyng tympanic tube and nasal part of the pharynx.

Olfactory Organ.—The true olfactory organ is situated in the upper par or **olfactory region,** of each nasal cavity. The **olfactory epithelium,** which cove

e mucous membrane of this region, is developed from the upper part of the orresponding olfactory pit.

External Nose.—The *dorsum* and *tip* of the nose, and the *columna nasi*, are eveloped from the portion of the mesial nasal process which lies between the lobular processes. The *upper* and *lower nasal cartilages* are derived from the artilaginous core of the corresponding lateral nasal process. The **anterior asal aperture** of each side represents, as stated, the external orifice of the

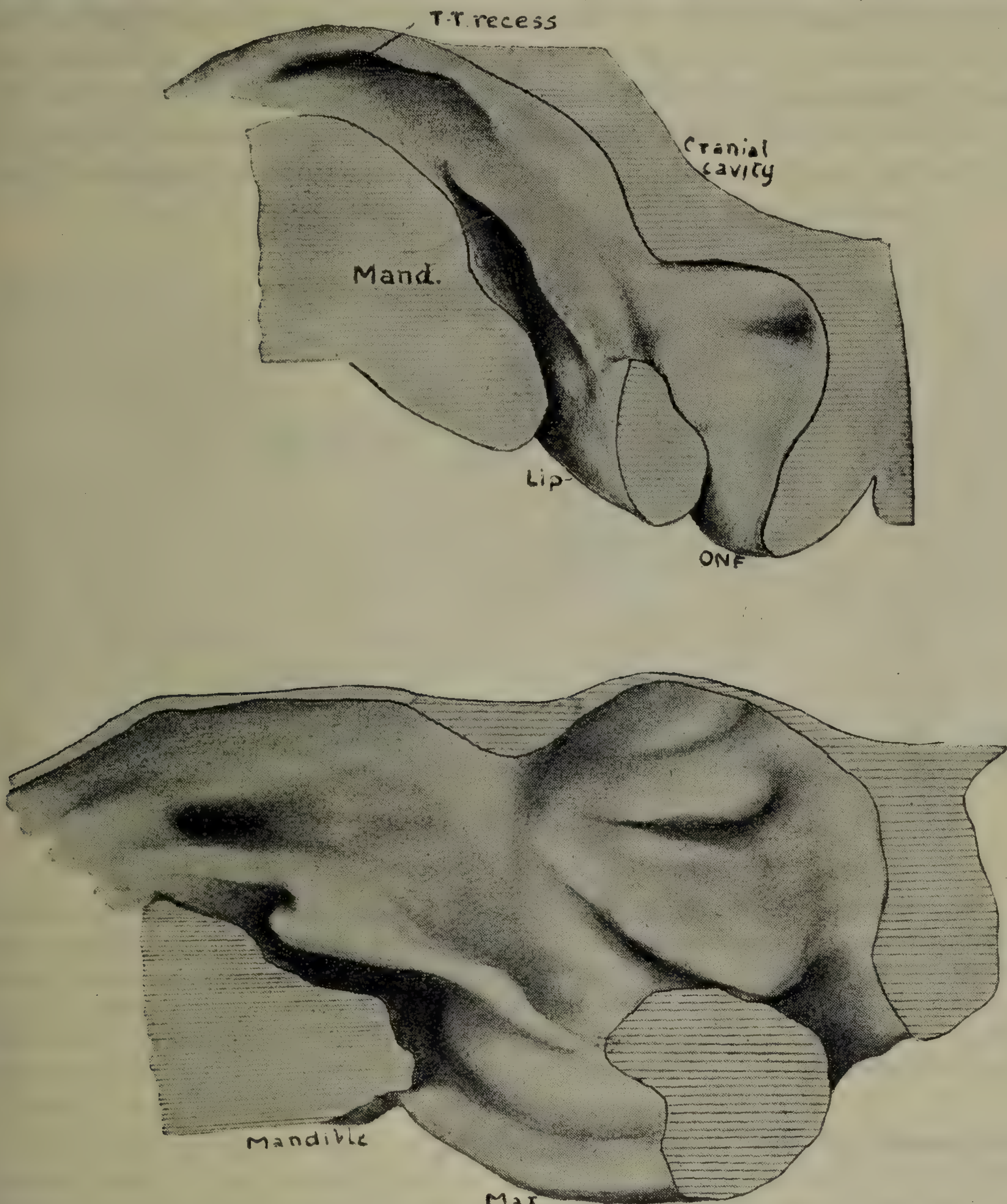


FIG. 828.—ANTERO-POSTERIOR SECTIONS OF HEADS OF EMBRYOS OF 16 AND 28 MM.

corresponding olfactory pit, but it is modified by secondary extensions of maxillary mesoderm round its margins.

The Vomero-nasal Organ (Organ of Jacobson).—The vomero-nasal organ is rudimentary in man, but is well developed in reptiles.* It takes the form of a blind pouch, which is situated in the lower and anterior part of the nasal septum on either side. The minute orifice

* There is some doubt as to whether the rudimentary structure of man is really vestigial of that of the lower forms.

of the pouch lies above the recess or depression of mucous membrane which projects slightly into the upper end of the incisive canal. Th pouch extends upwards and backwards in the nasal septum for a ver short distance, and ends in a blind extremity. The vomero-nasa (subvomerine) cartilage lies underneath it. The vomero-nasal orga does not seem to perform any function in man. In those animal however, in which it is well developed it receives two nerves, one c which is olfactory, the other being derived from the spheno-palatin ganglion. Moreover, its epithelial lining is similar to that of the o factory region of the nasal cavity, inasmuch as it contains olfactor cells, the deep poles of which are continuous with olfactory filament In such animals it acts as a supplementary organ of smell.

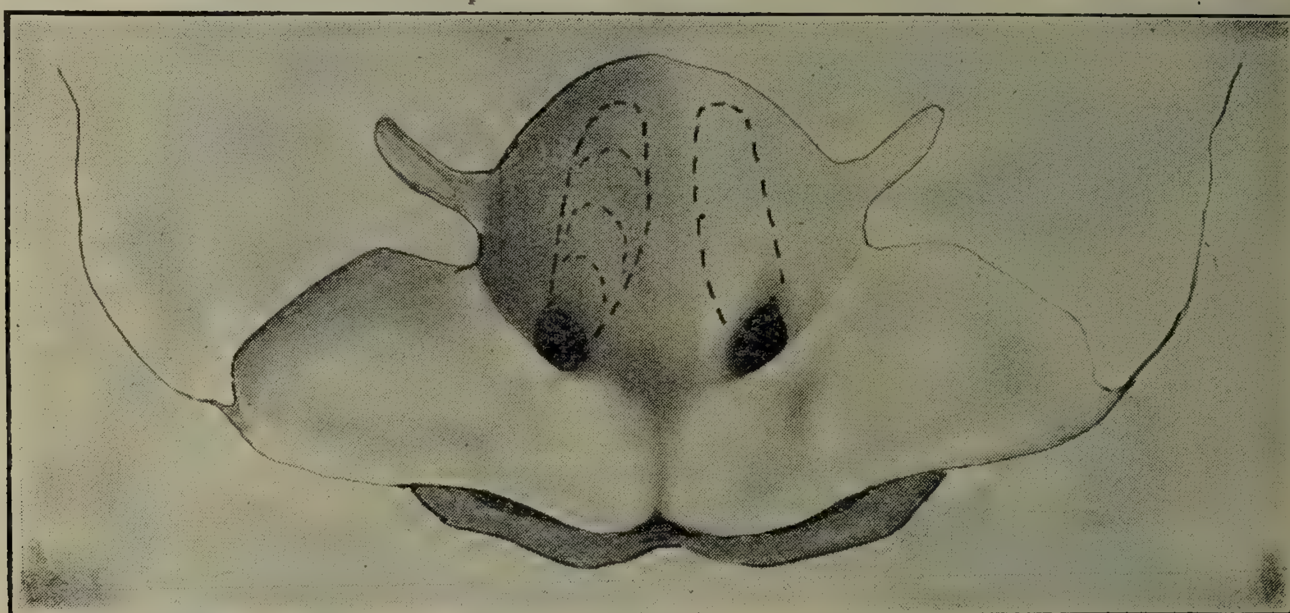


FIG. 829.—VIEW, FROM BELOW AND BEHIND, OF THE ROOF OF THE MOUTH OF AN EMBRYO OF 16 MM. (SIXTH WEEK).

Showing the palate folds reaching the fronto-nasal process, the evident sha of this process, though covered by a layer of maxillary mesoderm, and t growth of the labial extension of the mesoderm, only just meeting its fello in the middle line. This will become much thicker and vertically deepe hiding the fronto-nasal form altogether. The interrupted lines indica the extension upward of the upper level of the posterior nasal apertures.

Development of the Vomero-nasal Organ.—This organ is developed as diverticulum of a portion of the ectoderm of the olfactory pit. The diverticulu projects upwards and backwards into a recess situated laterally within t lower and anterior part of the septal nasal cartilage just above the upper e of the incisive canal; it marks the meeting of the paraxial and visceral mesoder in the septum.

The Pharynx.

The pharynx is situated behind the posterior nasal apertures, th oropharyngeal isthmus, and larynx, and it extends from the basil region of the base of the skull to the level of the lower border of th cricoid cartilage of the larynx, where it becomes continuous with th œsophagus. It is a musculo-aponeurotic tube about 5 inches lon and it attains its greatest width between the base of the skull an

e hyoid bone. Below the latter level it narrows, and is flattened om before backwards, so as to assume the form of a transverse cleft, cept during the act of deglutition.

Relations.—*Posteriorly* it rests upon the bodies and discs of the rvical vertebræ as low as the sixth, and the prevertebral muscles vered by the prevertebral fascia. Between it and the last-named scia is the retropharyngeal space, which is occupied by connective ssue, but this is so loosely arranged that no obstacle is offered to e movement of the tube, and a post-pharyngeal abscess can readily ffuse itself. *Anteriorly* it communicates with (1) the nasal cavities rough the posterior nasal apertures, (2) the pharyngo-tympanic

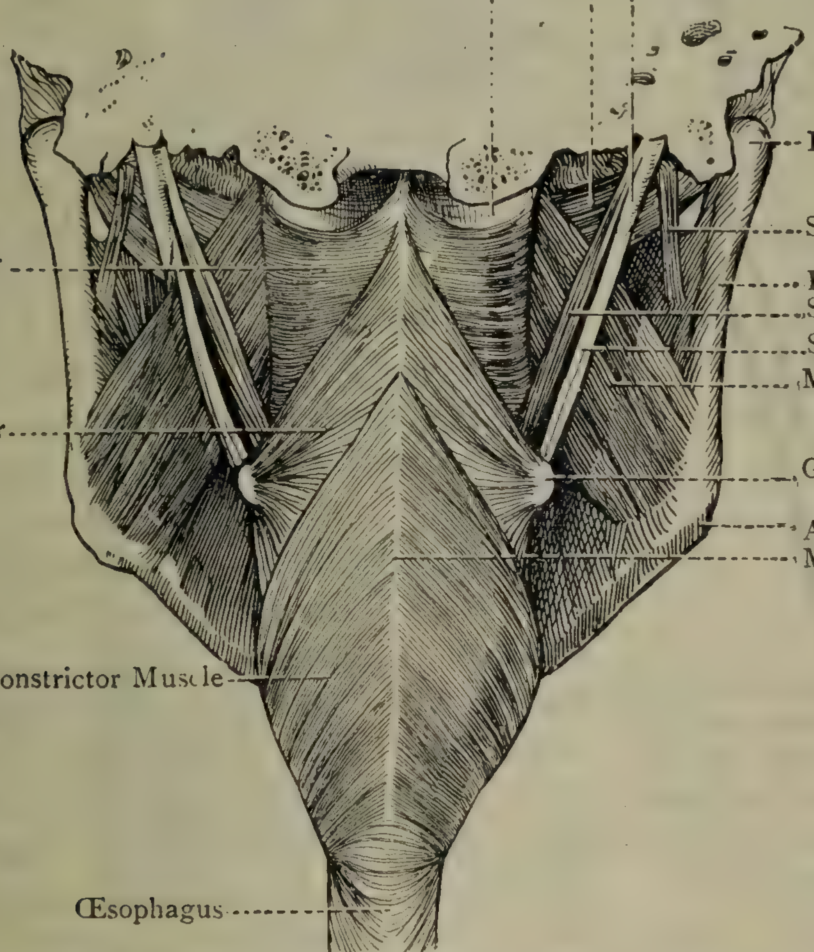


FIG. 830.—THE POSTERIOR WALL OF THE PHARYNX AND ADJACENT STRUCTURES.

ubes, (3) the buccal cavity through the oropharyngeal isthmus, and 4) the larynx. On this aspect its attachments are effected by means f the constrictor muscles in its walls. *Laterally* it is related to the rincipal bloodvessels and nerves of the neck, and comes into contact vith the styloid muscles and the process from which they arise. *Superiorly* it is attached to the basilar region of the base of the skull. *Inferiorly* it is continuous with the œsophagus.

The wall of the pharynx consists of the following four strata, rom without inwards: (1) the pharyngeal portion of the bucco-pharyngeal fascia, (2) the muscular coat, (3) the pharyngo-basilar ascia, and (4) the mucous coat.

Bucco-pharyngeal Fascia.—This is an offshoot of the prevertebra layer of the deep cervical fascia along the medial aspect of the caroti sheath. In front it becomes continuous with the fascia covering th buccinator muscle. In association with this fascial stratum there ar many veins upon the posterior and lateral walls of the pharynx, whicl constitute the pharyngeal venous plexus.

Muscular Coat.—This is composed on either side of the three con strictor muscles—inferior, middle, and superior—the stylo-pharyngeus and the palato-pharyngeus (including th salpingo-pharyngeus).

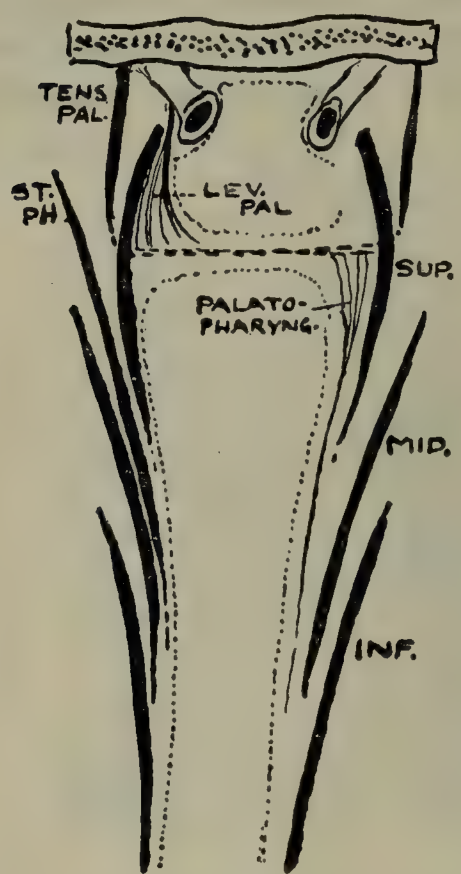


Fig. 831.—Scheme to show Planes in Composition of Pharyngeal Wall, with Relation of Muscles to Mucous Membrane (Dotted Line).

SUP., MID., INF., upper, middle, and lower constrictors. Sinus of Morgagni is the interval between upper constrictor and skull base; the tube is seen coming through this.

Inferior Constrictor—*Origin.*—(1) The sid of the cricoid cartilage at its posterior part (2) the inferior horn of the thyroid cartilage and (3) the outer surface of the lamin behind the oblique line.

Insertion.—The median raphé on the pos terior wall of the pharynx, where it meet its fellow of the opposite side.

The lower fibres of the muscle are hori zontal, but the upper fibres pass upward and backwards more and more obliquel and the highest fibres of the two muscle meet in the raphé to form a peak, which i about an inch below the basilar part of th occipital bone. The lower border of th muscle overlaps the upper end of the œso phagus. The recurrent laryngeal nerve an inferior laryngeal artery pass upwards be neath the lower border behind the cricc thyroid joint. The upper border, which i very oblique, overlaps the lower portion c the middle constrictor, and the interna laryngeal nerve and the superior larynge artery, on their way to pierce the thyro-hyoi membrane, pass between the two muscle anteriorly.

Middle Constrictor—*Origin.*—(1) The oute border of the greater horn of the hyoid bon over its entire length, (2) the lesser horr and (3) the hyoid extremity of the stylo hyoid ligament.

Insertion.—The median raphé on the posterior wall of the pharyn where it meets its fellow of the opposite side.

The muscle is fan-shaped, and its fibres consequently diverg very much as they pass round to reach the raphé. The inferior fibre descend very obliquely, and are overlapped by the upper fibres c the inferior constrictor, the internal pharyngeal nerve and superic laryngeal artery passing to the thyro-hyoid membrane between th

o muscles anteriorly. The middle fibres pass more or less trans-
rsely. The superior fibres ascend obliquely, and reach the basilar
rt of the occipital bone. They overlap the lower portion of the
perior constrictor, and the stylo-pharyngeus muscle and glosso-
aryngeal nerve pass between the two. The lingual artery lies
perficial to the muscle at the greater horn of the hyoid bone.

Superior Constrictor—*Origin.*—(1) The lower third of the posterior
rder of the medial pterygoid plate, and the pterygoid hamulus
ocess of the sphenoid bone; (2) the posterior aspect of the pterygo-

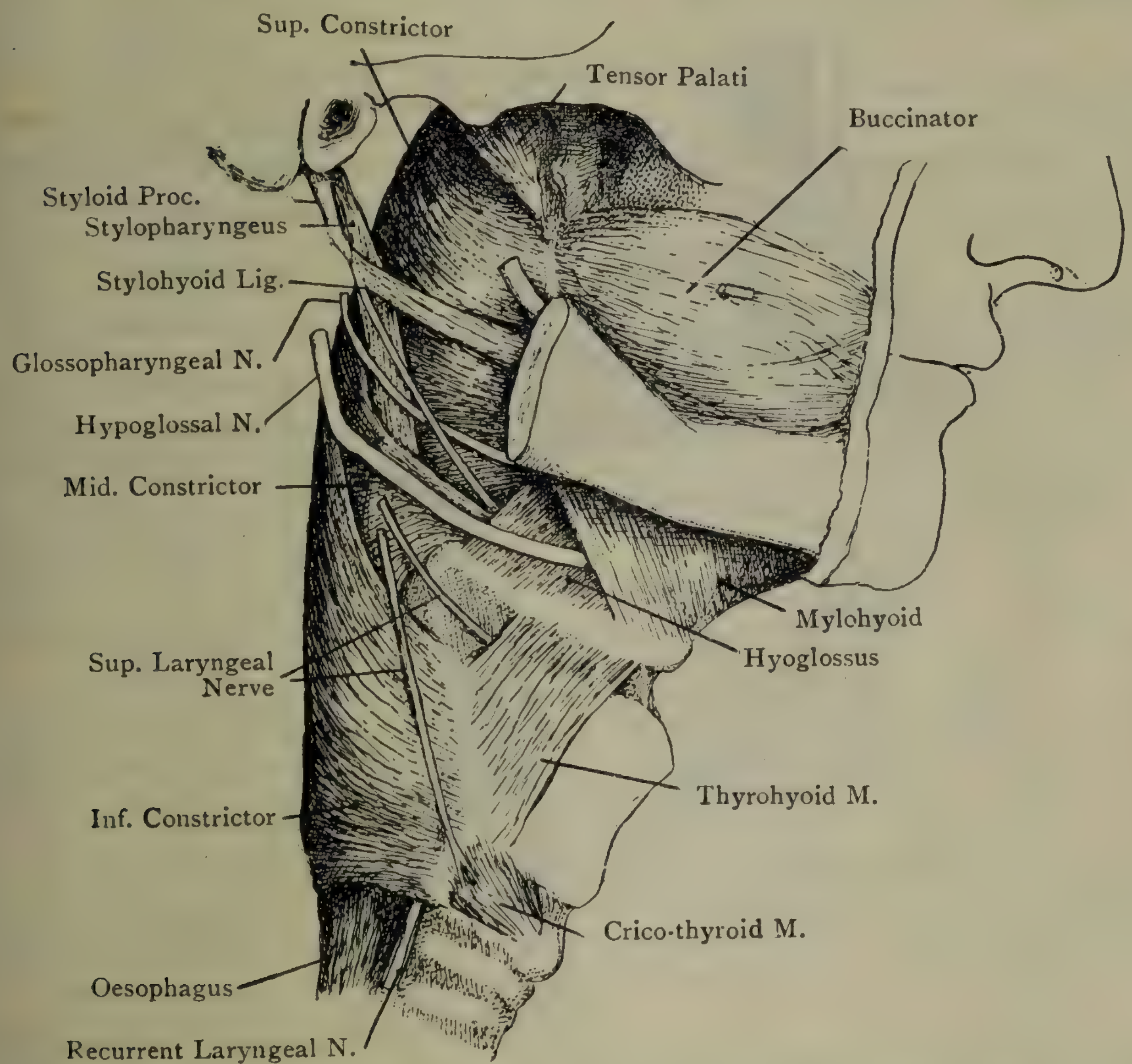


FIG. 832.—DISSECTION SHOWING THE CHEEK, PHARYNX, SUBMANDIBULAR REGION, AND LARYNX (RIGHT VIEW).

andibular ligament, along which it meets the buccinator muscle;
3) the posterior extremity of the mylo-hyoid line of the mandible;
4) the mucous membrane of the mouth; and (5) the side of the tongue.

Insertion.—The median raphé on the posterior wall of the pharynx,
here it meets its fellow of the opposite side. A few of the highest
bres are inserted into the pharyngeal tubercle on the under surface
f the basilar part of the occipital bone.

The muscle is four-sided. The fibres for the most part pass hori-
ontally, but the lower fibres radiate in a downward direction, whilst
he upper fibres curve backwards and upwards. The lower portion

of the muscle is overlapped by the upper part of the middle constricto the stylo-pharyngeus muscle and glosso-pharyngeal nerve passir between the two. Between the upper, concave border and the bas of the skull there is an interval occupied by the pharyngo-basila fascia, which is here stronger than elsewhere, and so compensates fo the absence of muscular fibres. This interval is semilunar, and known as the **sinus of Morgagni.**

Nerve-supply of the Constrictor Muscles.—The nerves are derive from the pharyngeal plexus, which is formed by the pharyngeal branc

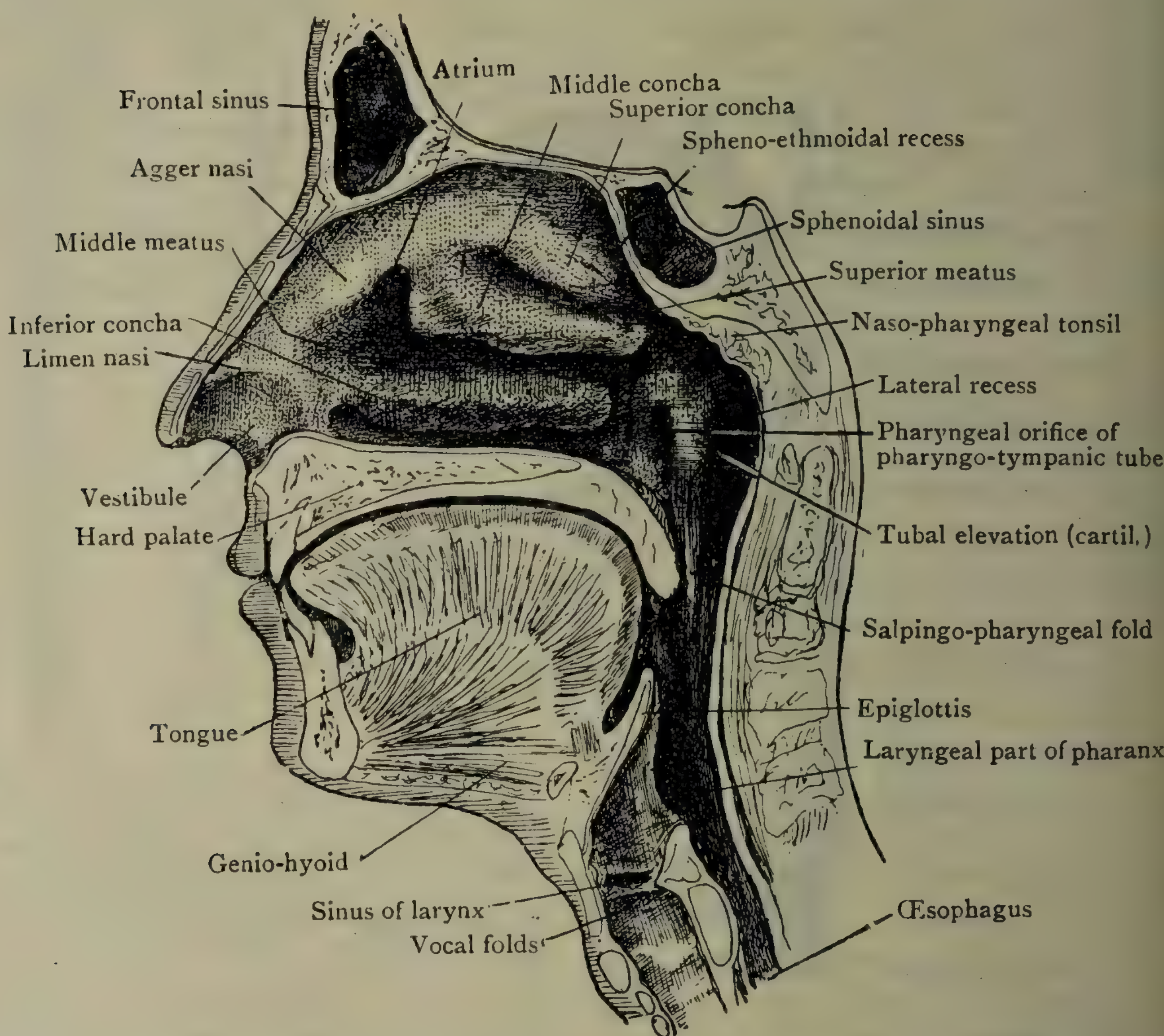


FIG. 833.—SAGITTAL SECTION THROUGH THE NASAL CAVITY, MOUTH, PHARYNX, ŒSOPHAGUS, AND LARYNX.

The outer wall of the right nasal cavity is shown.

of the vagus, the pharyngeal branches of the glosso-pharyngeal, an sympathetic filaments. The motor fibres of the plexus are derive from the pharyngeal branch of the vagus, but their ultimate source i the **cranial root of the accessory nerve.** The inferior constrictor muscl also receives twigs from (1) the external laryngeal branch of th superior laryngeal nerve, and (2) the recurrent laryngeal nerve as i passes beneath the lower border of the muscle.

Action.—The constrictor muscles are concerned in the act of de glutition. The superior constrictor and upper portion of the middl constrictor act upon the nasal part of the pharynx—that is, the con

ırtment of the pharynx which lies above the soft palate—and is in ·mmunication with the nasal cavities through the posterior nasal ›ertures. They narrow the nasal part of the pharynx in the lateral rection, and this movement, in conjunction with the action of the ılato-pharyngeal arch, shuts off the cavities, thus preventing re- ırgitation into and through the nasal cavities. The lower portion of ıe middle constrictor and the inferior constrictor diminish the calibre the oral part of the pharynx. Coming into action during the second age of deglutition, they grasp the bolus of food and press it downwards ıto the œsophagus. The constrictor muscles contract rapidly, and order from above downwards.

For a description of the stylo-pharyngeus and palato-pharyngeus ıuscles (including the salpingo-pharyngeus), see pp. 1323 and 1352.

Pharyngo-basilar Fascia (Pharyngeal Aponeurosis).—This is situated ›etween the muscular coat and the mucosa. Inferiorly it is weak and ıdistinct, but superiorly it acquires greater firmness and density, ›pecially where it is attached to the basi-occipital, the apex of the ›etrous part of the temporal bone, the adjacent portion of the pharyngo- ympanic tube, and the medial pterygoid plate of the sphenoid bone. : receives an accession of strength in the median line from a strong undle of fibres which descends from the pharyngeal tubercle on the nder surface of the basilar process of the occipital bone, and which ›rms the raphé of the pharynx.

Interior of the Pharynx.—The mucous membrane, which forms ıe deepest stratum in the pharyngeal wall, is of a papillary ıaracter, and has the following important continuations: (1) with ıe mucous membrane of the pharyngo-tympanic tube, and thence ith that of the tympanic cavity; (2) with that of the nasal cavities ırough the posterior nares; (3) with that of the cavity of the mouth ırough the oropharyngeal isthmus; (4) with that of the larynx through ıe superior laryngeal aperture; and (5) with that of the œsophagus. ıt its upper and back part it is richly provided with lymphoid tissue, › be noticed presently, and in the submucous tissue there are many cinous glands of a mucous character.

The soft palate projects into the cavity of the pharynx in a down- ard and backward direction, and divides it into two regions, upper nd lower. The upper region is known as the nasal part of the pharynx, nd is in communication with the nasal cavities and pharyngo-tympanic ıbes. It also communicates with the lower region by means of ıe **pharyngeal isthmus.** The lower region is subdivided into two arts, oral and laryngeal. The buccal part is limited above by the oft palate, and below by the inlet of the larynx, and it communicates ith the cavity of the mouth through the oropharyngeal isthmus. he laryngeal part is situated behind the larynx, with which it ommunicates, as well as with the œsophagus inferiorly.

The Nasal Part of the Pharynx.—This is entirely respiratory in ınction, and is therefore always patent. It measures a little more ıan an inch from above downward, and about 2 inches from side to

side, while from before backward it is about $\frac{3}{4}$ inch. It is bounded front by the posterior nasal apertures and the posterior border of t vomer; behind, by the vertebral column; above, by the basilar pa of the occipital and part of the body of the sphenoid; and below the soft palate, which can be elevated and depressed. Four openin communicate with it. The anterior wall has the oval openings the posterior nasal apertures leading from the nasal cavities, a separated from each other by the posterior border of the vomer. Ea opening in the recent state measures about 1 inch from above dow wards, and about $\frac{1}{2}$ inch from side to side. Through it, on the out wall of the corresponding nasal cavity, are seen the posterior par

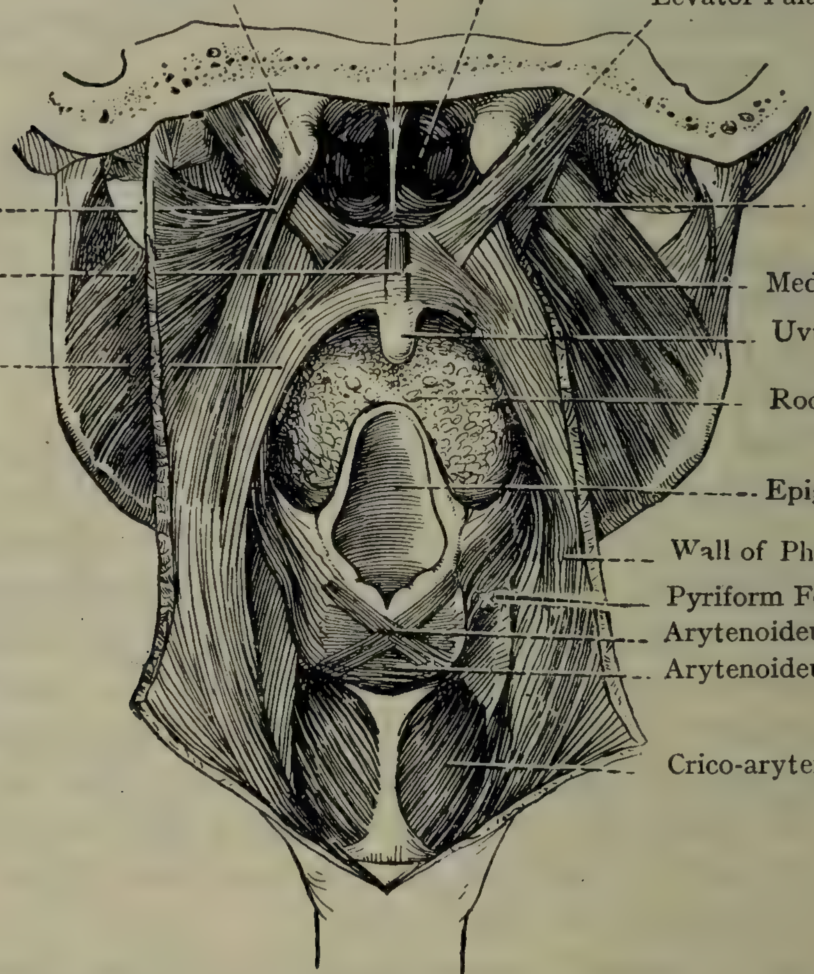


FIG. 834.—THE PHARYNX OPENED FROM BEHIND.

of the middle and inferior nasal conchæ, covered by mucous membran and above and below the inferior nasal concha are seen the posteri parts of the middle and inferior meatus. The orifice of the pharyng tympanic tube is situated on each lateral wall behind and external the corresponding posterior nasal aperture, and on the same lev as the posterior end of the inferior nasal concha. It is somewh triangular, and has, above and behind, a prominent round bord formed of cartilage covered by lymphoid tissue, called the *tub elevation*. Behind the tubal elevation there is a deep pouch on t lateral wall of the nasal part of the pharynx, called the **pharynge recess (fossa of Rosenmüller)**, which is a secondary widening of t

of of the primitive pharynx. The mucous membrane extending etween the pharyngeal recesses at the upper and back part has a umber of folds containing a large amount of lymphoid tissue, which nstitute the **naso-pharyngeal tonsil.** When enlarged, this mass is ble to obstruct the orifices of the pharyngo-tympanic tubes, and ven the posterior nasal apertures, and is known as adenoids. At e lower part of the naso-pharyngeal tonsil there may be seen a small edian recess, called the **pharyngeal bursa,** which leads upwards and ackwards towards the pharnygeal tubercle on the basilar part of the ccipital bone.

The mucous membrane is covered by ciliated columnar epithelium.

The Oral Part of the Pharynx.—This part is situated between the oft palate and the inlet of the larynx. Anteriorly it communicates ith the cavity of the mouth, through the oropharyngeal isthmus, elow which the root of the tongue forms its anterior wall. Each teral wall shows the palato-pharyngeal arch, the interval between e two arches corresponding to the pharyngeal isthmus. In front f each arch is a triangular depression which lodges the tonsil.

Laryngeal Part of the Pharynx.—This part is situated behind the rynx. Anterior to it there are the epiglottis, the inlet of the larynx, n either side of which is a recess called the **pyriform fossa,** and the osterior parts to the arytenoid and cricoid cartilages, with the muscles elated to them. It communicates with the larynx anteriorly and he œsophagus inferiorly.

The mucous membrane of the buccal and laryngeal portions is overed by stratified squamous epithelium.

Blood-supply.—The **arteries** of the pharynx are derived from the scending pharyngeal branch of the external carotid, the ascending alatine and tonsillar branches of the cervical part of the facial artery, nd the greater palatine and pharyngeal branches of the maxillary.

The **veins** form a copious *pharyngeal plexus,* which is disposed pon the lateral and posterior walls of the pharynx. It communicates uperiorly with the pterygoid venous plexus, and receives tributaries om the soft palate, tonsils, and pharyngo-tympanic tubes. Inferiorly he blood is conveyed from it into the internal jugular vein.

Lymphatics.—The lymphatic vessels from the upper part of the harynx pass to the deep facial lymph glands, which are associated ith the lateral walls of the tube, and those from the remaining part ass to the upper group of deep cervical lymph glands. Some of the mphatics from the upper part pass to the **retropharyngeal lymph lands** of its own side, each of which lies upon the upper part of the orresponding longus capitis muscle.

evelopment of the Pharynx and of the Pharyngeal Pouches or Visceral Grooves and Visceral Arches (see Chapter II.).

The pharynx is developed from the anterior or cephalic part of the fore-gut. On the ventral wall or floor of this part certain grooves are found at an arly stage running more or less transversely, and separated from one another y thick and transversely directed masses of mesoderm; these are the **visceral**

arches, and the grooves are known as **visceral grooves (clefts).** Each groov runs out to the lateral part of the cavity, where it terminates in a deepe **pharyngeal pouch,** which can again be divided into *dorsal* and *ventral* part each of these being the seat of distinct developments. On the outer aspect the embryo the *arches* are visible, except in the case of the fifth and sixth, an the *external grooves* between them, lined with ectoderm, are at first in contac with the entodermal linings of the corresponding lateral pharyngeal pouche This contact is soon lost, save in the case of the first (external meatus).

As growth proceeds, the arches (and grooves) are placed (see Fig. 835) mo obliquely as they are followed back. They run medially into a central long tudinal prominence, the *hypobranchial eminence,* especially in the case of th

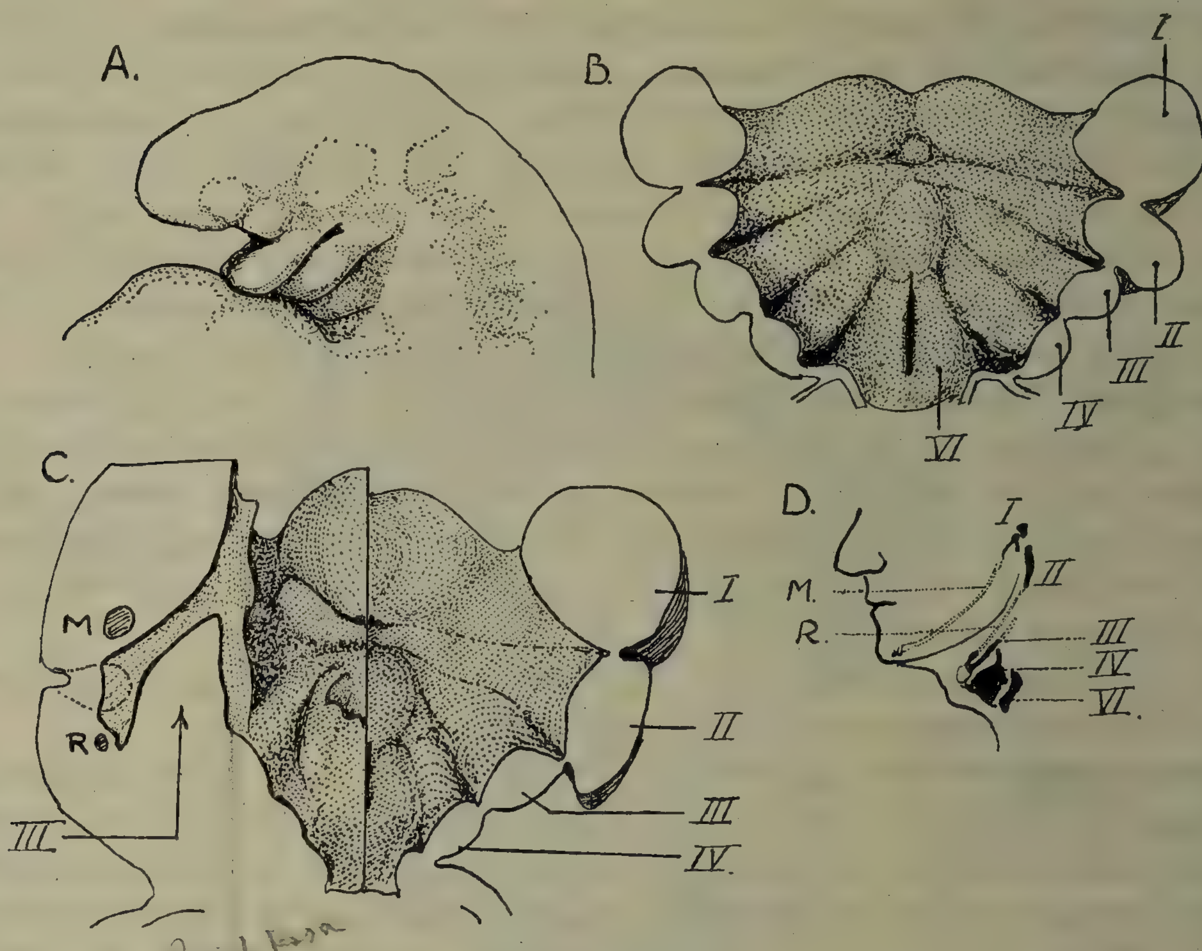


FIG. 835.

FIG. 835.—A, external pharyngeal arches, 4 mm. B, floor of early pharyn exposed from above. C, shows on left the adult formations, their arch origins being indicated on right. D, indicates remnants of skeletal structure of arches. Visceral arches are numbered in Roman figures. M, R, Meckel and Reichert's bars. On left, in C, the forward growth of third arch shown not only in tubo-tympanic part, but in back of tongue, across tonsi fossa, and in pharyngeal extension to palate.

third and fourth, and in front of this is the little *tuberculum impar,* centrall placed in the first groove. The opening of the *pulmonary outgrowth* is *sagittall* placed just behind the *eminence.*

The arches and grooves are numbered from before backwards, the numbe of each groove being that of the arch just in front of it. The first is often terme the **mandibular** arch, as the lower jaw forms in it; its upper and outer part lie under the head region in front of the ear, and from here a **maxillary proces** grows forwards from it below the eye to form the upper arcade of the mouth.

There are six arches and five grooves. The first four arches are distinc (see Fig. 49A). *The fifth is rudimentary, and is buried with its groove at the bottor of the fourth pouch.* The sixth forms the immediate boundary on each sid of the pulmonary opening. The first four grooves are distinct, the fifth i

uded in the fourth, and no definite groove limits the caudal part of the th arch.

The widest part of the cavity is opposite the second arch. Here is formed *tubo-tympanic recess* from which the **tympanic cavity** and **tube** are differentid as the result of forward growth of the third arch over the second. This wth goes over the region of the large second lateral pouch, but leaves the *sal* or outer part of this in the tympanic cavity, while its *ventral* part remains the pharyngeal wall and becomes the fossa in which the **tonsil** will develop. e growth forward of the third arch comes up against the first arch to some ent, and obliterates its groove so far, but the dorsal part of the first pouch nains in the tympanic cavity (Fig. 835, C).

The hypobranchial eminence forms the main **epiglottic** mass; the third arch ning from this becomes the **pharyngo-epiglottic fold,** and the fourth forms **ary-epiglottic fold.** The third pouch marks the **pyriform fossa,** while the rth is lost, occasionally indicated as a depression beside the lower margin the cricoid. The sixth arches are joined with an upward growth of the fourth form a paired mass standing up behind the epiglottis; this mass (**arytenoid inences**) is separated from the epiglottis by a *transversely disposed* cleft, bounded erally by the **ary-epiglottic folds,** and hides the sagittal opening from view d makes the *supraglottic* part of the larynx. The **tongue** is developed in front the hypobranchial eminence, the tuberculum impar being enlarged to form **front part of the organ,** while paired growths from the front of the eminence d (?) the central parts of the second arches make its **back part** behind the cus terminalis.

The *ventral* part of the third pouch gives origin to the bud from which the **ymus** is formed. A similar bud from the fourth pouch develops into an ithelial mass embedded in the back of the lobe of the thyroid. The **thyroid ind** proper is formed from a *central* entodermal downgrowth which takes ce early just behind the tuberculum impar; the situation of this is therefore rked in the adult by the **foramen cæcum,** which is formed by the two masses at make the back of the tongue meeting each other at an angle, and being us applied to the front portion of the organ.

The third pouch and the constituents of the fourth pouch complex give off rtain outgrowths which separate from them through atrophy of the pharynal connection, and which may be divided into *dorsal* and *ventral* bodies. *Ventral* dies from the third pouch make the **thymus,** shifting caudally; from the rth, make a '**rudimentary thymus**' which remains applied to the back of e thyroid lobe; from the fifth rudiment, constitute an '**ultimo-branchial dy**' which remains in the same situation. *Dorsal* bodies: from the third, e **lower parathyroid,** carried down with the thymus; from the fourth, **upper rathyroid,** remaining more or less *in situ*; no dorsal body from the fifth has t been found in human embryos.

At a later stage each visceral arch presents the following four elements:) an artery; (2) a visceral myotome or muscle-segment; (3) a nerve (or nerves); d (4) a rod of cartilage. The artery is known as a *visceral arch artery*, and it one of the primitive aortic arches, establishing communications between the rresponding primitive ventral and dorsal aortæ.

Myotomes of Visceral Arches.—The **visceral myotome** in each arch gives rise certain muscles. The **myotome** of the *first arch* furnishes (1) the *anterior lly* of the **digastric;** (2) the **mylo-hyoid;** and (3) the **muscles of mastication**—imely, (*a*) masseter, (*b*) temporalis, (*c*) lateral pterygoid, and (*d*) medial pterygoid.

The **myotome** of the *second arch* furnishes (1) the *posterior belly* of the **digastric;**) the **stylo-hyoid;** and (3) the **stapedius.** From this myotome are also derived e **muscles of expression** on the face and epicranial region, as well as the **platysma.** iese muscles migrate during ontogeny over the neighbouring areas.

The **myotome** of the *third arch* furnishes the **stylo-pharyngeus,** and the **middle nstrictor of the pharynx** may be regarded as derived from it.

The **myotome** of the *fourth arch* (and perhaps that of the *fifth arch*) may be garded as furnishing the **inferior constrictor** of the pharynx.

Nerves of Visceral Arches—First or Mandibular (Oral) Arch.—The comm nerve of this arch is the **trigeminal nerve.** The *mandibular division* belongs the mandibular process of the arch, and to its muscles, and the lower teeth one side; the *maxillary division* belongs to the maxillary process of the arch, a to the upper teeth of one side. The *ophthalmic division* is not concerned in t supply of the arch; it is a distinct nerve phylogenetically, only supplying parax formations.

Second or Hyoid Arch.—The nerve of this arch and of the first pharynge pouch is the **facial nerve.** The **auditory nerve** may be included.

Third or Thyro-hyoid Arch. — The nerve of this arch and of the seco pharyngeal pouch is the **glosso-pharyngeal nerve.**

Fourth Arch.—The nerve of this arch is the **superior laryngeal nerve,** whi is a branch of the vagus.

Sixth Arch.—The nerve of this arch is the **recurrent laryngeal nerve,** which a branch of the vagus.

The **bar of cartilage** in each arch is developed in the mesenchyme, whi forms the core of the arch.

Metamorphoses of the Visceral Arches.

First Visceral or Mandibular Arch.—This arch is situated, as stated, betwe the first pharyngeal pouch and the stomodæum or primitive oral cavity. I artery is the **first primitive aortic arch;** its nerve is the mandibular divisi of the **trigeminal nerve;** its cartilaginous bar is known as **Meckel's cartilage.** T ventral end of this cartilage meets its fellow of the opposite side, and is join to it by connective tissue. The dorsal end is related to the *periotic cartilagino capsule,* and furnishes an offshoot, called the manubrium.

1. The *upper* or *dorsal end* of Meckel's cartilage, becoming ossified, giv rise to the **malleus,** and probably the **incus.**

2. The *lower* or *ventral end* of Meckel's cartilage is ossified in the **incis portion** of the **mandible.**

3. The part of Meckel's cartilage *between the upper and lower ends* disappea The *membranous investment* of the *lower* or *mandibular portion* of this part giv rise to the chief part of one-half of the **body** of the **mandible,** and the *lower h of the ramus* as high as the mandibular foramen. The membranous investme of the *upper portion,* between the periotic cartilaginous capsule and the mandibul foramen, forms the **spheno-mandibular ligament.**

4. The **maxillary process,** aided by part of the **fronto-nasal process**—namel the *globular* and *lateral nasal processes*—gives rise to the **maxilla** (see Develo ment of the Skull).

5. The upper end of the first arch on its superficial surface gives rise to t tragus, and part of the helix of the pinna.

Second or Hyoid Arch.—This arch is situated, as stated, between the fi and second pharyngeal pouches. Its artery is the **second primitive aortic arc** its nerve is the **facial nerve,** with the **chorda tympani;** and its cartilaginous b is called the **hyoid bar,** or *cartilage of Reichert.* This bar *ventrally* is connect with its fellow of the opposite side by a transverse **copula,** forming part of t body of the hyoid bone.

The second bar becomes transformed into the following structures:

1. The *upper* or *dorsal segment* of the hyoid bar gives rise to the *head, nec* and *limbs* of the **stapes,** the *foot-piece* of that ossicle perhaps being develop from the cartilaginous capsule of the labyrinth within the fenestra vestibuli.

2. The *succeeding segment* of the hyoid bar gives rise to (*a*) the *tympan hyal,* and (*b*) the *stylo-hyal,* which collectively constitute the **styloid process** the temporal bone.

3. The *next portion* of the hyoid bar becomes converted into fibrous tiss and forms the **stylo-hyoid ligament,** which sometimes exists as an *epi-hyal bon*

4. The *lower* or *ventral segment* of the hyoid bar gives rise to the *cerato-hy* or *lesser horn* of the **hyoid bone.**

The second arch also gives rise *superiorly* to the *antihelix*, *antitragus*, and *ule* of the **pinna**; and *inferiorly*, along with the third arch, possibly helps to m one-half of the **posterior third of the tongue.**

Third or Thyro-hyoid Arch.—This arch is situated between the second and rd pharyngeal pouches. Its artery is the **third primitive aortic arch**; its nerve he **glosso-pharyngeal nerve**; and its cartilaginous bar is known as the **thyro-oid bar.** This bar is connected ventrally with its fellow by a **copula.**

A large portion of the thyro-hyoid bar disappears, but its lower or ventral ment gives rise to the *thyro-hyal* or *greater horn* of the **hyoid bone.** The *i-hyal* or *body* of the hyoid bone is developed from the **copula.**

Fourth and Fifth Visceral Arches.—The artery of the *fourth* arch is the **fourth mitive aortic arch,** and its nerve is the **superior laryngeal nerve,** which is a nch of the vagus. The artery of the *fifth* arch is the **fifth primitive aortic h,** and its nerve a small and transient branch of the vagus. The greater tions of these two arches disappear; but the *lower* or *ventral ends* of their tilaginous bars are by some regarded as giving rise to a small part of the *ina* of the **thyroid cartilage.** The lower *musculature of the pharynx* comes m the cells of the *fourth* arch, as does also the *crico-thyroid.*

Sixth Visceral Arch.—The artery of this arch is the **sixth primitive aortic h.** Its nerve is the **recurrent laryngeal.** The sixth arch itself, being un-ferentiated, leaves no traces behind it, but the internal intrinsic muscles of larynx are formed from its cells.

The metamorphoses of the pharyngeal pouches have been already described connection with these pouches.

The **first external furrow,** corresponding to the first internal pharyngeal ich, gives rise, as stated, to the **external auditory meatus,** and the walls of upper part of this furrow become differentiated into the component parts the **pinna.**

Sinus Cervicalis and Cervical Fistula.—The first or mandibular and second hyoid arches increase more rapidly in all directions than the succeeding hes. The third and fourth visceral arches therefore become overlapped the second or hyoid arch, and now lie at the bottom of a depression. This ression is called the **sinus cervicalis.** The lining membrane of the sinus is med by the ectodermic coverings of the overlapped visceral arches. The us is, as a rule, transitory, the second arch atrophying rapidly, and the rd external groove disappearing, while the third arch flattens. The fourth h is partly covered from behind, a ' placodal duct ' being enclosed for a short ie. Otherwise there is no ' closing of a cervical sinus ' in man such as has n described in lower forms.

Morphology of the Visceral Arches and Clefts.—In aquatic animals—*e.g.*, hes and Amphibia at an early stage, but only in Perennibranchiata per-nently—these are called the **branchial** or **gill-arches** and **clefts.** The clefts ge in number from five to eight, and they differ from those of Mammals l Birds, inasmuch as they are *complete* clefts, the **closing membrane** being sent. They therefore establish free communications between the exterior l the fore-part of the alimentary canal, or throat, for the entrance and exit water.

The functional branchial arches are those which are *post-oral*, commencing h the second. The second branchial or gill-arch is not, however, a real nchial arch in the functional sense, but is *opercular*, giving rise on either e to the **operculum** or **gill-cover.** The real branchial or gill-arches, properly called functionally, are those which succeed to the second, of which the third l fourth are conspicuous. The mucous membrane of the real branchial hes is folded into parallel lamellæ, which are placed close together, and freely furnished with capillary bloodvessels, the blood being derived from branchial-arch arteries. These lamellæ constitute the **branchiæ** or **gills.**

Aquatic respiration consists in the passage of currents of water containing ygen through the complete gill-clefts into the pharyngeal part of the fore-t. As the water bathes the branchiæ, or gills, its oxygen is taken up into the

blood within the branchial capillaries, and the carbon dioxide of the capilla blood is yielded up to the water. Thereafter the water is expelled throu the gill-clefts, and is immediately replaced by a fresh current of respirato water. The branchiæ, or gills, of aquatic animals therefore correspond functio ally to the lungs of Mammals and Birds, whose respiration is aerial.

The Pharyngo-tympanic Tube.

The pharyngo-tympanic tube (Eustachian tube) leads from t tympanic cavity to the nasal part of the pharynx, and is about 1½ inch in length. It is directed forwards, inwards, and slightly downwar and is composed of two parts, bony and cartilaginous. The bo or postero-lateral part is about ½ inch long, and is situated in the an between the petrous and squamous parts of the temporal bone. T cartilaginous or antero-medial part is about 1 inch in length, and l on the groove between the greater wing of the sphenoid and the api portion of the petrous part of the temporal bone. It is at first narro but gradually enlarges, so as to resemble a trumpet. The narrow part of the whole tube is at the junction of the bony and cartilagino parts; this is the **isthmus,** and the widest part is at the pharyng orifice. The roof, inner wall, and upper part of the outer wall of t cartilaginous part consist of a triangular plate of cartilage, the marg of which are slightly rolled towards each other. The floor and m of the outer wall are formed of a dense fibrous membrane. T **pharyngeal orifice** of the tube is expanded, and is situated on the late wall of the nasal part of the pharynx behind, and external to, t corresponding posterior nasal aperture, and on the same level as t posterior end of the inferior nasal concha. It is somewhat triangul and above and behind is the tubal elevation, already described, form by the thick margin of the cartilage, and posterior to this is the phar geal recess.

The tube is lined with mucous membrane, which is continu with that of the tympanic cavity on the one hand, and of the na part of the pharynx on the other. It is thin in the bony part of t tube, but in the cartilaginous part it is thick, and contains muc glands and lymphoid tissue. It is covered by stratified column ciliated epithelium.

Muscles connected with the Pharyngo-tympanic Tube.—The **leva palati** has an origin from the lower margin of the cartilage of the tu the **tensor palati** from the outer side of the cartilage, and the **salping pharyngeus** is attached to the lower and front part of the tube. Duri deglutition the orifice of the tube is opened.

Arteries are derived from the artery of the pterygoid canal, fr the third part of the maxillary, and the ascending pharyngeal bra of the external carotid.

Nerves.—The nerves come from the tympanic plexus on the in wall of the tympanic cavity, and the nerve of the pterygoid canal.

Development.—From the tubo-tympanic recess of the primitive phary modified and narrowed by forward growth of the third arch (Fig. 835, C).

The Larynx.

The larynx is the upper part of the respiratory passage, being odified in structure so as to enable it to act as the organ of voice. is situated in the median line of the neck above the trachea, and it s opposite the fourth, fifth, and sixth cervical vertebræ. Superiorly opens into the laryngeal portion of the pharynx, and inferiorly into e trachea. It is covered in front by the integument and the deep rvical fascia, and the laryngeal portion of the pharynx lies behind On either side it is in relation with the upper part of the lobe the thyroid gland, the sterno-hyoid, omo-hyoid, sterno-thyroid, d thyro-hyoid muscles, and the common carotid artery.

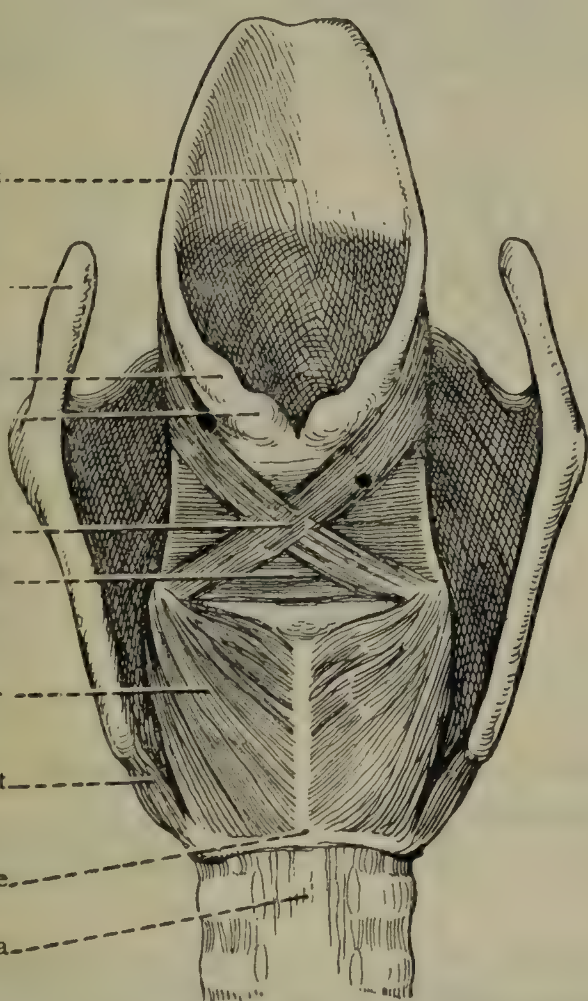


FIG. 836.—THE INTRINSIC MUSCLES OF THE LARYNX (POSTERIOR VIEW).

Structure.—The larynx consists of a framework of cartilages, some which are connected by joints and ligaments; it is provided with ecial muscles, spoken of as *intrinsic*; and it is lined with mucous embrane.

Cartilages are nine in number, three being single and three arranged pairs. The single cartilages are the epiglottis, the thyroid, and the icoid; and the three arranged in pairs are the arytenoid, corniculate, d the cuneiform.

The **epiglottis** is a leaf-like plate of yellow elastic fibro-cartilage, hich is placed between the base of the tongue and the inlet of the rynx. Its lower part forms a stalk which is attached to the receding gle of the thyroid cartilage, just below the thyroid notch on its

upper border, by means of a fibro-elastic band, called the **thyr epiglottic ligament.** Above it has a broad, round, free margin. Ea lateral border is free above, but its lower part is contained within t ary-epiglottic fold of mucous membrane. The anterior or lingu surface is free over its upper part, where it faces the base of the tongu and is covered by mucous membrane. This membrane is prolong on to the base of the tongue as the **glosso-epiglottic fold,** which medially placed. It is also prolonged from the sides of the epiglott on to the lateral walls of the pharynx as the **pharyngo-epiglottic fold** On either side of the glosso-epiglottic fold, between it and each pharyng epiglottic fold, there is a depression or fossa, which is known as t **vallecula.** Lower down than these folds the anterior surface is co nected to the back of the upper border of the body of the hyoid bo by an elastic, semilunar membrane, called the **hyo-epiglottic ligame**

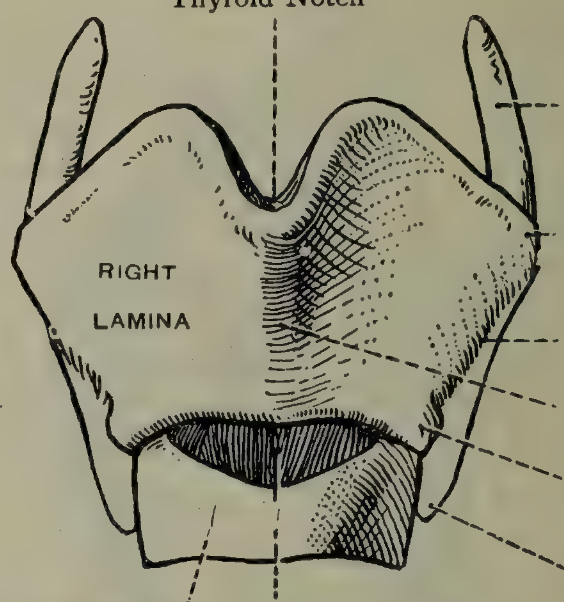


FIG. 837.—THE THYROID AND CRICOID CARTILAGES OF THE LARYNX (ANTERIOR VIEW).

Above the upper border of the thyroid cartilage the anterior surfa is attached to the back of the body of the hyoid bone and of the thyr hyoid membrane by dense connective tissue. The posterior or lary geal surface is free over its whole extent, and is covered by muco membrane. It is concave from side to side, and concavo-conve from above downwards. The lower convexity forms the **tuberc (cushion).** When the mucous membrane is removed, the epiglott presents a number of small glandular pits.

Development.—The epiglottis is developed from the hinder part of the hyp branchial eminence.

Thyroid Cartilage.—This cartilage is composed of two flat quad lateral **laminæ (alæ),** which meet in front by their anterior border but diverge widely behind. The angular projection formed by the union is called the **laryngeal prominence (pomum Adami).** The unic is confined to about the lower half of each anterior border, and the

left superiorly a deep triangular cleft called the **thyroid notch.** The sterior border, of greater length than the anterior, is round, and ves attachment to fibres of the palato-pharyngeus and stylo-pharyn-us muscles. At either extremity it is prolonged into a projection, e superior horn and inferior horn respectively. The **superior horn** ves attachment to the lateral thyro-hyoid ligament, and the **inferior rn,** which is slightly incurved, is faceted on its inner aspect to ticulate with the cricoid cartilage. The superior border is for the ost part convex, and near its back part is a slight eminence, called e **superior thyroid tubercle.** The inferior border is almost horizontal, d has an eminence about the junction of the posterior third with the terior two-thirds, called the **inferior thyroid tubercle.** It gives tachment to the median portion of the crico-thyroid ligament and e crico-thyroid muscle. The outer surface of the lamina is marked

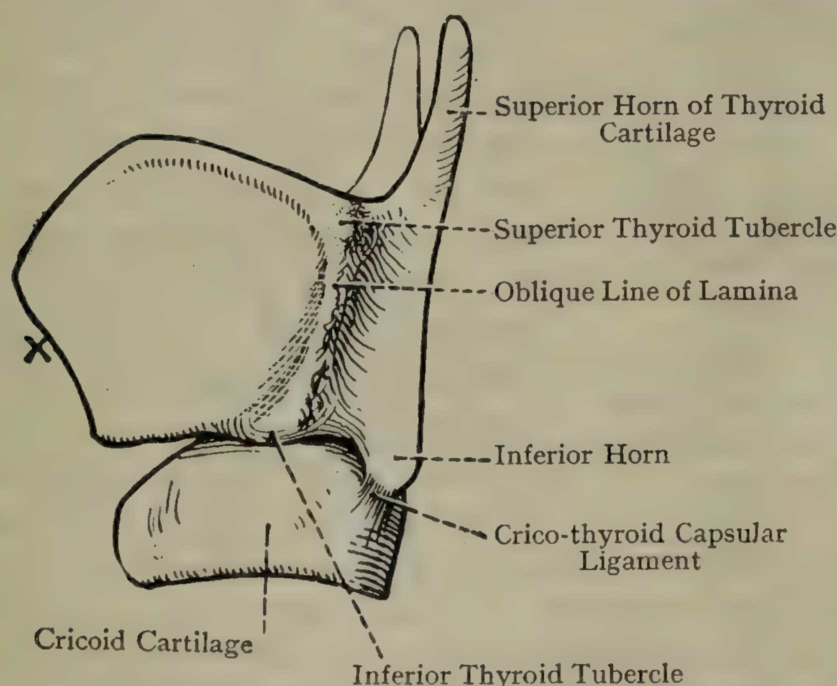


FIG. 838.—THE THYROID AND CRICOID CARTILAGES OF THE LARYNX (LATERAL VIEW).

an oblique line, which extends downwards and forwards from the perior to the inferior tubercle. This line gives insertion to the rno-thyroid, and origin to the thyro-hyoid muscles. It divides the ter surface into two unequal parts—an anterior three-fourths and posterior fourth, the latter giving origin to fibres of the inferior nstrictor muscle. The inner surface of the lamina is smooth, slightly ncave, and covered by mucous membrane. In the median line, hind the laryngeal prominence, there is a vertical depression known the **receding angle.** Beginning just below the thyroid notch on e upper border and passing downwards, this region gives attach-nt to the following structures: the thyro-epiglottic ligament, the stibular ligaments, and the vocal ligaments, in association with which e the fibres of the thyro-arytenoid muscles.

Development of the Thyroid Cartilage.—The thyroid cartilage represents e ventral portions of the skeletal cartilages of the fourth (and ? fifth) visceral hes of either side, which become united by a median plate.

Cricoid Cartilage.—The cricoid cartilage is situated below tl thyroid cartilage, and forms the lower part of the larynx. It bea some resemblance to a signet-ring, and it consists of two parts—a anterior arch and a posterior lamina.

The **arch** is narrow from above downwards as well as from sic to side. The *inferior border* is horizontal, and is connected with tl first ring of the trachea by a fibro-elastic membrane. The *superi border* is connected with the inferior border of thyroid cartilage b the crico-thyroid ligament.

The **lamina** is quadrilateral, broad, and deep. Its depth is owin to the rapid elevation of the superior border of the arch as it pass backwards. The *inferior border* is connected laterally with the fir ring of the trachea by a fibro-elastic membran and medially, where the tracheal rings are d ficient, to the same membrane. The *superi border* has a median notch, and on either side this an oval convex facet for articulation wi the base of the arytenoid cartilage. The *posteri surface* is divided into two depressed areas by median vertical ridge, which gives attachment the longitudinal muscular fibres of the œsophagu The depressed area on either side of this media vertical ridge gives origin to the crico-arytenoide posterior.

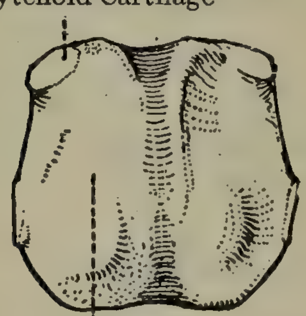


Fig. 839.—The Cricoid Cartilage of the Larynx (Posterior View).

The *outer surface* of the cricoid cartilage pr sents posteriorly a circular facet for articulatic with the inferior horn of the lamina of the thyroid cartilage. Tl upper sloping border of this part gives attachment along its inn margin to the lateral portion of the crico-vocal membrane.

The *internal surface* of the cricoid cartilage is lined with the muco membrane of the larynx.

Development.—The cricoid cartilage, like the rings of the trachea, is develop in the mesoderm of the respiratory tube, in the sixth arch.

Arytenoid Cartilages.—These cartilages are placed above the crico cartilage posteriorly. Each has the form of a three-sided pyrami and measures about ½ inch in height, and about ¼ inch in width the base. The apex looks upwards, and is curved in a backward ar inward direction. It is surmounted by the corniculate cartilag The base looks downwards, and is slightly concave and faceted articulate with the superior border of the cricoid cartilage posteriorl Two of the three angles of the base project. The **anterior angl** somewhat pointed, is directed straight forwards to form the *voc process*. It gives attachment to the vocal ligament. The **extern angle,** thick and somewhat round, has an inclination backwards well as outwards, and is known as the *muscular process*. Anterior it gives insertion to the crico-arytenoideus lateralis, and posterior to the crico-arytenoideus posterior. The surfaces are antero-later

sterior, and medial. The **antero-lateral surface,** a little above the cal process, attaches to the vestibular ligament, and above and eral to the vocal process the thyro-arytenoideus muscle. The **sterior surface** is triangular and concave, and gives attachment to portion of the arytenoideus transversus. The **medial surface** faces fellow of the opposite side, and is covered by mucous membrane. forms the posterior part of the lateral boundary of the rima glottidis. ie borders are anterior, posterior, and lateral. The **anterior border** parates the medial from the antero-lateral surface, and terminates low in the vocal process. The **posterior border** separates the medial om the posterior surface. The **lateral border** separates the antero-lateral om the posterior surface, and ends below in the muscular process.

The thyroid and cricoid cartilages usually retain their cartilaginous con- ion up to about the twentieth year. In the case of the thyroid cartilage sification proceeds from the inferior horn, there being a special osseous nucleus the region of the laryngeal prominence.

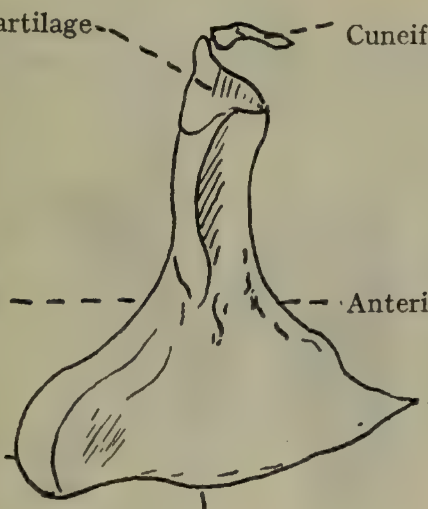


FIG. 840.—THE RIGHT ARYTENOID CARTILAGE AND CORNICULATE CARTILAGE (LATERAL ASPECT ENLARGED).

The anterior part and lower margin of the cricoid cartilage remain carti- ginous for some time, but the remainder undergoes ossification simultaneously ith the thyroid cartilage.

Ossification of the arytenoid cartilages takes place at a later date than in e case of the two preceding cartilages.

Corniculate cartilages (**cartilages of Santorini**) are two small, some- hat conical nodules of yellow elastic cartilage which cap the apical rts of the arytenoid cartilages, their direction being backwards and wards. Each lies within the ary-epiglottic fold of mucous membrane.

Cuneiform cartilages are two nodules of yellow elastic cartilage, hich are situated, one on either side, in the ary-epiglottic fold of ucous membrane at its back part, not far from the corniculate rtilages.

Development.—The arytenoid cartilages are formed in the sixth arches, d the ary-epiglottic folds from the fourth. The **corniculate cartilages** are fshoots of the arytenoid cartilages. The **cuneiform cartilages** are derived from ie **epiglottis.**

Ligaments of the Larynx—Thyro-hyoid Membrane.—This is broad membranous sheet, which passes between the superior borde of the thyroid cartilage and the back of the upper border of the bod of the hyoid bone, as well as the deep border of each greater horn Its central and lateral portions are strong, and are composed largel of elastic tissue. The central portion is known as the *median thyro hyoid ligament,* its lower attachment being to the border of the thyroi cartilage. The lateral portions, round and cord-like, are very elastic and are known as the *lateral thyro-hyoid ligaments.* Each extend from the superior horn of the thyroid cartilage to the tip of the greate horn of the hyoid bone, and enclosed within it, towards its upper part there is a small nodule of cartilage called the **cartilago triticea** Between the upper median portion of the thyro-hyoid membrane and the concave posterior surface of the body of the hyoid bone there i a synovial bursa. It is to be noted that the superior attachment o

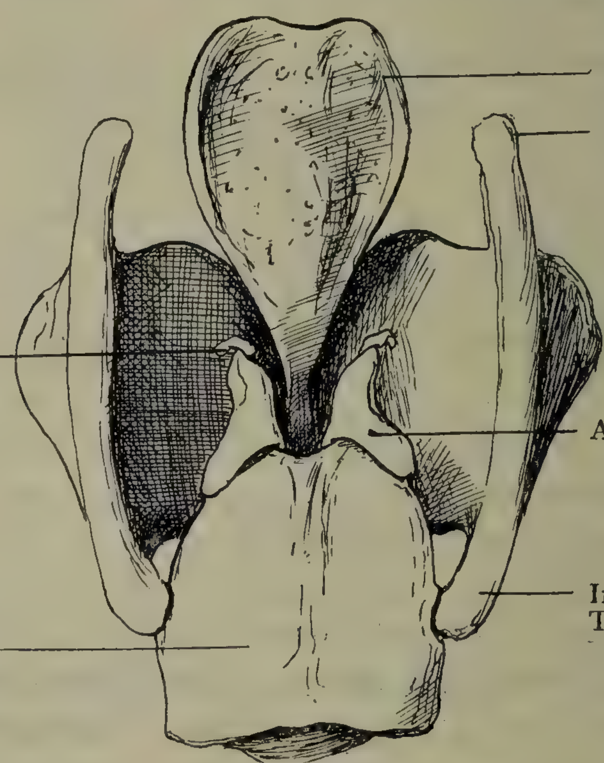


FIG. 841.—LARYNGEAL CARTILAGES (POSTERIOR VIEW).

the thyro-hyoid membrane is such as to enable the upper part of the thyroid cartilage, when raised, to be received within the outline o the hyoid bone. The central portion of the membrane is subcutaneous but on either side it is covered by the thyro-hyoid muscle. Beneath the posterior border of this muscle the internal laryngeal nerve and superior laryngeal artery pierce the membrane.

Crico-vocal Membrane.—This membrane is composed of an anterior and two lateral portions. The **anterior portion** or **crico-thyroid ligament portion,** elastic and triangular, is attached by its base to the lowe border of the thyroid, and by its apex to the upper border of the cricoid, close to the mid-line. It is subcutaneous in the median line except that it is crossed by the crico-thyroid branch of the superio thyroid arteries. Through this portion laryngotomy may be performed. The **lateral part** of the crico-vocal membrane is connected

elow with the upper border of the lateral part of the cricoid cartilage. uperiorly it is not connected with the thyroid cartilage, but passes eep to its lamina into the larynx, where it expands in an inward irection, and extends from the back of the lamina of the thyroid artilage in its lower part, close to the receding angle, to the under spect of the vocal process of the arytenoid cartilage. Between these oints it becomes continuous with the vocal ligament. The lateral ortion of the crico-thyroid membrane (within the lamina of the thyroid artilage) is covered by the crico-arytenoideus lateralis and thyro-rytenoideus.

Vestibular Ligaments (Superior Thyro-arytenoid Ligaments).—These orm two small fibrous bands, one at either side, which lie within the olds of mucous membrane, called the *vestibular folds* (*false vocal cords*). Each is attached in front to the receding angle of the thyroid cartilage mmediately below the attachment of the thyro-epiglottic ligament, nd behind to the antero-lateral surface of the arytenoid cartilage little above the vocal process.

Vocal Ligaments (Inferior Thyro-arytenoid Ligaments).—These nportant ligaments, covered by mucous membrane, constitute the *ocal folds* (*true vocal cords*), and each is continuous with the upper art of the expanded lateral portion of the crico-vocal membrane. Each is composed of yellow elastic tissue, and with its fellow is attached n front to the receding angle of the thyroid cartilage at its centre nd behind to the vocal process of the arytenoid cartilage. Its inner order, which is covered by mucous membrane, is free and clearly efined. In its front part there is a very small nodule of elastic artilage.

Crico-thyroid Joint.—This belongs to the class of **synovial joints.** The articular surfaces are the facet on the inner surface of the inferior orn of the thyroid cartilage, and that on the outer surface of the ricoid cartilage posteriorly. The joint is surrounded by a capsular gament, and this is lined with a synovial membrane. The **move-ments** allowed are as follows: (1) rotation of the thyroid cartilage round n axis passing transversely through both joints; and (2) gliding, in which the cricoid moves upwards and backwards, or downwards and orwards, this movement partaking somewhat of a swinging character.

The recurrent laryngeal nerve ascends close behind the crico-hyroid joint before entering the larynx.

Crico-arytenoid Joint.—This belongs to the class of **synovial joints.** The articular surfaces are the convex facet on the superior order of the cricoid cartilage posteriorly, and the concave under urface of the base of the arytenoid cartilage. The joint is surrounded y a capsular ligament, and this is lined with a synovial membrane. The **movements** allowed are as follows: (1) rotation, in which the rytenoid cartilage rotates on a nearly vertical axis, the effect being o invert or evert the vocal process; and (2) gliding in a lateral direction, n which one cartilage moves inwards towards its fellow, or outwards way from its fellow.

The corniculate cartilages are usually connected to the arytenoi cartilages by fibrous tissue, but in some cases there is a synovia articulation.

Prelaryngeal Lymph Glands.—One or two glands may lie upon th median portion of the crico-vocal membrane in the interval betwee the crico-thyroid muscles. Thei *afferent* vessels are derived from (1) the infraglottic portion of th larynx, the lymphatics from whic pierce the crico-vocal membrane (2) the beginning of the trachea and (3) the *upper part* of the isthmu of the thyroid gland. Their *efferen* vessels pass either to the inferio deep cervical lymph glands, or t the pretracheal glands as an inter mediate gland-station.

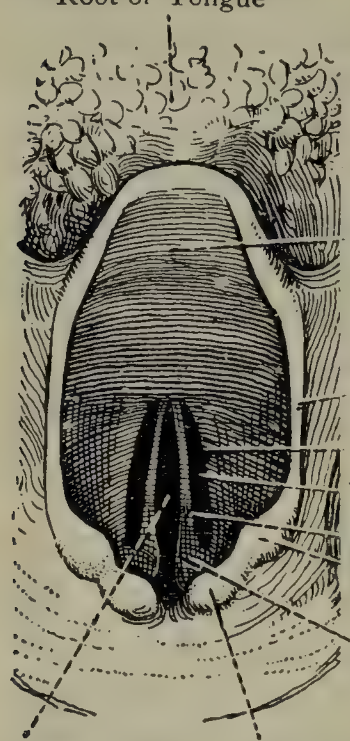


FIG. 842.—THE INLET OF THE LARYNX AND ADJACENT PARTS.

The Cavity of the Larynx.—Th **inlet of the larynx** is situated be hind and below the epiglottis. I is triangular, being wide in fron and narrow behind, and its plan is sloped obliquely downwards an backwards. Above and in front i is bounded by the epiglottis, an behind by the fold of mucous membrane which stretches between the arytenoid cartilages. On either side are the prominent ary-epiglottic folds, which extend from the tips of the arytenoid cartilages to the sides of the epiglottis and contain muscular fibres. Each of these folds, close to the arytenoid cartilage, contains the corniculate cartilage, which gives rise to a slight elevation, and a little in front of this another slight elevation is produced by the cuneiform cartilage. Between the arytenoid cartilage and the back part of the ary-epiglottic fold medially and the back part of the lamina of the thyroid cartilage laterally there is a depression, opening upwards, called the **pyriform fossa.** This is important, because unless an instrument intended for the interior of the larynx is kept carefully to the mid-line it will enter the foss and be pressed against its floor, just below the mucous membrane o which the internal laryngeal nerve passes on its way to the larynx.

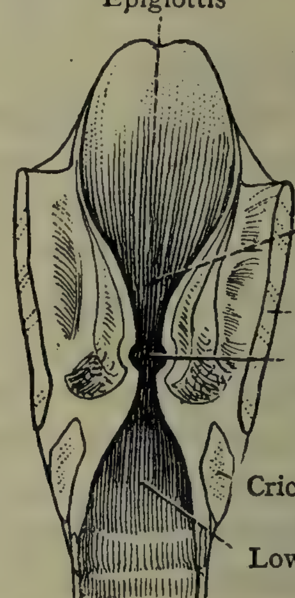


FIG. 843.—VERTICAL TRANSVERS SECTION OF THE LARYNX, SHOW ING THE POSTERIOR SURFACE O THE ANTERIOR HALF OF TH ORGAN (MARSHALL).

The **cavity of the larynx** begins at the inlet, and ends on a level with he lower border of the cricoid cartilage. It is divided into three ompartments by means of two antero-posterior folds of mucous nembrane, which project into it from each lateral wall. The upper pair of folds are called the vestibular cords, and the lower pair the ocal folds. The upper compartment is known as the **vestibule of he larynx,** and it extends as low as the vestibular folds. It is wider bove than below, and its anterior depth exceeds the posterior. The **niddle part** is situated between the vestibular folds above and the ocal folds below. On either side is a recess, called the **sinus of the arynx (ventricle).** This is bounded above by a vestibular fold, and elow by a vocal fold. Its outer wall is covered by fibres of the hyro-arytenoid muscle. At the anterior part of the sinus there is

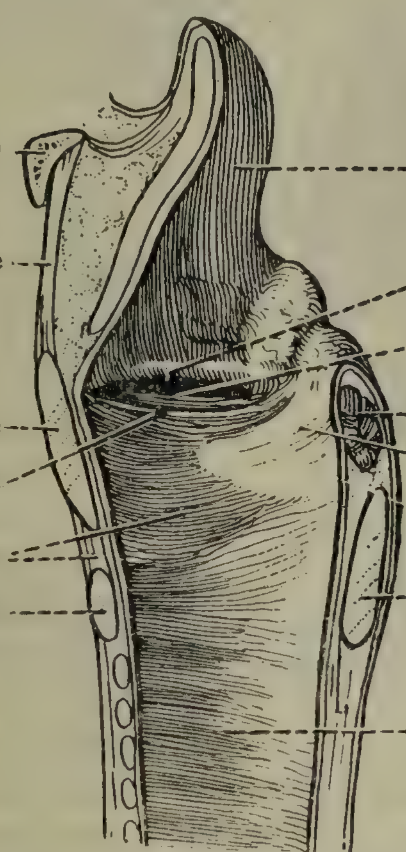


FIG. 844.—SAGITTAL SECTION OF THE LARYNX AND TRACHEA, SHOWING THE VOCAL FOLDS AND SINUS OF THE RIGHT SIDE.

a small valvular aperture, which leads to a diverticulum of the ventricle, called the **saccule of the larynx.** This extends upwards between the vestibular fold and the lamina of the thyroid cartilage, reaching as high as the upper border of the latter. On its medial aspect there are some muscular fibres, which are known as the compressor sacculi laryngis.

The **lower part** of the larynx is compressed from side to side above, but becomes circular inferiorly, where it opens into the trachea.

The **vestibular folds (false vocal cords)** are two folds of mucous membrane, which extend at either side from the receding angle of the thyroid cartilage immediately below the attachment of the thyro-epiglottic ligament to the antero-lateral surface of the arytenoid cartilage a little above the vocal process. Each contains some fibrous

tissue, forming the vestibular ligament. The vestibular folds ar widely separated from each other by an interval known as the *rim vestibuli* (*false glottis*), so that the vocal folds are visible on lookin into the larynx from above.

The **vocal folds** (**true vocal cords**) are concerned in the productio of the voice. They are prominent folds at either side, which ar rather less than an inch in length, and extend from the receding angl of the thyroid cartilage to the vocal process of each arytenoid cartilage Each cord consists of the vocal ligament, which is continuous with th upper part of the expanded lateral portion of the crico-vocal membrane and is composed of yellow elasti tissue. The mucous membran covering the fold is thin, an firmly adherent to the elasti tissue of the ligament, and it has characteristic pearly white colour The vocal folds are much neare to each other than the false, s that the latter are not visibl when the larynx is viewed from below.

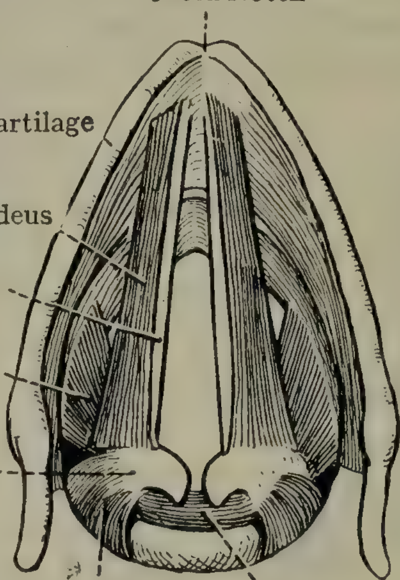


FIG. 845.—DISSECTION OF THE LARYNX, SHOWING THE MUSCLES, VOCAL FOLDS, AND RIMA GLOTTIDIS (SUPERIOR VIEW).

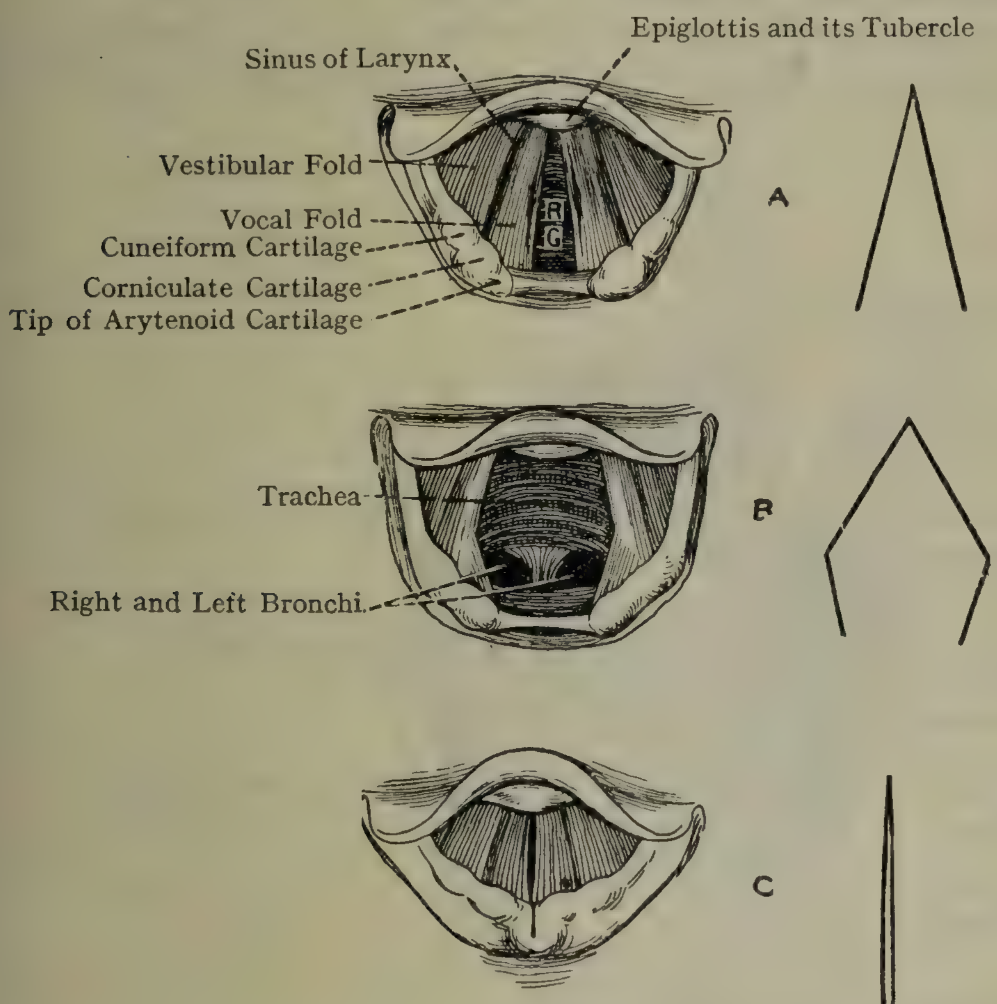
Rima Glottidis.—The rima glot-tidis, or true *glottis*, is the narrow fissure by which the upper and lower parts of the larynx com-municate with each other, and it is the narrowest part of the cavity. It is elongated from before back-wards, and is narrow in front at the receding angle of the thyroid cartilage, but wider behind, where it is closed by the interarytenoid fold of mucous membrane. It is divisible into an *intermembranous part* and an *intercartilaginous part.* The intermembranous part is narrow, and is bounded on either side by the vocal cord. Its length is rather less than an inch, and it forms about two-thirds of the entire aperture. The intercartilaginous part is wider than the inter-membranous part, and is bounded on either side by the inner aspect of the base of the arytenoid cartilage. It is about $\frac{1}{4}$ inch in length, and forms about one-third of the length of the entire aperture.

The shape of the rima glottidis is subject to alteration, and has to be considered under three conditions:

(1) During *quiet respiration* it has the form of an elongated triangle, the apex being in front at the thyroid cartilage, and the base behind at the interarytenoid fold of mucous membrane. (2) During a *deep inspiration* the rima is widely dilated, and assumes a diamond shape, the widest part being opposite the tips of the vocal processes of the arytenoid cartilages, where the lateral angles of the diamond are placed, the posterior angle at the interarytenoid fold of mucous mem-

rane being truncated. (3) While talking, and especially in *singing igh notes*, the vocal folds become so closely approximated as to be ractically parallel, and the rima glottidis assumes the form of a narrow hink.

Mucous Membrane of the Larynx.—This is continuous above with he mucous membrane of the pharynx, and below with that of the rachea. Above the level of the rima glottidis its subjacent attach-nent is loose on account of the presence of submucous areolar tissue, articularly near the ary-epiglottic folds, a condition which favours



'IG. 846.—THE INLET OF THE LARYNX AND THE RIMA GLOTTIDIS, AS SEEN BY THE AID OF THE LARYNGOSCOPE UNDER DIFFERENT CONDITIONS.

(The Figures on the left side are copied from Czermak.)

A, Ordinary quiet inspiration
B, Very deep inspiration
C, Vocalization, especially in singing high notes
R.G. Rima glottidis

he occurrence of œdema, but over the laryngeal surface of the epi-lottis it is firmly attached. Over the vocal folds it is very thin, nd is so firmly connected to the vocal ligaments that œdema cannot ass this point. The membrane is covered by ciliated columnar pithelium, except (1) near the margin of the ary-epiglottic folds, vhere it is of the stratified squamous variety, as in the laryngeal ortion of the pharynx and the cavity of the mouth; and (2) over the ocal folds, where it is also of the stratified squamous variety. Bodies esembling the taste-buds of the tongue are met with on the laryngeal urface of the epiglottis, the inner surfaces of the arytenoid cartilages

and of the ary-epiglottic folds, and over the margins of the vestibula[r]
folds.

The mucous membrane contains a large number of acinous mucou[s]
glands, the ducts of which open freely on the surface, except over th[e]
vocal folds, where there are no glands. They are arranged in the follow-
ing groups: (1) epiglottic glands, which are very numerous, and occupy
the pits on the laryngeal surface of the epiglottis; (2) arytenoid glands
in front of the arytenoid cartilages, and in the adjacent portions o[f]
the ary-epiglottic folds; (3) along the vestibular folds; and (4) in th[e]
wall of the laryngeal saccule, where they are very numerous.

It is of practical importance to remember that an opening mad[e]
in the crico-thyroid space enters the larynx below the vocal folds[;]

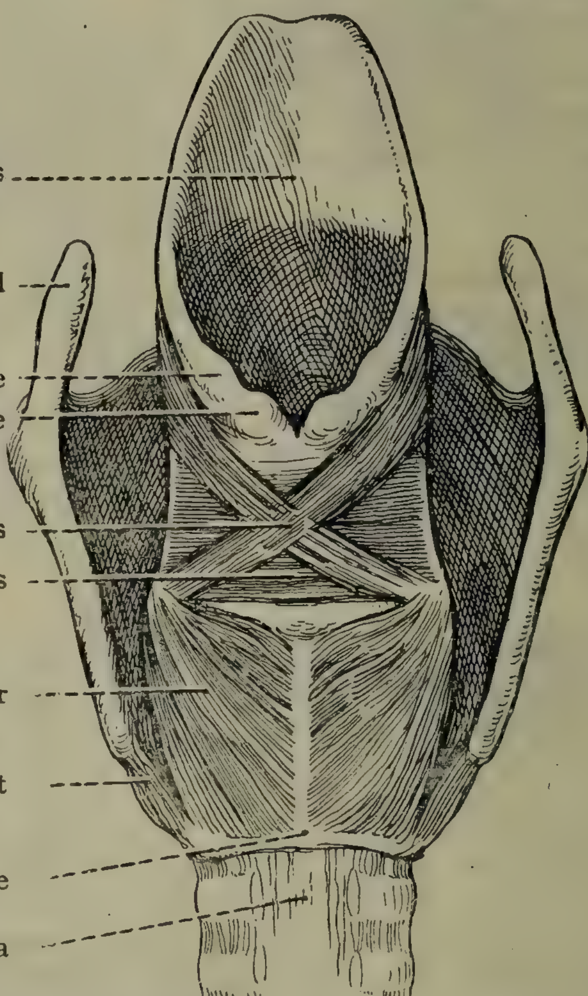


FIG. 847.—THE INTRINSIC MUSCLES OF THE LARYNX (POSTERIOR VIEW).

consequently, in those cases in which suffocation is threatened b[y]
a foreign body impacted in the upper part of the larynx, the simpl[e]
operation of laryngotomy or incising the crico-thyroid space wil[l]
usually give relief.

Intrinsic Muscles.—These are the muscles by which the cartilage[s]
are moved and the condition of the vocal folds determined. They ar[e]
the crico-thyroideus, crico-arytenoideus posterior, crico-arytenoideu[s]
lateralis, thyro-arytenoideus, arytenoideus, and aryepiglotticus. Th[e]
arytenoideus is a single muscle, but all the others are arranged i[n]
pairs.

Crico-thyroideus—*Origin.*—The antero-lateral part of the cricoi[d]
cartilage.

Insertion.—The lower margin of the lamina of the thyroid cartilage, nd the front of the inferior horn.

Nerve-supply.—The external laryngeal branch of the superior ryngeal nerve.

The fibres are directed upwards and backwards in a diverging anner, the posterior being horizontal and the anterior oblique. hese two sets of fibres are often distinct.

Action.—To approximate the front parts of the cricoid and thyroid rtilages in the following manner: the posterior horizontal fibres raw the cricoid cartilage backwards, and the anterior oblique fibres

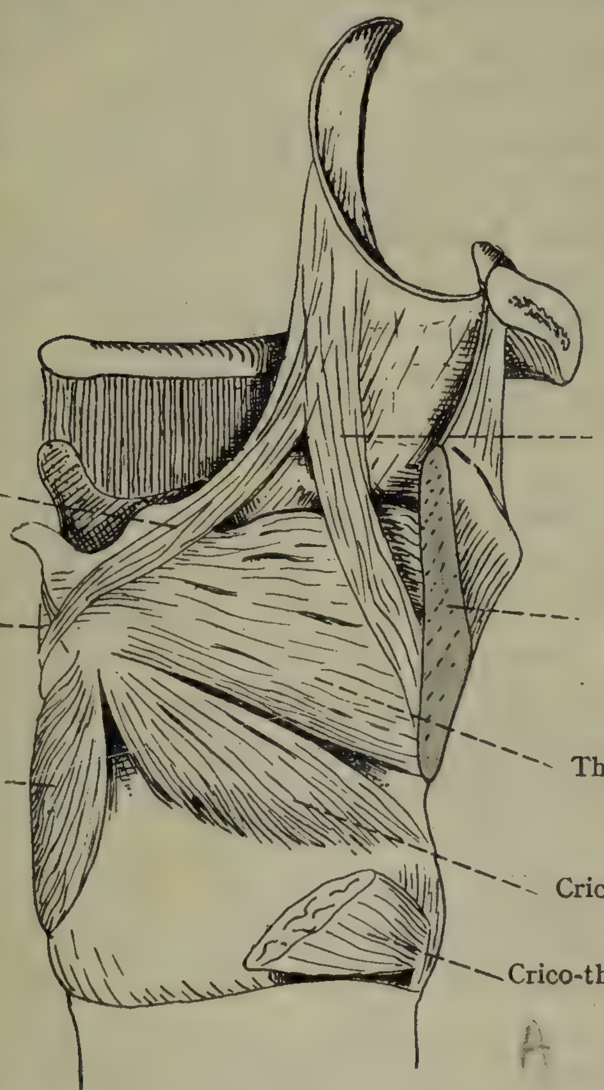


FIG. 848.—THE INTRINSIC MUSCLES OF THE LARYNX (LATERAL VIEW). The greater part of the right lamina of the thyroid cartilage has been removed.

levate the anterior part of the cricoid cartilage. As a result of this novement the posterior part of the cricoid cartilage, carrying the rytenoid cartilages on its upper border, is depressed and carried ackward. Thus the vocal folds are put upon the stretch, and the nuscle is a tensor of the fold.

Between the two muscles anteriorly there is a triangular interval bout ½ inch wide, in which the central portion of the crico-vocal nembrane is visible, this portion being crossed at its centre by the rico-thyroid arch of arteries. In this region, just above the cricoid artilage, laryngotomy may be performed.

Crico-arytenoideus Posterior (see Fig. 847)—*Origin.*—The posterior surface of the cricoid cartilage on one side of the median vertical ridge.

Insertion.—The posterior aspect of the muscular process of the arytenoid cartilage.

Nerve-supply.—The recurrent laryngeal nerve.

The fibres of the muscle are directed upwards and outwards, the highest being short and nearly horizontal, the middle being oblique, and the lowest almost vertical.

Action.—To draw the muscular process of the arytenoid cartilage backwards, thereby swinging the vocal process outwards, the result of which is to open the rima glottidis. The muscle is, therefore, a dilator of the rima glottidis.

The muscle is separated from its fellow by the median vertical ridge on the back of the cricoid cartilage.

Crico-arytenoideus Lateralis (see Fig. 848)—*Origin.*—The lateral portion of the cricoid cartilage along its upper sloping border, extending as far back as the crico-arytenoid joint.

Insertion.—The anterior aspect of the muscular process of the arytenoid cartilage, and the adjacent portion of the antero-lateral surface.

Nerve-supply.—The recurrent laryngeal nerve.

The fibres of the muscle are directed backwards and upwards.

Action.—To draw the muscular process of the arytenoid cartilage forwards, thereby swinging the vocal process inwards, the result of which is to narrow the rima glottidis. The two muscles therefore approximate the vocal folds, and come into action in speaking. When the crico-arytenoidei posteriores et laterales act together they prevent rotation, and thus indirectly assist the arytenoideus in approximating the arytenoid cartilages, and so the rima glottidis is closed. The crico-arytenoideus lateralis is covered laterally by the lamina of the thyroid cartilage and the upper fibres of the crico-thyroideus, and medially by the lateral expanded portion of the crico-vocal membrane.

Thyro-arytenoideus.—This muscle consists of two parts, lateral and medial.

Lateral Part—*Origin.*—(1) The lower half of the inner surface of the lamina of the thyroid cartilage, and (2) the outer surface of the lateral portion of the crico-vocal membrane.

Insertion.—The front of the muscular process and the adjacent part of the outer border of the arytenoid cartilage, a few of the fibres passing round the cartilage to become continuous with the arytenoideus. The uppermost fibres of this part pass upwards and backwards to the ary-epiglottic fold, and thence to the epiglottis, under the name of the **thyro-epiglotticus.**

Medial Portion—*Origin.*—(1) The receding angle of the thyroid cartilage, and (2) the anterior part of the vocal fold. The most medial fibres of this portion, known as the **vocalis** muscle, spring from the anterior part of the vocal fold.

Insertion.—The outer surface of the vocal process of the arytenoid rtilage, and the neighbouring part of the antero-lateral surface.

The fibres pass from before backwards, some of them having a ght inclination outwards, and the highest backwards.

Nerve-supply.—The recurrent laryngeal nerve.

Action—(1) **Medial Part.**—To draw forwards the arytenoid cartilage, d the posterior part of the cricoid cartilage, swinging the latter in upward and forward direction. e result of this action is to relax vocal folds by approximating the ytenoid cartilage to the thyroid carti- ge. This part of the muscle is, erefore, the antagonist of the crico- yroideus. It is to be borne in mind, wever, that one factor in relaxation the vocal folds must of necessity be stic recoil. The fibres representing vocalis muscle act by rendering ise that part of the vocal fold which in front of them, and relaxing the rt behind them.

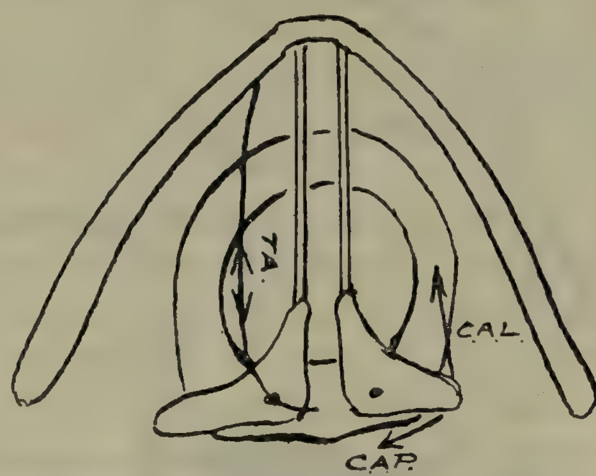


FIG. 849.—SCHEME TO SHOW ACTIONS ON THE ARYTENOID CARTILAGE OF LATERAL AND POSTERIOR CRICO-ARYTENOIDS (CAL, CAP) AND THYRO-ARY- TENOID (TA).

A very important action of the edial part of the thyro-arytenoideus, en it is acting in conjunction with crico-thyroid, is accurately to approximate and straighten the cal fold. A loss of accurate fitting of the fold of one side against fellow is one of the first signs of incipient paralysis of the recurrent yngeal nerve from pressure or stretching, and, when it happens on left side, suggests an intrathoracic aneurism or new growth. The tion of the vocalis part of the thyro-arytenoideus is to tighten a rtion of the vocal fold, and may be concerned in the production of falsetto voice.

(2) **Lateral Part.**—In virtue of its insertion into the muscular process the arytenoid cartilage, this portion will draw forwards that process, e effect of which is to swing inwards the vocal process. The fibres own as the thyro-epiglotticus have been supposed to assist in pressing the epiglottis.

The outer portion of the muscle lies within the lamina of the thyroid rtilage. Its lower border touches the crico-arytenoideus lateralis, d its upper fibres lie on the outer wall of the sinus and saccule. The ner portion of the muscle is in close contact with the outer side of e vocal fold.

Arytenoideus.—The arytenoideus muscle lies across the posterior rfaces of the arytenoid cartilages. It consists of two parts—super- ial and deep. The superficial part is composed of two decussating ndles, each of which is known as the arytenoideus obliquus; and e deep part constitutes the arytenoideus transversus.

Arytenoideus Obliquus.—Each of these muscles, which has the

form of a narrow oblique bundle, arises from the back of the muscu process of the arytenoid cartilage. Its direction is upwards a inwards, and at the median line it decussates with its fellow of t opposite side, thus X. Having reached the summit of the oppos arytenoid cartilage, a few of the fibres end, but the majority en

FIG. 850.—SKELETAL STRUCTURES OF LARYNX, WITH CRICO-THYROID MUSCLE IN POSITION.

the corresponding a epiglottic fold. Being inforced by a few fib from the summit of t arytenoid cartilage, t fibres now constitute t **ary-epiglotticus musc** which passes forwa within the ary-epiglot fold to be inserted ir the side of the epiglott Associated with the a epiglotticus there are th fibres of the lateral porti of the thyro-arytenoide which are known as t **thyro-epiglotticus.**

Nerve-supply.—The current laryngeal nerve.

Action.—The two mu cles, having the aryten cartilages within their embrace, draw these cartilages together, which action they are aided by the arytenoideus transversus a ary-epiglotticus muscles, and the inlet of the larynx is narrowed.

Arytenoideus Transversus.—The fibres of this muscle extend tra versely from the posterior surface and outer border of one aryten cartilage to those of the other.

Nerve-supply.—The recurrent laryngeal nerve.

Action.—To draw the arytenoid cartilages together, and th approximate the vocal folds, and even close the rima glottidis.

The arytenoideus transversus muscle, clothed with mucous me brane anteriorly, bounds the rima glottidis posteriorly; and its sup ficial or posterior surface is in contact with the decussating arytenoi obliqui muscles.

Compressor Sacculi Laryngis is a thin layer of muscular fibres the medial side and upper end of the saccule of the larynx. The fib are related superiorly to those of the ary-epiglotticus, which are co tained within the ary-epiglottic fold.

Summary of the Actions of the Laryngeal Muscles.—The intrin muscles of the larynx, by regulating the condition of the rima glottid contribute to vocalization, and modify the pitch of notes. In so doi they lengthen, so as to render tense, or shorten, so as to relax, t vocal folds; and they also bring the folds together, or draw the

art. In other words, the intrinsic muscles bring about *tension* and *rallelism* of the true vocal folds, or give rise to the opposite con-ions—namely, *relaxation* and *divergence*.

Tension is effected by the crico-thyroidei muscles (see p. 1390).

Convergence of the vocal folds is effected by the crico-arytenoidei erales and the arytenoidei.

Relaxation of the vocal folds is brought about by the thyro-ary-ıoidei muscles, which draw the arytenoid cartilages, along with the sterior part of the cricoid cartilage, forwards. The vocal folds are the same time shortened by their own elastic recoil. The fibres of thyro-arytenoideus muscle, known as the vocalis, act by producing al variations in tension.

Divergence of the vocal folds and **opening of the rima glottidis** is ected by the crico-arytenoidei posteriores, which draw the muscular ocesses of the arytenoid cartilages backwards and inwards, the result which is to rotate the vocal processes outwards.

Function of the Epiglottis.—The epiglottis is never folded down like id. The superior aperture of the larynx is closed during deglutition the action of the arytenoideus transversus and the lateral portions the thyro-arytenoidei. The arytenoideus transversus approximates e arytenoid cartilages, and the lateral portions of the thyro-ytenoidei draw the arytenoid cartilages forwards until their apical rts come into contact with the tubercle of the epiglottis.

The sphincter-like action of the ary-epiglottici upon the inlet of the ynx must also be taken into account.

Nerves.—The nerves of the larynx are the superior and recurrent yngeal, both of which are branches of the vagus.

The **superior laryngeal nerve** divides into two branches, external d internal. The **external laryngeal nerve,** which is comparatively ıall, supplies the **crico-thyroideus,** and also gives twigs to the inferior nstrictor muscle of the pharynx. The **internal laryngeal nerve** is *nsory*, passes deep to the posterior border of the thyro-hyoid muscle, d enters the larynx by piercing the thyro-hyoid membrane in com-ny with the superior laryngeal artery, above which it lies. Crossing e floor of the pyriform fossa, where a ganglion is situated upon it, breaks up into branches, some of which ascend to the ary-epiglottic ld and epiglottis, a few of them passing as far as the posterior surface the tongue close to the mid-line. The other branches descend supply the laryngeal mucous membrane, and one of them joins a ig from the recurrent laryngeal nerve.

The **recurrent laryngeal nerve** is the principal *motor* nerve of the ynx. On the *right side* it arises from the vagus at the root of the ck, and hooks round the first part of the right subclavian artery. ı the *left side* it arises from the vagus in the upper part of the thorax, d hooks round the arch of the aorta.

Having ascended in the groove between the trachea and œsophagus, at the side of the trachea, it passes beneath the lower border of the ferior constrictor muscle, and ascends upon the cricoid cartilage,

lying close behind the crico-thyroid joint. Here it divides into tv branches, anterior and posterior. The *anterior branch* ascends und cover of the thyroid cartilage, and is distributed to the crico-ar tenoideus lateralis, thyro-arytenoideus, thyro-epiglotticus, and ar epiglotticus muscles. The *posterior branch* passes upwards on t back of the cricoid cartilage beneath the crico-arytenoideus posteri muscle, which it supplies, and then it goes on to end in the arytenoide muscle.

Perhaps the most practically important relation of the recurre laryngeal is the thyroid gland, since it passes just behind the pla where that structure is most firmly attached to the cricoid cartila and first ring of the trachea. During removal of one half of t thyroid the nerve is in great danger of being cut in freeing the glan particularly as it is so often farther forward than its reputed positi in the groove between the trachea and œsophagus. Its relation the inferior thyroid artery is variable, and branches often pass bo in front of and behind the nerve, though most commonly the arte is in front. It has been noticed already that, in its course, the ner is in close relation with the paratracheal lymph glands.

The recurrent laryngeal nerve carries some *sensory* branches the mucous membrane of the larynx below the rima glottidis, and communicates with the internal branch of the superior larynge The motor fibres of the external branch of the superior laryngeal ar of the inferior laryngeal are derived from the cranial root of the acce sory nerve.

Summary of the Laryngeal Nerves.—The **superior laryngeal nerve,** throu its **internal branch,** is *sensory,* and its **external branch** supplies the *crico-thyroide* and in part the inferior constrictor muscle of the pharynx.

The **inferior** or **recurrent laryngeal nerve** is chiefly *motor,* and it suppli the intrinsic muscles of the larynx, *with the single exception of the crico-thyroide* it also supplies a twig to the inferior constrictor.

Arteries.—The arteries of the larynx are the superior and t inferior laryngeal. The **superior laryngeal artery** is a branch of t superior thyroid. It accompanies the internal laryngeal nerve, belo which it lies, and enters the larynx by piercing the thyro-hyoid mem brane. The **inferior laryngeal artery** is a branch of the inferior thyroi and it accompanies the recurrent laryngeal nerve.

Veins.—The **superior laryngeal vein** opens into the superior thyroi and the **inferior laryngeal vein** into the inferior thyroid vein.

Lymphatics.—These are arranged in two sets—superior and inferi The superior lymphatics come from the portion of the larynx abo the rima glottidis. Having pierced the thyro-hyoid membrane, th pass to the upper group of deep cervical lymph glands. The inferi lymphatics come from the portion of the larynx below the rin glottidis. Having pierced the crico-vocal membrane, they pass the lower group of deep cervical lymph glands, having previous traversed the pre- and para-laryngeal lymph glands.

In early life the larynx occupies a higher position than it does

adult, its descent, which is gradual, being completed by puberty. to that period the projection known as the laryngeal prominence ıot present. After puberty important changes take place. The tilages increase in size, the laryngeal prominence assumes marked elopment, especially in the male, and the vocal folds undergo rease in length. These various changes account for the modifications ich the voice undergoes at and after puberty.

Development of the Larynx.—The larynx is developed from the upper part ı median diverticulum from the ventral aspect of the fore-gut, which diverılum by its lower part gives rise to the trachea. The general development is en on p. 73. The *epiglottis* is formed from the caudal part of the hypochial eminence, its pharyngo-epiglottic fold being a remnant of the third h and its ary-epiglottic fold of the fourth arch. The cricoid is formed in sixth arch, as are the internal intrinsic muscles. The thyroid cartilage elops in the ventral part of the fourth arch, the lower part of the inferior strictor belonging to the dorsal part; the crico-thyroideus is a part of this scle cut off by the downgrowth of the lower thyroid horn to meet the cricoid. vocal folds are formed in the edges of the original sagittal opening in the ryngeal floor; the part of the larynx above the folds is a modification of s floor, while the lower part comes from the upper end of the pulmonary growth. The pyriform fossa marks the site of the third lateral pouch.

Prevertebral Muscles.

Longus Capitis (**Rectus Capitis Anticus Major**)—*Origin.*—By four ort tendons from the anterior tubercles of the transverse processes the third, fourth, fifth, and sixth cervical vertebræ, the same tachment as that of the scalenus anterior.

Insertion.—The inferior surface of the basilar process of the occipital ne, from the pharyngeal tubercle obliquely outwards and forwards r about ½ inch.

Nerve-supply.—The cervical plexus.

The muscle is directed upwards and inwards.

Action.—To flex the head and neck.

Relations—*Anterior.*—The upper part of the common carotid and e internal carotid arteries, the internal jugular vein, the vagus rve and sympathetic trunk, and the pharynx. *Posterior.*—A part the longus cervicis, a large portion of the rectus capitis anterior, d the transverse processes of the cervical vertebræ.

Rectus Capitis Anterior (**Rectus Capitis Anticus Minor**)—*Origin.*—ıe front of the lateral mass of the atlas.

Insertion.—The inferior surface of the basilar part of the occipital one between the foramen magnum and the outer part of the insertion the longus capitis.

Nerve-supply.—The anterior primary ramus of the first cervical rve.

The muscle is directed upwards and slightly inwards.

Action.—To flex the head.

Rectus Capitis Lateralis—*Origin.*—The upper aspect of the exemity of the transverse process of the atlas at its front part.

Insertion.—The inferior surface of the jugular process of tl occipital bone.

Nerve-supply.—The anterior primary ramus of the first cervic nerve.

Relations.—*Anteriorly* is the internal jugular vein, with the vag accessory, and hypoglossal nerves close to it, while only a little distan in front is the styloid process, parotid gland, and facial nerve. *Po teriorly* is the obliquus capitis superior. *Laterally* are the occipit

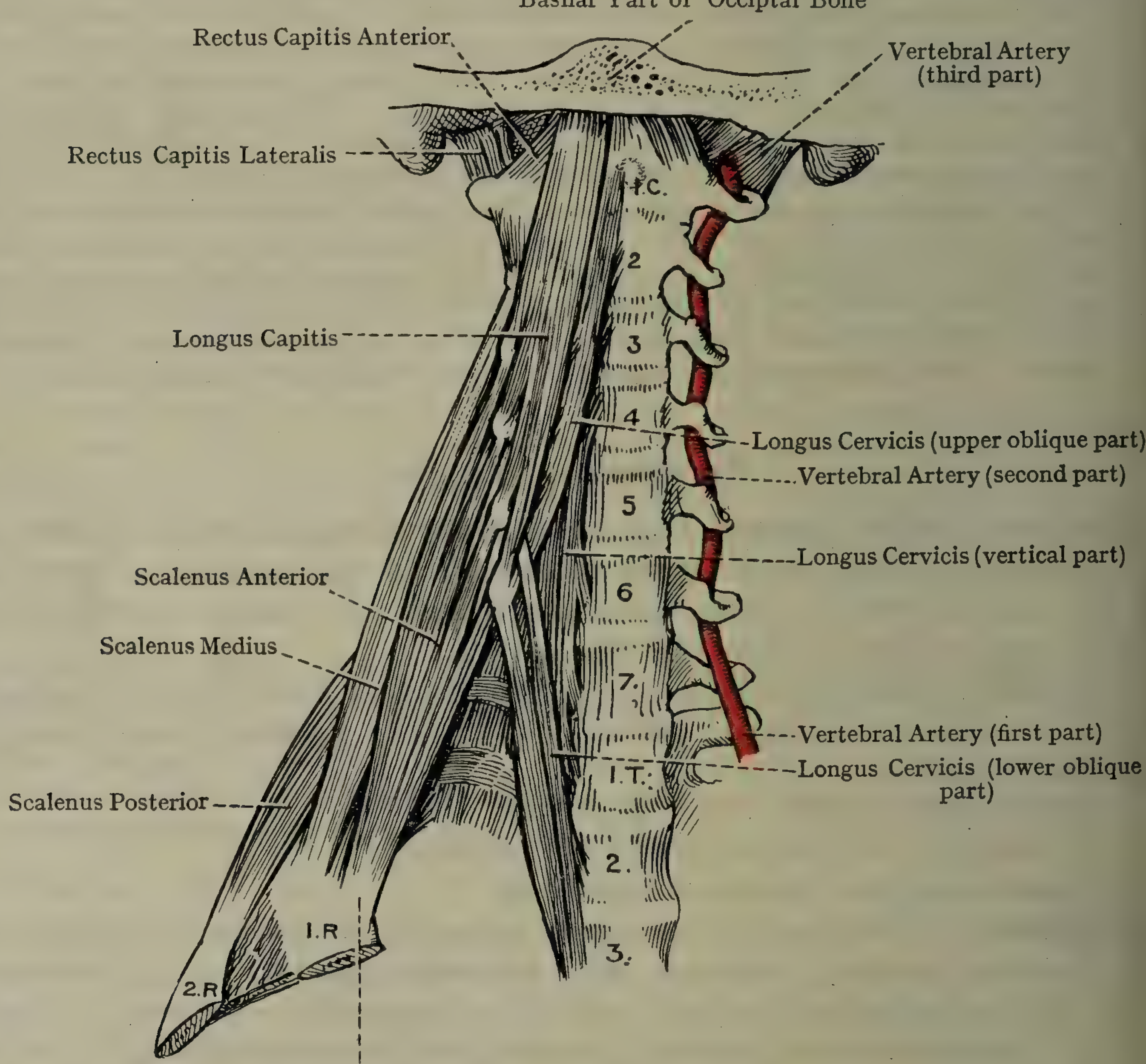


FIG. 851.—THE RIGHT PREVERTEBRAL MUSCLES.
The vertebral artery is also shown.

artery, and often the accessory nerve, forming an X, and still mo superficially the origin of the digastric; while *medially* the vertebr artery comes up through the foramen transversarium.

The muscle passes vertically upwards.

Action.—To incline the head to one side.

Longus Cervicis (Longus Colli).—This muscle consists of thr portions—superior oblique, vertical, and inferior oblique.

Superior Oblique Portion—*Origin.*—The anterior tubercles of tl

ısverse processes of the third, fourth, fifth, and sixth cervical tebræ.

Insertion.—The lateral aspect of the tubercle on the anterior arch. The fibres are directed upwards and inwards.

Vertical Portion—*Origin.*—The fronts of the bodies of the last two vical and first three thoracic vertebræ.

Insertion.—The fronts of the bodies of the second, third, and fourth vical vertebræ.

Inferior Oblique Portion—*Origin.*—The fronts of the bodies of the t three thoracic vertebræ in common with the lower portion of the tical part.

Insertion.—The anterior tubercles of the transverse processes of fifth and sixth cervical vertebræ.

Nerve-supply.—The anterior primary rami of the adjacent spinal ves.

Action.—To flex the cervical part of the vertebral column.

Relations—*Anterior.*—The pharynx, œsophagus, and retro-pharyn-l cellular tissue; the common and internal carotid arteries, and ernal jugular vein; the vagus nerve, and the sympathetic trunk; longus capitis superiorly; and the recurrent laryngeal nerve, inferior roid artery, and first part of the subclavian artery inferiorly. *sterior.*—The bodies and discs of the adjacent vertebræ, and their nsverse processes.

Petrous Portion of the Internal Carotid Artery.—This part of the ernal carotid artery is contained within the carotid canal of the trous part of the temporal bone. It is at first directed upwards, d then, describing a bend, it passes forwards and inwards to the amen lacerum, where it enters upon the cavernous part of its course. e vessel is surrounded by a plexus of veins, and is accompanied by internal carotid branch of the superior cervical ganglion of the mpathetic trunk. This branch breaks up into two divisions. One these lies on the outer side of the artery and gives rise to the in-nal carotid sympathetic plexus, whilst the other lies on the inner le of the artery and goes on to form the medial part of the latter exus.

As the artery ascends in the carotid canal it is situated in front , and below, the tympanic cavity and cochlea; as it bends it has the aryngo-tympanic tube on its anterior and outer side; and as it sses forwards and inwards it has the trigeminal ganglion above it, e partition between the two being partly membranous.

Branches.—The petrous portion gives off a *carotico-tympanic branch,* hich enters the tympanic cavity through the posterior wall of the rotid canal, and it may furnish a *petrosal branch* to accompany the ep petrosal nerve.

For the cavernous portion of the internal carotid artery, see p. 1169.

Petrous Part of the Facial Nerve.—This part of the nerve extend. om the orifice of the internal auditory meatus, on the posterior rface of the petrous part of the temporal bone, to the stylo-mastoid

foramen, and it traverses (1) the internal auditory meatus, and (2) t
facial canal.

Meatal Portion.—The motor root of the nerve is directed outwar
and is accompanied by the *sensory root* (*pars intermedia of Wrisber*
the auditory nerve, and the internal auditory artery. It is plac
upon the upper and anterior aspect of the auditory nerve, and t
sensory root lies between the two, and here joins the facial nerv
At the deep end of the internal auditory meatus the facial ner
parts company with the auditory nerve, and enters the faci
canal.

Branches.—Two branches connect the facial nerve with the audito
nerve.

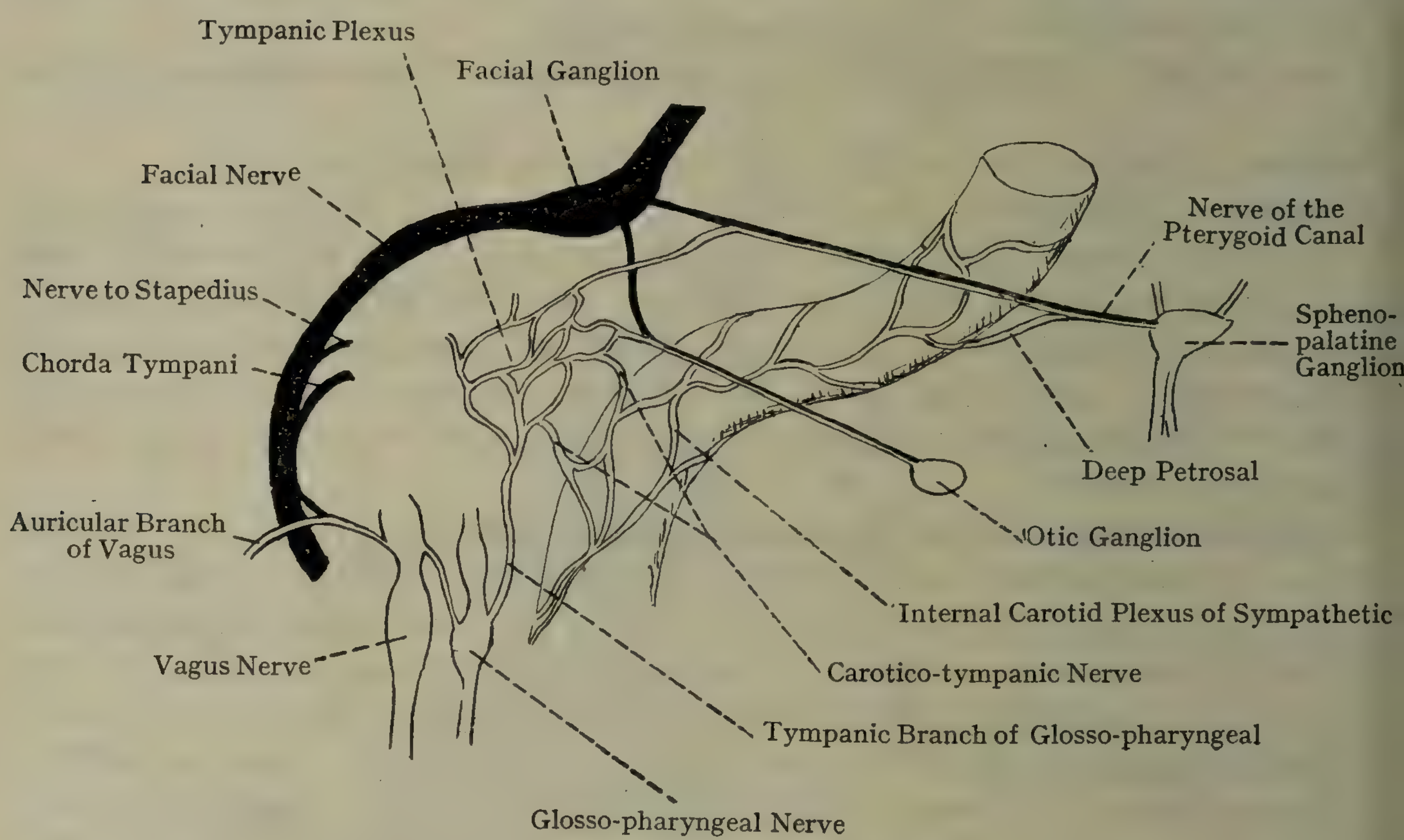


FIG. 852.—RELATIONS OF THE PETROUS PORTION OF THE INTERNAL CAROTID ARTERY.

Portion in the Facial Canal (Aqueduct of Fallopius).—The directio
of this portion of the nerve corresponds to that of the canal. It
divided into three stages. In the *first stage*, which is very short, t
nerve passes horizontally outwards, between the cochlea and vestibul
to the inner wall of the tympanic cavity, where there is an enlargemen
called the **facial ganglion (geniculate ganglion).** Here it bends sharpl
and in the *second stage* passes backwards, lying above the fenest
vestibuli and enclosed in a very thin-walled bony canal which ma
easily be damaged in scraping the inner wall of the tympanic cavit
Then it describes another less abrupt curve, and in the *third sta*
descends behind the posterior wall of the tympanic cavity to the styl
mastoid foramen, by which it escapes from the facial canal. T
hiatus for greater superficial petrosal nerve (*hiatus Fallopii*) leads fro
near the beginning of the facial canal to the superior surface of t

etrous part of the temporal bone. As the facial canal descends it ommunicates with the canal of the pyramidal eminence of the tympanic avity, and below this is another opening, called the *posterior canaliulus for the chorda tympani nerve.*

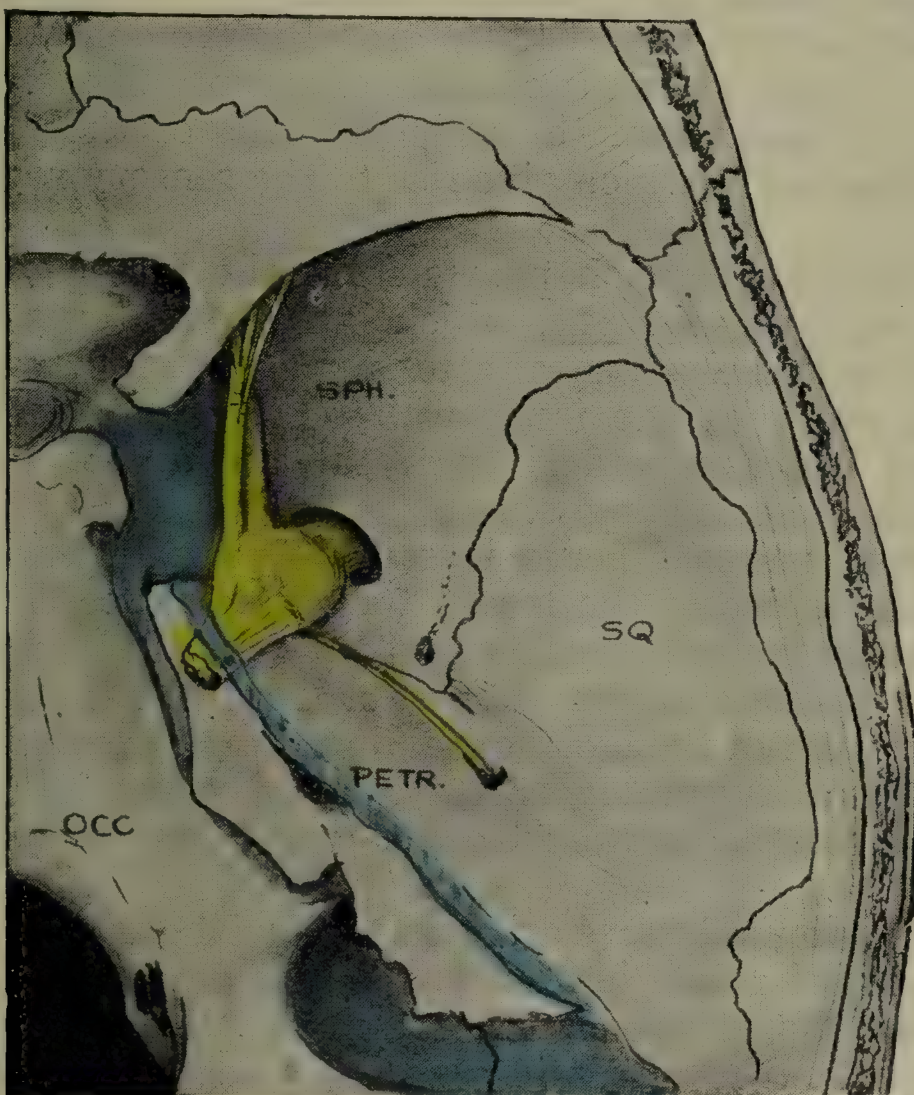


FIG. 853.

ẓreater superficial petrosal nerve is seen lying on bone, exposed by removal of dura mater. It enters foramen lacerum, having passed deep to trigeminal ganglion. In the foramen lies by lateral side of internal carotid and its plexus; is joined by a branch from this, and enters interpterygoid foramen.

Branches :

From facial ganglion:
- Greater superficial petrosal (to spheno-palatine ganglion).
- Communicating branch to lesser superficial petrosal (to the otic ganglion).
- External petrosal (to sympathetic plexus on middle meningeal artery).*

Nerve to the stapedius muscle.
Chorda tympani nerve.
Communicating branch to the auricular branch of the vagus.

The **greater superficial petrosal nerve** arises from the facial ganglion, ınd passes forwards through the corresponding hiatus, by which it eaves the facial canal. It then courses inwards and forwards in a ẓroove on the anterior surface of the petrous part of the temporal

* There is grave doubt whether this nerve really exists in the body.

bone, and passes beneath the trigeminal ganglion to the foramer lacerum. In the upper part of this foramen it joins the deep petrosa nerve from the internal carotid plexus to form the nerve of the pterygoi canal, which passes forwards through the pterygoid canal into th pterygo-palatine fossa, and joins the back part of the spheno-palatin ganglion. The greater superficial petrosal nerve contains some moto fibres, but to a large extent it consists of sensory fibres. These repre sent peripheral branches of the unipolar cells of the facial ganglion the central branches of which give rise to the sensory root of the facia nerve.

A **communicating branch** passes from the facial ganglion to th *lesser superficial petrosal nerve,* which latter represents the tympani branch of the glosso-pharyngeal after it has left the tympanic plexu on the promontory of the inner wall of the tympanic cavity. By means of the lesser superficial petrosal nerve this communicatin branch reaches the otic ganglion.

The **external petrosal nerve** is said to pass through an openin just within the orifice of the hiatus for greater superficial nerve, an to join the sympathetic plexus around the middle meningeal artery.

The **nerve to the stapedius muscle** arises from the facial nerve i the descending part of the facial canal opposite the pyramidal eminenc of the tympanic cavity. It enters a small canal in the pyramida eminence, and so reaches the stapedius as that muscle lies within th canal.

The **chorda tympani nerve** arises in the facial ganglion, but is boun up with the facial nerve in the descending part of the facial canal A little above the stylo-mastoid foramen it leaves the nerve, an passes upwards and forwards in a recurrent course through a minut canal, called the *posterior canaliculus for chorda tympani nerve,* b which it enters the tympanic cavity. At first it is placed on th posterior wall of the tympanic cavity close to the posterior margi of the tympanic cavity, and to the outer side of the pyramidal eminence The nerve then passes forwards medial to the tympanic membran near its upper margin, lying between its mucous and fibrous layers, s as to be ensheathed by the mucous membrane. In this part of it course it passes between the inner aspect of the handle of the malleu and the limb of the incus. Having arrived at the inner end of th petro-tympanic fissure, it leaves the tympanic membrane by passin through the *anterior canaliculus for chorda tympani nerve* (*canal o Huguier*). It grooves the spine of the sphenoid, and then enters th pterygo-maxillary region, and passes downwards and forwards deep t the lateral pterygoid muscle, where it receives a communicating twi from the otic ganglion, and then joins the lingual nerve at an acut angle at the upper margin of the medial pterygoid muscle. It shoul be noted that the chorda tympani lies deep to all the vessels and nerve with which it comes in contact in the pterygoid region. The distribu tion of the nerve has been already described (see p. 1315).

The chorda tympani is composed of fibres, which are the peri

heral processes of the unipolar cells of the ganglion of the facial erve. These represent the fibres which are distributed to the sides nd dorsum of the tongue over its anterior two-thirds. They are herefore regarded as *gustatory*, and functionally are afferent. They re connected with the fibres of the sensory root by means of the nipolar cells of the ganglion of the facial nerve. The chorda tympani erve, however, also contains secretory fibres of the submandibular nd sublingual glands. The nerve is therefore a mixed nerve.

A **communicating branch** is given off from the facial nerve just bove the stylo-mastoid foramen, which connects it with the auricular ranch of the vagus.

Sensory Root of Facial Nerve (Pars Intermedia of Wrisberg).—he fibres of this small nerve arise from the unipolar cells of the ganglion f the facial, being the central processes of these cells, the peripheral rocesses representing the principal fibres of origin of the chorda ympani. The sensory root is at first closely incorporated with motor oot of the facial nerve, and passes from the facial canal into the nternal auditory meatus. Here it separates from the facial nerve, nd lies between it and the auditory nerve. After passing through the rifice of the internal auditory meatus the sensory runs to the lower order of the pons, where it enters the medulla oblongata, and ends n the **nucleus of the tractus solitarius.**

The Ganglion of the Facial Nerve (Geniculate Ganglion).—The acial ganglion is situated on the facial nerve in the facial canal t the point where the canal, having reached the inner wall of the ympanic cavity, makes a sharp bend before passing backwards. ike a spinal ganglion and the trigeminal ganglion, it consists of unipolar ells, each of which has a central and a peripheral process. The anglion is the nucleus of origin of the sensory fibres of the facial erve. The *central processes* of the unipolar cells form the **sensory oot** of the facial nerve, and the majority of the peripheral processes orm the **chorda tympani nerve.** Some of the peripheral processes, owever, pass into the greater superficial petrosal nerve and the ommunicating branch to the lesser superficial petrosal nerve.

Summary of the Petrosal Nerves.—There are four petrosal nerves—namely, reater superficial, lesser superficial, external, and deep; and there are two deep etrosal nerves—namely, great and small.

Superficial Petrosal Nerves.—The *greater superficial petrosal nerve* is described n p. 1401.

The *lesser superficial petrosal nerve* issues from the tympanic plexus on the nner wall of the tympanic cavity, and represents the continuation of the tympanic ranch of the inferior ganglion of the glosso-pharyngeal nerve. As it traverses canal in the petrous portion of the temporal bone it is joined by a small branch rom the ganglion of the facial nerve. Emerging from this canal through the iatus for the lesser superficial petrosal nerve, it passes through the canaliculus nnominatus, when present, or through the fissure between the petrous portion f the temporal bone and greater wing of the sphenoid, or sometimes through he foramen ovale, into the infratemporal fossa, where it joins the otic ganglion lose below the foramen ovale.

The *external petrosal nerve* (of doubtful existence) is a branch of the ganglion f the facial nerve. It leaves the petrous part of the temporal bone through

a small opening (inconstant) close to the hiatus for greater superficial petrosa nerve, and joins the sympathetic plexus on the middle meningeal artery.

Deep Petrosal Nerve.—The *deep petrosal nerve* is a branch of the interna carotid plexus of the sympathetic. It joins the greater superficial petrosa in the upper part of the foramen lacerum medium to form the nerve of th pterygoid canal, which, as stated, passes through the latter canal into the pterygo palatine fossa, and joins the back part of the spheno-palatine ganglion.

The *carotico-tympanic nerves* from the tympanic plexus are often referrec to as the *small deep petrosal nerves,* which form a communication with the in ternal carotid plexus by piercing the wall of the carotid canal. There may b more than one such connection between the two plexuses.

Auditory Nerve in the Internal Auditory Meatus.—This nerve passe outwards in the internal auditory meatus in company with the sensor and motor roots of the facial nerve, and the internal auditory artery The motor root of the facial nerve is placed upon its upper and anterio aspect, and the sensory root lies between the two. Two branche connect the auditory nerve with the facial.

At the deep end of the meatus the auditory nerve breaks up int two divisions—an upper, called the vestibular, and a lower, called th cochlear nerve. The **vestibular nerve** has a ganglion, called th

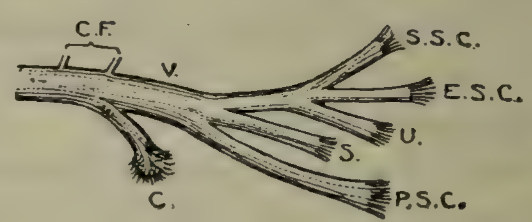


FIG. 854.—SCHEME OF THE AUDITORY NERVE (FLOWER).

C.F. Communicating with Facial
C. Cochlear Nerve
V. Vestibular Nerve
S.S.C. To Superior Semicircular Duct
E.S.C. To Lateral Semicircular Duct
U. To Utricle
S. To Saccule
P.S.C. To Posterior Semicircular Duct

vestibular ganglion (*Scarpa's ganglion*), situated at the deep end of the meatus, its bipolar cells giving origin to the vestibular fibres. Late it breaks up into two branches, upper and lower. The **superior branc** gives branches to the ampullary crests of the superior and latera semicircular ducts, and to the utricle. These pass through the fora-mina of the *superior vestibular area* of the upper fossa of the *lamina cribrosa* at the deep end of the meatus (see Fig. 126, p. 190). The **inferior branch** supplies branches to the ampullary crest of the posterio semicircular duct and to the saccule. The former pass through the *foramen singulare* in the lower fossa of the lamina cribrosa, and the latter through the foramina of the *inferior vestibular area* of the lowe fossa of the lamina cribrosa.

The branches of the **cochlear nerve** pass through the foramina o the *cochlear area* of the lower fossa of the lamina cribrosa.

The Joints of the Atlas, Axis, and Occipital Bone.

Atlanto-axial Joints.—These are three in number, and they belong to the class of **synovial joints.** One is medially placed, the articula surfaces being the atlantal facet on the anterior surface of the odontoid

cess of the axis and the odontoid facet on the posterior surface the anterior arch of the atlas. This joint belongs to the sub- ision of **pivot-joints.** The other two are placed one on either e, the articular surfaces of each being the inferior articular process the atlas and the corresponding superior articular process of the s. These two joints belong to the subdivision of **plane-joints.**

Ligaments.—These are the transverse ligament, the capsular ments, and the accessory ligaments. Besides these there are the permost part of the anterior longitudinal ligament and the posterior anto-axial ligament, which are not directly related to any of the nts.

The **transverse ligament of the atlas** is the transverse portion of the ciate ligament, to be presently referred to, and is a strong band, ich is attached on either side to the tubercle on the inner aspect

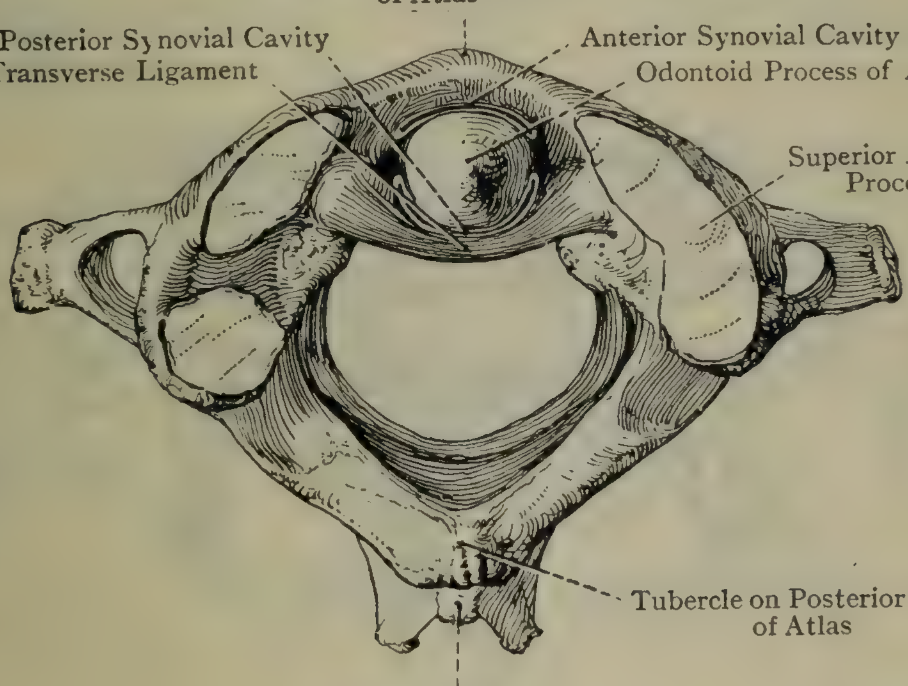


Fig. 855.—The Articulation between the Anterior Arch of the Atlas and the Odontoid Process of the Axis.

the lateral mass of the atlas. It is arched backwards behind the lontoid process, and at the median line it is connected on the posterior pect with the limbs of the vertical portion of the cruciate ligament. etween the ligament and the odontoid process there is an extensive novial membrane, which extends well over each lateral aspect of e process, so as to come very near another synovial membrane etween the front of the process and the anterior arch of the atlas.

The **capsular ligaments** are loose sacs which surround the articula- ons between the inferior articular processes of the atlas and the perior articular processes of the axis.

The **accessory ligament** on each side extends from the posterior rface of the body of the axis, close to the root of the odontoid pro- ess, to the inner and posterior part of the lateral mass of the atlas ee Fig. 857). The direction of each ligament is upwards and out-

wards, and it is closely related superiorly to the capsular ligamen which it strengthens internally and posteriorly. The accessory lig ments are auxiliary in function to the alar ligaments, and limit rotatic of the atlas upon the axis.

The uppermost part of the **anterior longitudinal ligament** (**anteri atlanto-axial ligament**), broad, thin, and membranous, is attache superiorly along the lower margin of the anterior arch of the atla and inferiorly to the anterior aspect of the body of the axis. It continuous below with the anterior longitudinal ligament of the bodi of the vertebræ, and its central portion is rendered thick by accessor fibres derived from that ligament.

The **posterior atlanto-axial ligament,** also broad, thin, and mem branous, extends from the under aspect of the posterior arch of tl atlas to the upper borders and adjacent portions of the outer surfac

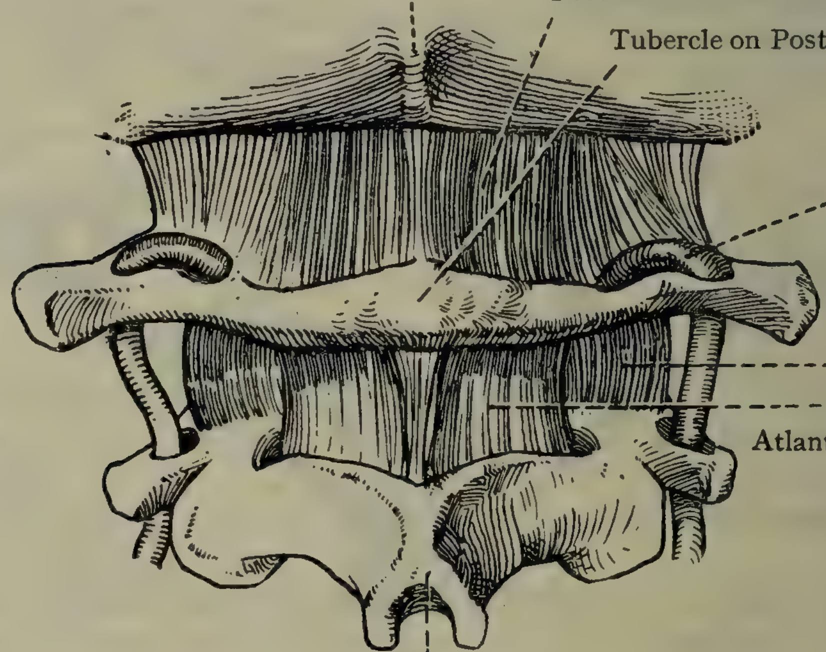


FIG. 856.—THE OCCIPITAL, ATLANTAL, AND AXIAL LIGAMENTS (SUPERFICIAL POSTERIOR VIEW).

of the laminæ of the axis. It is serially continuous with, and repr sents, the ligamenta subflava of succeeding vertebræ.

Atlanto-occipital Joints.—These belong to the class of **synovi joints** of the **condyloid type.** The articular surfaces are the condyl of the occipital bone and the superior articular processes of the atlas

Ligaments.—These are the capsular ligaments and the anteric and posterior atlanto-occipital membranes, the latter two being ir directly connected with the joints.

The **capsular ligaments** are loose sacs which directly surroun the articulations. Their fibres are attached superiorly round th margins of the occipital condyles, and inferiorly to the lateral masse of the atlas round the superior articular processes.

The **anterior atlanto-occipital membrane,** thin and membranous, i attached inferiorly to the upper margin of the anterior arch of th

tlas, and superiorly to the under surface of the basilar part of the ccipital bone, close to the front part of the foramen magnum, between he occipital condyles. In the median line it is thickened by fibres vhich are attached below to the tubercle on the anterior arch of the tlas, but some of them are prolonged into the thickened part of the nterior longitudinal ligament.

The **posterior atlanto-occipital membrane,** broad, thin, and mem-ranous, is attached inferiorly to the upper margin of the posterior rch of the atlas, except in the region of the vertebrarterial grooves, nd superiorly to the lower margin of the foramen magnum behind he occipital condyles. Over each vertebrarterial groove of the atlas his ligament forms an arch which is sometimes ossified (see p. 131), nd beneath which the vertebral artery and suboccipital nerve pass.

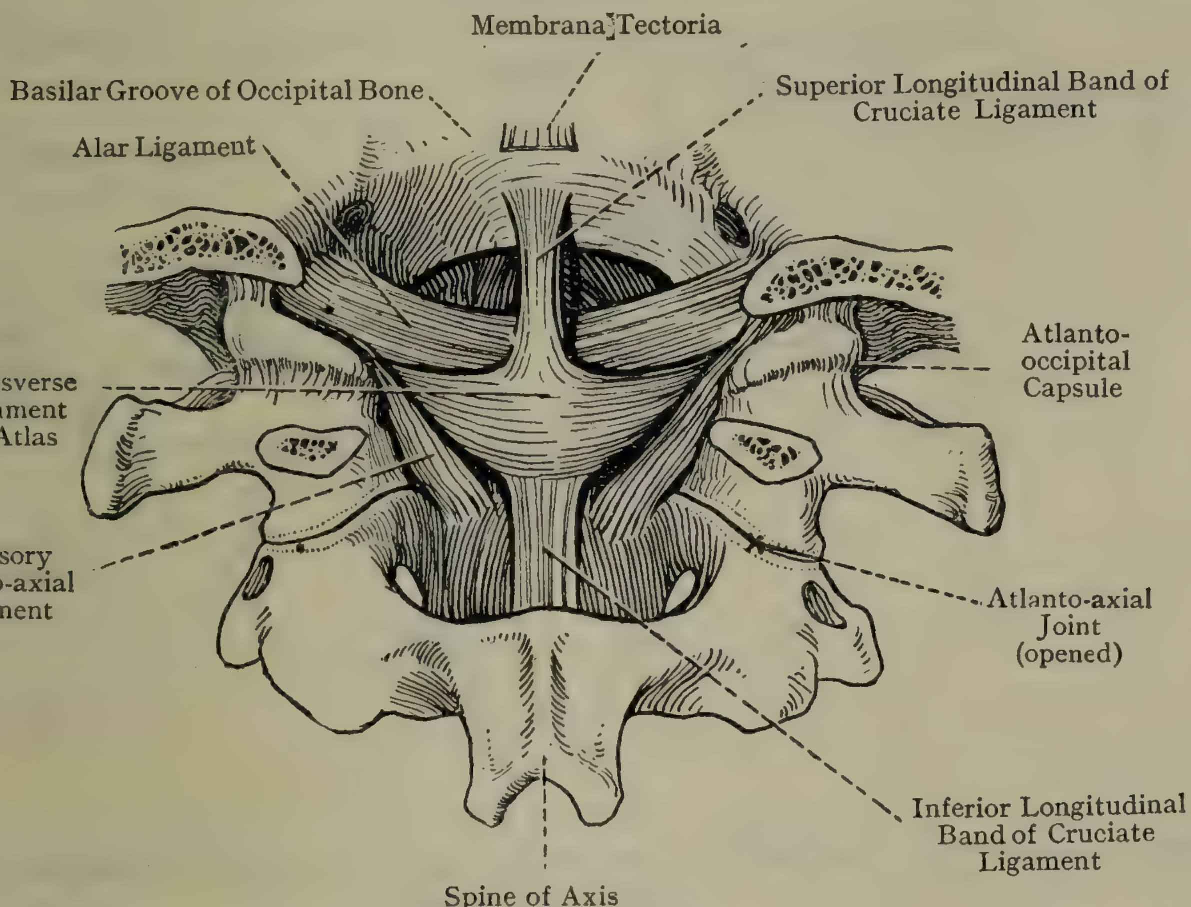


FIG. 857.—OCCIPITAL, ATLANTAL, AND AXIAL LIGAMENTS (POSTERIOR VIEW).

Occipito-axial Ligaments.—These are the membrana tectoria; the lar ligaments; the apical ligament; and the vertical portion of the ruciate ligament.

The **membrana tectoria (posterior occipito-axial ligament)** is a road membranous band which is attached inferiorly to the posterior urface of the body of the axis, where it is continuous with the fibres f the posterior longitudinal ligament of the bodies of the vertebræ, nd superiorly to the posterior part of the basilar groove of the ccipital bone. It covers the odontoid process of the axis and the lar and cruciate ligaments.

The **vertical portion of the cruciate ligament** consists of *superior* nd *inferior longitudinal bands.* The superior band extends from the osterior surface of the transverse ligament of the atlas at the mid-

line to the posterior part of the basilar groove of the occipital bone between the anterior margin of the foramen magnum and the upper attachment of the membrana tectoria, under cover of which it lies. This band, as it ascends, is in contact with the posterior surface of the head of the odontoid process. The *inferior band* extends from the posterior surface of the transverse ligament of the atlas at the mid-line to the posterior surface of the body of the axis above the inferior attachment of the membrana tectoria.

The **transverse portion of the cruciate ligament** is the transverse ligament of the atlas, already described.

The **apical ligament of the odontoid process (middle odontoid ligament)** is a narrow round cord which is attached below to the ridge of

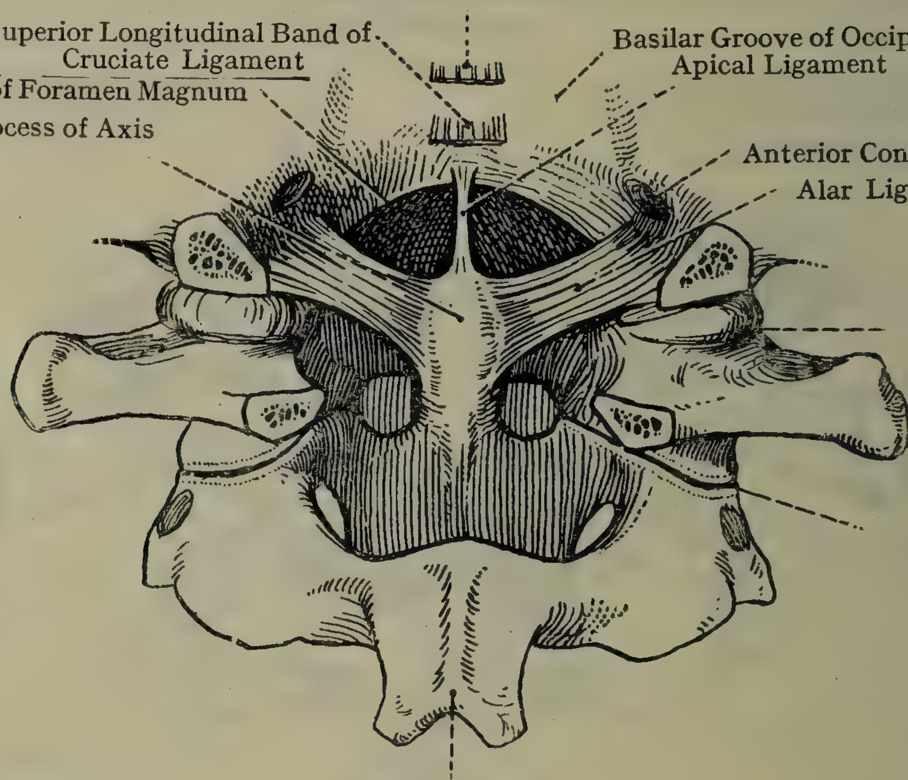


FIG. 858.—THE OCCIPITAL, ATLANTAL, AND AXIAL LIGAMENTS (DEEP POSTERIOR VIEW).

the head of the odontoid process, and above to the anterior margin of the foramen magnum in the mid-line.

This structure has little or no ligamentous function, but is a remnant of the notochordal sheath.

The **alar ligaments of the odontoid process (check ligaments)** form two very strong bands which are attached medially to the lateral surfaces on the head of the odontoid process, and laterally to an impression on the inner surface of each condylar part of the occipital bone. The direction of each ligament is outwards and slightly upwards.

Movements—Atlanto-axial Joints.—The atlas, bearing the head, rotates on the axis, the odontoid process of which serves as a pivot. The extent of rotation is about 30 degrees, and is limited by the alar, aided slightly by the accessory atlanto-axial ligaments. On p. 130 it has been seen that the superior

icular processes of the axis are each divided by a slight transverse impression o two parts—anterior and posterior. When the face is directed straight wards, the inferior articular processes of the atlas are not in accurate contact th the superior articular processes of the axis. Between the contiguous pairs ere is a distinct interval all round. When, however, the atlas is rotated, the *terior division* of the axial articular process of one side is brought into accurate ntact with the corresponding atlantal articular process, and the *posterior vision* of the opposite axial articular process into accurate contact with the antal articular process of that side.

Atlanto-occipital Joints.—The movements allowed at these joints are flexion, tension, and oblique movement. **Flexion** and **extension** constitute the forward d backward, or *nodding*, movements. In over-extension (dorsi-flexion) the *sterior margins* of the superior articular processes of the atlas enter the *condylar sœ* of the occipital bone, and locking takes place. In complete forward or ntral flexion the *anterior margins* of the superior articular processes of the as come into contact with the occipital bone *in front* of each condyle.

CHAPTER XV

THE NERVOUS SYSTEM

THE nervous system is arranged in two main divisions, cerebro-spina and autonomic; this last contains the *sympathetic* and the *parasym pathetic*.

The **sympathetic system** consists of two gangliated cords situate on either side of the vertebral column, and three main prevertebra plexuses: the cardiac situated in the thorax; the epigastric or solar and the hypogastric plexus, the latter two being situated in th abdomen; subsidiary plexuses are associated with these.

The **parasympathetic** system includes *cranial* and *sacral* outflows leaving the cerebro-spinal axis through certain nerves without joinin the sympathetic cords.

The **cerebro-spinal nervous sytem** or **axis** consists of the encephalo and the spinal cord, the former being situated within the crania cavity, and the latter within the spinal canal. The continuity betwee these two divisions is established through the foramen magnum.

The cerebro-spinal axis is central in position, and is connecte with the various parts of the body by the cranial and spinal nerves It is composed of two kinds of nervous matter, white and grey. Th **white matter** consists chiefly of nerve-fibres, and the **grey matter** c nerve-cells, with their axis-cylinder processes or axons and dendrites the pervading supporting tissue in each case being called **neuroglia** In the spinal cord the white matter is disposed externally, whilst th grey matter is situated in the interior. In the brain there is the sam arrangement of grey matter in the centre, surrounded by white matte but a third and more modern layer of cortical grey matter has bee added to the surface of the white, a layer which is unrepresented i the spinal cord.

The cerebro-spinal axis is surrounded by three membranes, c *meninges*, which, from without inwards, are named the dura mate arachnoid membrane, and pia mater.

THE SPINAL CORD.

Membranes of the Spinal Cord.—The membranes are three: th dura mater, the arachnoid membrane, and the pia mater.

Dura Mater.—This is the most external covering of the cord. I forms a dense fibrous tube, known as the *theca*, which extends fro the margin of the foramen magnum of the occipital bone to the lowe level of the second sacral vertebra. *Inferiorly*, where it has becom

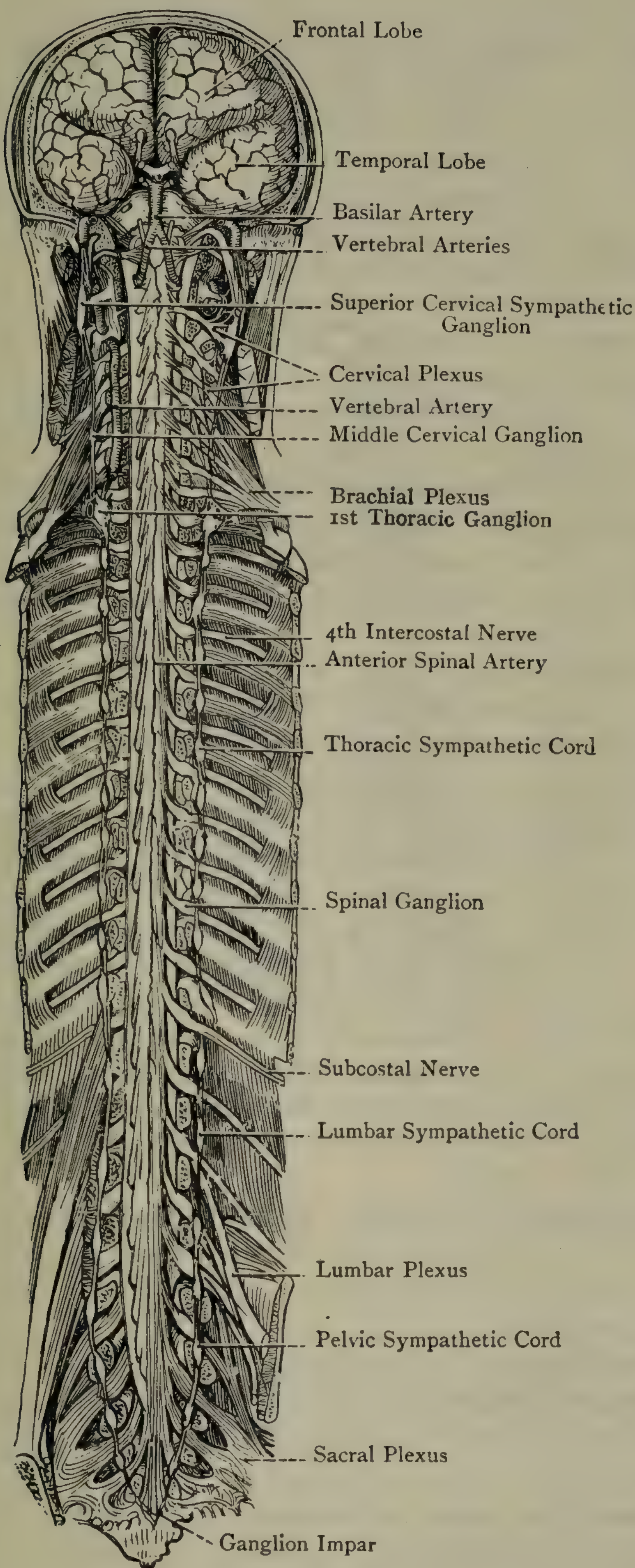


FIG. 859.—THE CEREBRO-SPINAL AND SYMPATHETIC SYSTEMS (ANTERIOR VIEW) (HIRSCHFELD AND LEVEILLÉ).

tapering behind the second sacral vertebra, the theca is perforate by the filum terminale, and from this level the spinal dura mater i prolonged downwards around the filum terminale, with which it blend: Finally, it is attached, along with the filum terminale, to the bac of the first coccygeal vertebra, where it is incorporated with th periosteum. In this situation the spinal dura mater is firmly fixed.

The theca surrounds the spinal cord very loosely, and it is separate from the wall of the spinal canal by an interval, called the **extra-dura space,** which is occupied by venous plexuses and loose areolar tissue.

Opposite the intervertebral foramina of each side the theca has series of openings, which are arranged in two parallel rows. Th openings constituting each pair are placed side by side, but are distinc from each other, and they transmit the ventral or anterior and dors: or posterior roots of the spinal nerves. Each of these roots, as it make its exit, receives a tubular sheath from the margin of the correspondin thecal opening, and these sheaths remain distinct as far as the spina ganglion of the dorsal root. After this the neighbouring sheath form one which blends with the sheath of the corresponding spina nerve.

The spinal dura mater is maintained in position by several cor nections. (1) *Superiorly* it is fixed to the margin of the forame magnum of the occipital bone. (2) Opposite the body of the ax it is firmly attached *anteriorly* to the posterior occipito-axial ligamen (3) Below the level of the axis it is loosely connected *anteriorly* wit the posterior longitudinal ligament of the bodies of the vertebræ b fibrous bands. (4) *Laterally* it is connected with the sheaths of th spinal nerves by means of the tubular sheaths which it gives to th ventral and dorsal nerve-roots. (5) *Inferiorly* it blends with th periosteum over the back of the first coccygeal vertebra through th filum terminale. Posteriorly it is quite free from connections.

The spinal dura mater differs from the cranial dura mater in th following respects: (1) It is destitute of an outer or periosteal laye (2) it does not send septa into the spinal cord; and (3) it does nc contain venous sinuses.

Blood-supply of Spinal Dura Mater.—The arteries are derive from (1) the spinal branches of the vertebral, intercostal, and lumba arteries; and (2) the lateral sacral arteries, which are branches of th internal iliac artery.

Nerve-supply.—The nerves are partly spinal and partly sympatheti

Lymphatic Vessels.—There are no lymphatic vessels, their plac being taken by perivascular lymph-spaces in connection with th arteries.

Structure.—The spinal dura mater consists of fibrous tissue and some elast tissue disposed in parallel longitudinal bundles. Its internal and extern surfaces are covered by endothelial cells.

Subdural Space.—Between the spinal dura mater and the arachnoi there is a narrow cleft-like interval, which is known as the **subdur space.** It contains a small amount of fluid, and communicates freel

h the lymph-spaces or clefts in the sheaths of the spinal nerves. has, however, no communication with the subarachnoid space.

Spinal Arachnoid Membrane.—This is a delicate transparent mbrane which loosely surrounds the spinal cord between the theca ernally and the pia mater internally. It is separated from the ca by the subdural space, and from the pia mater by the sub-chnoid space. *Superiorly* it is continuous with the cranial arach-d, and *inferiorly* it encloses the cauda equina. On either side it ms sheaths for the processes of the ligamentum denticulatum as as the inner surface of theca. The ventral and sal roots of the spinal ves also receive sheaths m it, which accompany m through the openings the theca, but soon cease. It is of practical import-ce to remember that the chnoid membrane usually ds at the lower level of the ond sacral vertebra, and ver extends lower than the rd.

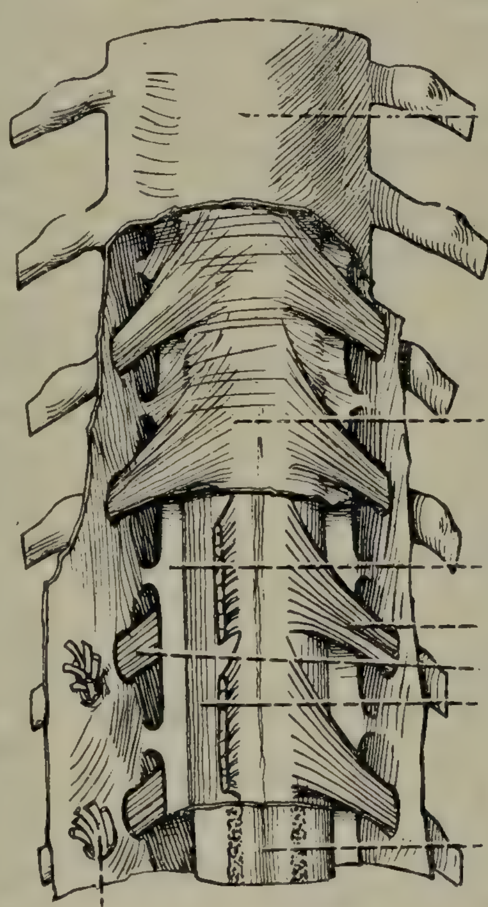


FIG. 860.—PORTION OF THE SPINAL CORD, SHOWING THE MEMBRANES, LIGAMENTA DENTICULATA, AND ROOTS OF THE SPINAL NERVES.

Subarachnoid Space (Ca-m Subarachnoidale).—This ace, which is wide, is uated, as stated, between arachnoid and pia mater. contains cerebro-spinal id, and its dorsal part is ntinuous superiorly with cerebello-medullary cis-na of the cranial sub-chnoid space, which com-inicates with the fourth ventricle by the 'foramen of Magendie,' e *median aperture* of the roof.

The subarachnoid space is partially divided into two compart-ents, *ventral* and *dorsal*, by *ligamenta denticulata*, which form in-mplete lateral septa. The ventral roots of the spinal nerves traverse e ventral compartment, and the dorsal roots the dorsal compart-ent. The dorsal compartment is partially subdivided into two rtions, right and left, by means of a third incomplete septum, called e *posterior septum*. This partition extends from the pia mater as crosses the dorsal median fissure of the spinal cord to the dorsal rt of the arachnoid at the median line. All the compartments of e subarachnoid space communicate freely with each other.

The subarachnoid space has no communication with the subdura ace.

Structure of the Arachnoid Membrane.—The arachnoid consists of fine fibrou tissue arranged in interlacing bundles, the intervals between these bundle being occupied by delicate cellular membranes. Several such layers, intimatel blended together, form the membrane.

Beneath the arachnoid, and constituting a part of it, there is a *reticulum* c *subarachnoid trabeculæ*. These trabeculæ consist, as in the case of the arachnoi proper, of fine fibrous tissue, but the intertrabecular spaces, instead of bein occupied by cellular membranes, contain cerebro-spinal fluid. The trabecula reticulum connects the arachnoid with the subjacent pia mater, and varie greatly in density in different parts.

Spinal Pia Mater.—This is the deepest membrane of the spina cord. It is definitely fibrous and very vascular, and closely invest the cord. *Superiorly* it is con tinuous with the cranial pi mater, and inferiorly it is pro longed from the conus medul laris over the upper half of th intrathecal part of the filun terminale. On either side i forms tubular sheaths for th ventral and dorsal roots of th spinal nerves, which blend witl the sheaths of the nerves.

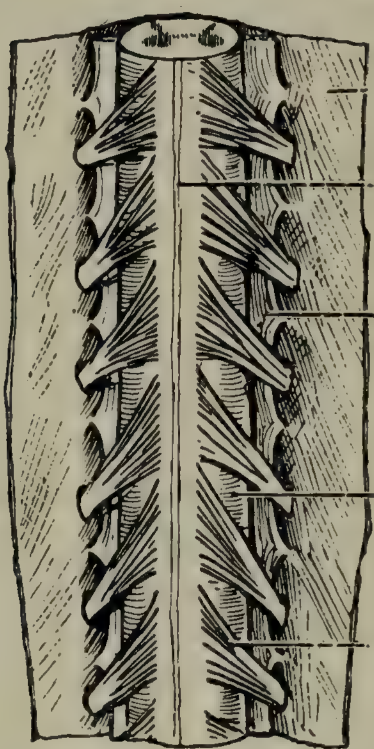


Fig. 861.—A Portion of the Spinal Cord (Anterior View).

The theca has been laid open, and the arachnoid membrane removed.

Along the course of th ventral median fissure of th cord it sends a vascular fol into that fissure. Along th course of the dorsal mediai fissure, *over which it passes* the neuroglial septum occupy ing that fissure is attached t it. From the deep orifice o the pia mater several septa ar prolonged into the cord, which carry with them portions of the glia sheath.

The pia mater is separated from the arachnoid by the subarach noid space, and opposite the dorsal median fissure of the cord it i connected with the dorsal part of the arachnoid by the posterio subarachnoid septum.

Blood-supply.—The pia mater derives its arteries from the anterio and posterior spinal arteries, and the neural branches of the latera spinal arteries.

Nerve-supply.—The nerves are derived from the sympathetic system

Structure.—The spinal pia mater consists of two layers—outer and inne The *outer layer* consists of fibrous tissue, which is disposed for the most part i parallel longitudinal bundles. The *inner layer* consists of areolar tissue containin a great many bloodvessels, and its outer and inner surfaces are covered by endo thelial cells. Between the two layers there are narrow cleft-like lymphati spaces, which communicate with the subarachnoid space, and with lymphati clefts around the arteries of the pia mater.

The spinal pia mater differs from the cranial pia mater in being icker and more adherent to the nervous matter. The greater thick-ss is due to the presence of the outer layer, the cranial pia mater presenting the inner layer of the spinal pia mater.

Linea Splendens.—The pia mater at times presents a glistening ppearance immediately in front of the ventral median fissure. This ea is known as the **linea splendens,** and it extends along the entire ngth of the cord and along the conus medullaris on to the filum rminale.

Ligamentum denticulatum is a band of *pia mater* which extends ong the spinal cord on each side opposite the corresponding lateral olumn. It lies between the ventral and dorsal roots of the spinal erves, and extends from the margin of the foramen magnum to the wer end of the cord. It lies within the subarachnoid space, and

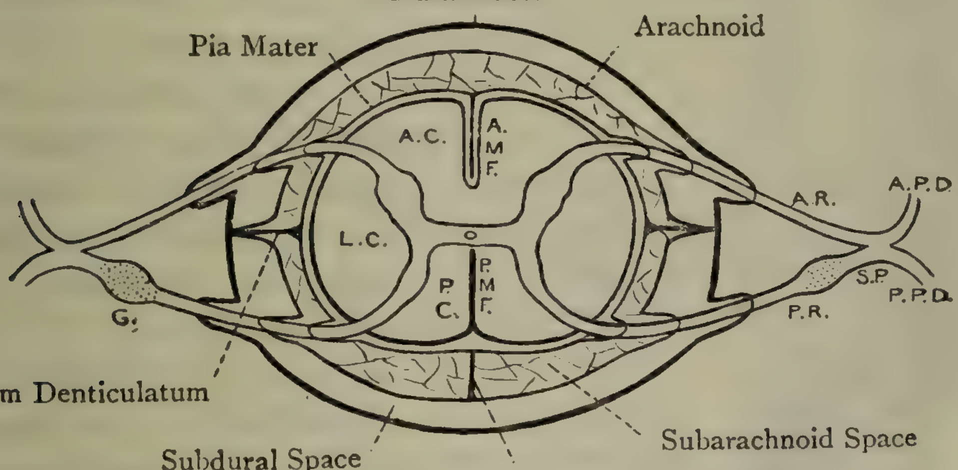


FIG. 862.—DIAGRAM OF A TRANSVERSE SECTION OF THE SPINAL CORD AND ITS MEMBRANES.

A.M.F. Anterior Median Fissure, with Process of Pia Mater
P.M.F. Posterior Median Sulcus
A.C. Anterior Column
L.C. Lateral Column
P.C. Posterior Column
A.R. Anterior Nerve-Root
P.R. Posterior Nerve-Root
G. Spinal Ganglion
S.P. Spinal Nerve
A.P.D. Anterior Primary Ramus
P.P.D. Posterior Primary Ramus

artially divides that space into two compartments—ventral and orsal.

Internally it forms an uninterrupted band which is attached to ne pia mater along the lateral column of the cord. *Laterally* it is enticulated. The denticulations (about twenty-one in number) carry ith them sheaths from the arachnoid, and their pointed outer ends re attached to the inner surface of the theca in the intervals between ach pair of openings for the exit of the ventral and dorsal nerve-roots. he topmost denticulation is at the foramen magnum, lying between ne eleventh nerve and the vertebral artery; the lowest is between ne last thoracic and first lumbar nerves, at the first lumbar vertebral evel.

The two ligamenta denticulata act as lateral supports to the spinal ord.

Structure.—Each ligamentum denticulatum consists of fibrous tissue, which s continuous with the outer layer of the pia mater.

External Characters of the Spinal Cord. — The spinal cord, o *medulla spinalis,* which is somewhat cylindrical, is that division o the cerebro-spinal axis which is situated within the spinal canal. I extends from the lower margin of the foramen magnum in the occipita bone to about the level of the disc between the bodies of the firs and second lumbar vertebræ, and it is about 18 inches in length Superiorly it is continuous with the medulla oblongata, and inferiorl it terminates in a tapering portion, called the **conus medullaris.** Fron the lower end of this cone a slender, glistening thread, called th **filum terminale,** about 10 inche long, is continued downward between the bundles of lumbar sacral, and coccygeal nerve of either side, which constitut the *cauda equina,* to be attache to the back of the first coccy geal segment.

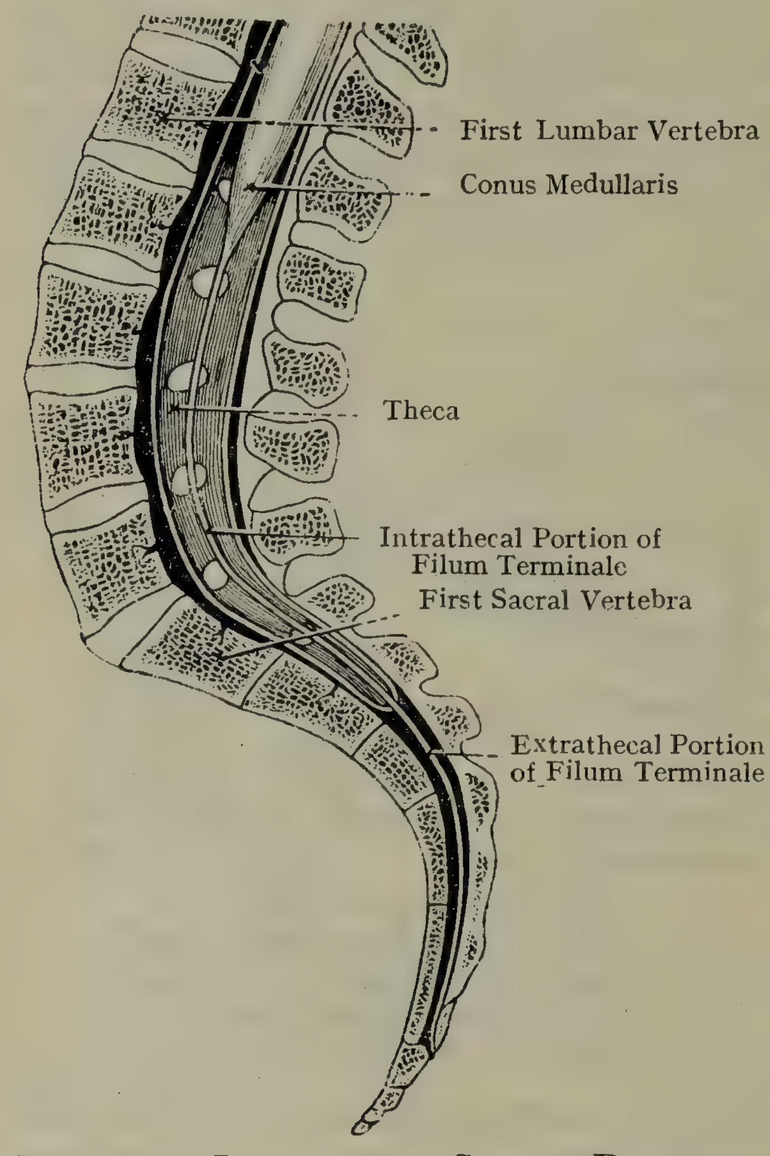


FIG. 863.—LUMBAR AND SACRAL PORTIONS OF SPINAL CANAL, SHOWING LATERAL VIEW OF CONUS MEDULLARIS, FILUM TERMINALE, AND THECA (TESTUT).

The spinal cord is of smalle dimensions than the spina canal, and is therefore relieve from pressure during the ordi nary movements of the verte bral column. It is surrounde by the three membranes alread described—the dura mater, th archnoid membrane, and th pia mater. Within its theca o dura mater the cord is sus pended by means of the liga menta denticulata, and th nerve-roots as they emerg through the openings in th theca.

The spinal cord varies i shape in different regions. I the *cervical region,* as seen i transverse section, it is trans versely oval, and is slightl flattened from before backwards. In the *thoracic region* it is almos circular, but the transverse diameter exceeds the antero-posterio In the *lumbar region* it is still more circular than in the thoraci region.

The cord has two swellings, which are known as the cervical an lumbar enlargements, and are associated with the numerous larg nerve-trunks destined for the upper and lower limbs. The **cervica enlargement** extends from near the upper end of the cord to the secon thoracic vertebra, and its breadth is greatest opposite the sixth cervica vertebra. The **lumbar enlargement,** which is less conspicuous tha

he cervical, extends from the level of the tenth thoracic vertebra o the conus medullaris, and its breadth is greatest opposite the twelfth horacic vertebra.

Filum Terminale.—This delicate glistening thread lies in the nedian line between the lumbar, sacral, and coccygeal nerves of either side, which constitute the cauda equina, and it extends from the apex of the conus medullaris to the back of the first coccygeal segment. It is about 10 inches in length. As low as the back of the body of the second or third sacral segment it is situated within the theca, but at that level it pierces the theca, from which it receives an investment, and then passes to be attached to the back of the first coccygeal segment, where it blends with the periosteum. The intrathecal portion is known as the *filum terminale internum*, and the extrathecal portion as the *filum terminale externum*.

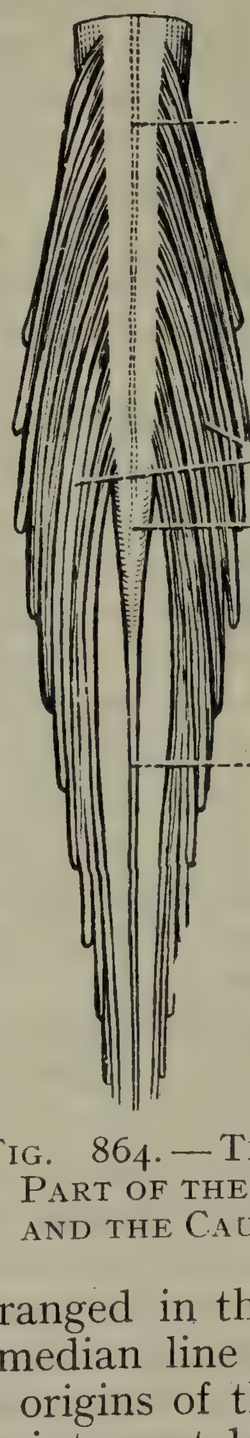


Fig. 864.—The Terminal Part of the Spinal Cord, and the Cauda Equina

Structure.—The filum terminale internum in its *upper half* consists of pia mater prolonged from the conus medullaris of the spinal cord. This encloses grey matter, within which, over about the upper third, there is a continuation of the central canal of the cord. The *lower half* consists chiefly of connective tissue. The filum terminale externum is a mere fibrous filament invested by a prolongation of the theca which blends with it. It is also composed of pia mater prolonged downwards from the conus medullaris, and reinforced by fibres derived from the lower portions of the ligamenta denticulata and linea splendens. Its lower part is purely fibrous.

Cauda Equina.—This is situated within the lower part of the theca. It consists of the roots of the lumbar, sacral, and coccygeal nerves of each side, which are arranged in the form of a leash, and the filum terminale lies in the median line between the two nerve-leashes. On account of the high origins of the individual nerves, relatively to the positions of the intervertebral foramina through which they pass, the direction of the nerves is almost vertical until they reach the level of their respective foramina of exit.

Fissures of the Spinal Cord.—The spinal cord, which is somewhat flattened in front and behind, is incompletely divided into two symmetrical halves by two median formations, anterior and posterior. The **anterior median fissure** extends into the cord for one-third of its thickness from before backwards, and it contains a fold of the pia

mater. At the bottom of the fissure the transverse band of nerve-fibres, called the *anterior white commissure,* crosses between the two halves of the cord. The **posterior median septum** is not an actual fissure like the anterior, and does not contain a fold of the pia mater, but is a septum of neuroglia, which extends into the cord for about half its thickness from before backwards. The *posterior grey commissure* lies at the bottom of the septum. The anterior median fissure is a definite depression, but it is not so deep as the posterior septum.

The posterior septum is marked on the surface by a median **sulcus.**

Each half of the cord presents a groove along the line of entrance of the fasciculi of the posterior nerve-roots, called the **postero-lateral sulcus,** but there is no similar groove along the line of emergence of the fasciculi of the anterior nerve-roots, these being spread over an area of some breadth. By means of the postero-lateral sulcus on the one hand, and the area corresponding to the emergence of the fasciculi of the anterior nerve-roots on the other, each half of the spinal cord is divided superficially into three white columns—anterior, lateral, and posterior.

The **anterior white column** is situated between the anterior median fissure and the most lateral fasciculi of the anterior nerve-roots; the **lateral white column** is the area between the most lateral fasciculi of the anterior nerve-roots and the postero-lateral sulcus; and the **posterior white column** lies between the postero-lateral sulcus and the posterior median sulcus. Practically the anterior column represents the region in front of the anterior nerve-roots, the lateral column the region between the anterior and posterior nerve-roots, and the posterior column the region behind the posterior nerve-roots. According to some authorities there are only two columns—namely, antero-lateral and posterior, the former extending from the anterior median fissure to the postero-lateral sulcus, and representing the combined anterior and lateral columns.

In the cervical region the surface of each posterior white column presents a slight groove which is situated nearer the posterior median sulcus than the postero-lateral sulcus. This groove is called the *posterior intermediate* or *paramedian furrow.* It contains a septum of pia mater, and in this manner the posterior column of the cord is marked off into two tracts. The medial and smaller tract is called the **fasciculus gracilis (postero-median column of Goll),** and the lateral and larger is called the **fasciculus cuneatus (Burdach's column, postero-lateral column).** These two columns extend throughout the cord, but it is only above the level of the mid-thoracic region that they are separated from each other by a septum of pia mater, known as the *posterior intermediate septum.*

Origin of the Spinal Nerves.—There are thirty-one pairs of spinal nerves, which arise from the sides of the spinal cord. They are arranged in five groups on either side as follows: **cervical,** *eight* in number; **thoracic,** *twelve*; **lumbar,** *five*; **sacral,** *five*; and **coccygeal,** *one.* Each spinal nerve is attached superficially to the cord by two roots, anterior

nd posterior, the posterior root being the larger of the two. The ortion of the cord from which each pair of spinal nerves arise is spoken f as a *segment* of the cord. Each root is ensheathed by tubular pro- ongations of the coverings of the cord—namely, the pia mater, arach- oid, and dura mater, in this order from within outwards—and these heaths ultimately blend with the perineurium. The roots are separated rom each other by the lateral column of the cord and the ligamentum enticulatum, and they pass through separate openings in the theca of ura mater.

The **anterior roots** are composed of *efferent* or *motor fibres*, and their asciculi emerge from the cord in an irregular manner, being spread ver an area corresponding in breadth to the *caput* of the anterior

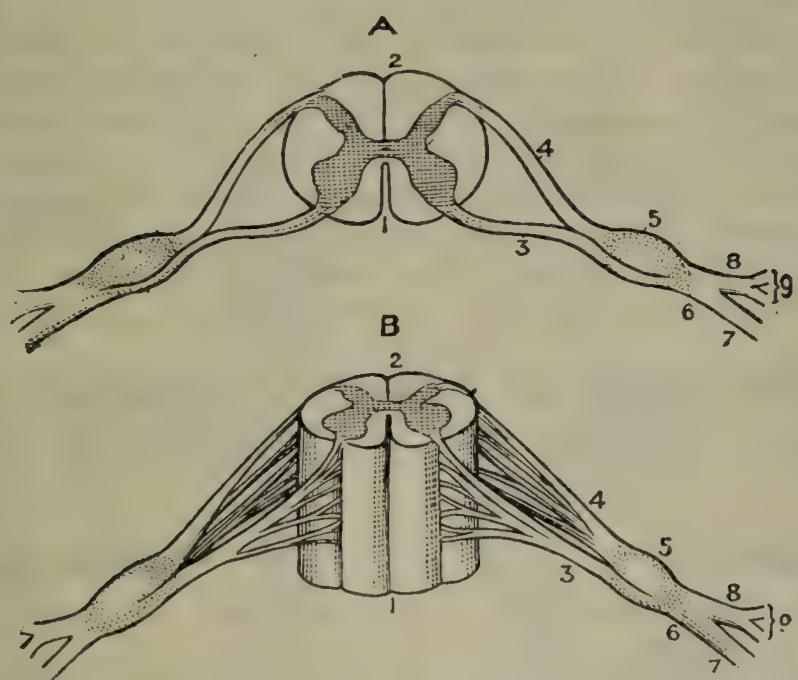


FIG. 865.—TWO SEGMENTS OF THE SPINAL CORD, SHOWING THE ATTACHMENTS OF THE ANTERIOR AND POSTERIOR NERVE-ROOTS, AND THE SPINAL GANGLIA.

A, superior view; B, anterior view.

1, 1. Anterior Median Fissure
2, 2. Posterior Median Sulcus
3, 3. Anterior or Motor Nerve-Root
4, 4. Posterior or Sensory Nerve-Root
5, 5. Spinal Ganglion
6, 6. Spinal Nerve
7, 7. Anterior Primary Ramus
8, 8. Posterior Primary Ramus
9, 9. Medial and Lateral Branches of Posterior Primary Ramus

horn of the grey matter in the interior. The **posterior roots** are com- posed of *afferent* or *sensory fibres*, and their fasciculi enter the cord in a straight line along the course of the postero-lateral sulcus. Each posterior root presents an oval swelling, called the **spinal ganglion.** These ganglia are for the most part situated in the intervertebral foramina, and immediately beyond each ganglion the anterior and posterior roots unite to form a **spinal nerve,** which is necessarily a *mixed* nerve, inasmuch as it is composed of afferent and efferent fibres.

Each spinal nerve breaks up into an *anterior* and a *posterior primary ramus.*

The upper cervical nerve-roots are short, and pass almost hori- zontally outwards. The succeeding nerve-roots, however, gradually increase in length, and incline downwards as they pass outwards,

This downward inclination goes on increasing until it becomes almost vertical in the case of the lumbar, sacral, and coccygeal nerves, which constitute the cauda equina. From this disposition it follows that in the majority of cases the superficial origins of the spinal nerves are on a higher level than the intervertebral foramina through which they emerge from the spinal canal.

Relation of the Spines of Vertebræ to the Bodies and to the Origins of the Nerves.—In the case of the cervical and the eleventh and twelfth thoracic vertebræ the extremities of the spinous processes correspond to the lower margins of the bodies of the respective vertebræ. In the case of the thoracic vertebræ, from the first to the tenth inclusive, the extremity of each spinous process corresponds to some part of the body immediately below. In the case of the lumbar vertebræ the extremity of each spinous process corresponds to the centre of the body of its own vertebra.

Each cervical spinous process is nearly opposite the lower fasciculi of the roots of the nerve below. The spinous process of the seventh cervical vertebra (vertebra prominens) is opposite the roots of the first thoracic nerve. From the third to the tenth thoracic vertebræ the spinous processes correspond to the second root below. The eleventh thoracic spine corresponds to the first and second lumbar nerves. The twelfth thoracic spine corresponds to the third, fourth, and fifth lumbar nerves. The first lumbar spine corresponds to the first, second, and third sacral nerves. (Gowers, from an original investigation.)

Mode of distinguishing the Anterior and Posterior Surfaces of the Spinal Cord.—These surfaces may be recognized by attending to the following points:

Anterior Surface.

1. Linea splendens in median line, especially in lower part.
2. Anterior spinal artery in median line.
3. Fasciculi of anterior nerve-roots spread over a wide area.
4. Presence of an anterior median sulcus which can be opened.

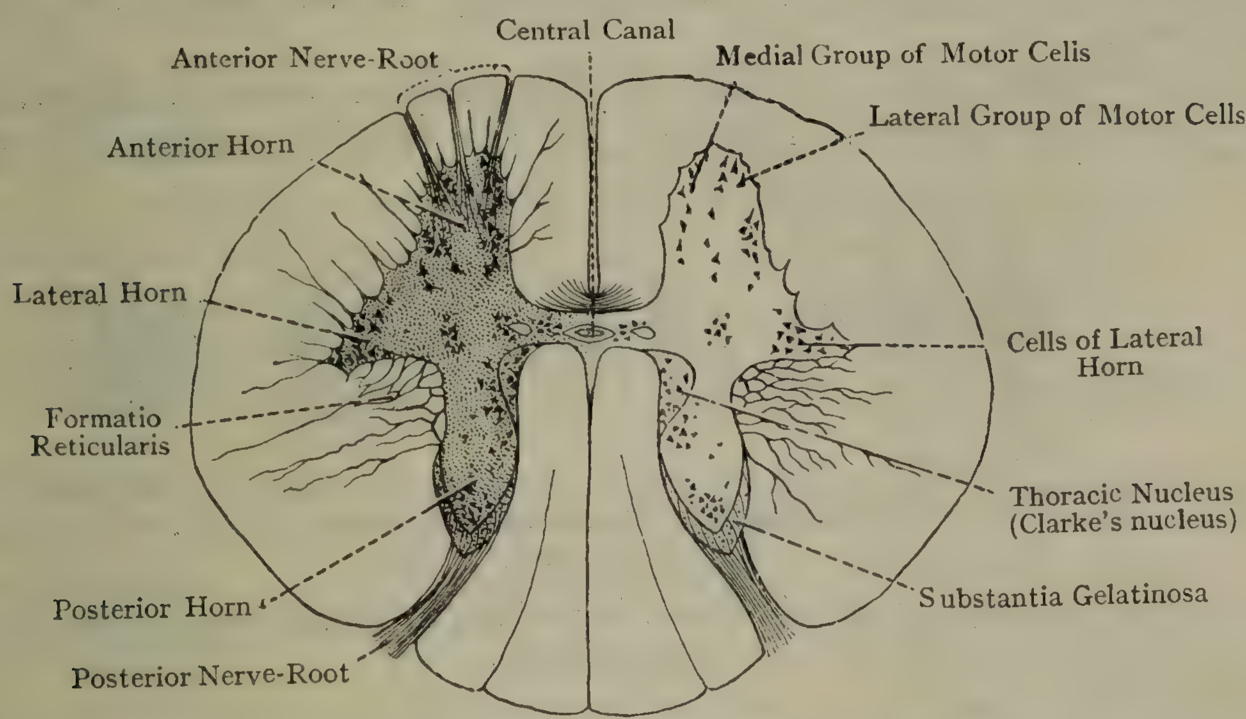
Posterior Surface.

1. Ganglion on each posterior nerve-root.
2. Arterial anastomotic chain behind and in front of the posterior nerve-roots.
3. Fasciculi of posterior nerve-roots lie in a straight line, and enter through postero-lateral sulcus.
4. Presence of a posterior median sulcus which cannot be opened.
5. Presence of gracile and cuneate fasciculi in upper part.

Internal Structure of the Spinal Cord.—The spinal cord, *as seen in transverse section*, consists of a central portion composed of grey matter, and an external portion composed of white matter.

Grey Matter.—This is arranged in the form of two irregular crescents, the concavities of which are directed outwards, and the convexities inwards, the latter being connected across the middle line by the grey commissure. The arrangement has been likened to the letter)–(. The **grey commissure** lies at the bottom of the posterior median sulcus, and presents about its centre the minute opening of the central canal of the cord. The part of the commissure in front of this canal is known as the *anterior grey commissure*, and the part behind as the *posterior grey commissure*. In front of the anterior grey commissure there is a transverse band of white matter, called the **anterior white**

ommissure, which lies at the bottom of the anterior median fissure. ach crescent of grey matter consists of two horns, anterior and osterior, the former being in front of, and the latter behind, the grey ommissure. The **anterior horn** is broad and blunt, and it stops short f the surface of the cord, being separated from the surface by white atter which is traversed by the fasciculi of the anterior nerve-roots. he blunt extremity of the anterior horn is called the *caput cornu,* and e portion adjoining the grey commissure, which is slightly constricted, called the *cervix cornu.* The **posterior horn** is for the most part ng, narrow, and tapering, and its pointed extremity almost reaches he surface of the cord at the bottom of the postero-lateral sulcus. his pointed extremity is called the *apex cornu,* and it contains a trans-icent substance, known as the **substantia gelatinosa** (of Rolando), hich forms the cap for the caput cornu posterioris. It contains a



IG. 866.—TRANSVERSE SECTION OF THE SPINAL CORD IN THE UPPER THORACIC REGION, SHOWING THE ARRANGEMENT OF THE GREY MATTER AND CELLS (SEMI-DIAGRAMMATIC) (AFTER POIRIER).

small amount of neuroglia, and numerous nerve-cells. The portion adjoining the grey commissure, which is slightly constricted, is called the *cervix cornu,* and the portion contiguous to the cervix, which is slightly enlarged, is called the *caput cornu.* The part between the two cornua is called the **body**.

About the centre of the concavity of the body crescent the grey matter projects into the lateral column in the form of processes arranged in a reticular manner and enclosing white matter. This network is called the **processus reticularis,** and it is most conspicuous in the cervical region. In the thoracic region, more particularly in its upper part, the grey matter of each crescent forms a triangular projection, which extends laterally for a short distance immediately in front of the processus reticularis, and adjacent to the junction of the anterior cornu with the grey commissure. This projection is known as the

lateral horn. When followed into the lower cervical and into the lumbar regions it blends with the anterior horn, the thickness of which it increases, but it is again present above the level of the fourth cervical vertebra.

The grey matter has been described, so far, as it would be seen on looking at transverse sections through the cord; under such conditions the use of the term 'horn' or 'cornu' is quite appropriate. As it exists in the complete cord, however, the grey matter is in the form of a continuous *column*, and in considering it in such a way it should be described as possessing anterior, posterior, and lateral 'columns,' rather than 'horns.'

The grey matter varies in amount in different parts of the cord. It is present in largest quantity in the lumbar enlargement, where the large nerve-trunks for the lower limbs arise, and next to this in the cervical enlargement, where the large nerve-trunks for the upper limbs arise.

The horns of the crescents of grey matter vary in shape, as seen on section, in different regions. In the cervical region the anterior

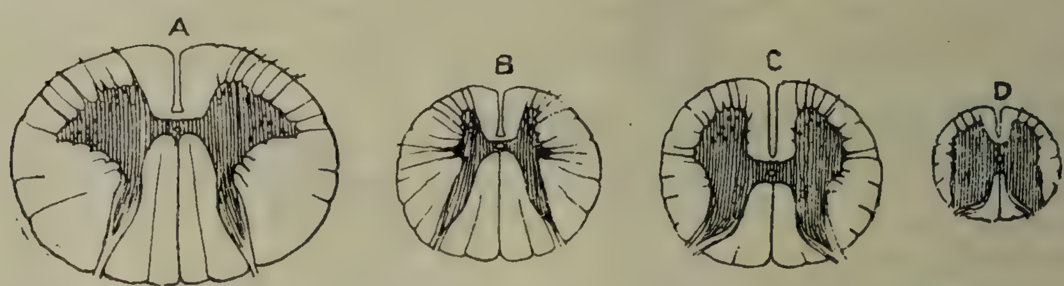


FIG. 867.—TRANSVERSE SECTIONS OF THE SPINAL CORD IN DIFFERENT REGIONS.

A, cervical region; B, mid-thoracic region; C, lumbar region; D, conus medullaris.

horns are short, broad, and blunt, and the posterior horns are long, narrow, and pointed. In the thoracic region both horns are narrow, though the posterior is more so than the anterior. In the lumbar region both are broad, though the anterior is more so than the posterior. These differences render sections of the spinal cord in the cervical, thoracic, and lumbar regions easily recognizable. As stated, the lateral horn is also a characteristic of the cord in the thoracic region, more particularly in its upper part.

Central Canal.—This minute canal is situated about the centre of the grey commissure, and extends throughout the entire length of the spinal cord. Superiorly it is continued into the lower half of the medulla oblongata, and it opens into the lower part of the fourth ventricle at the calamus scriptorius. Inferiorly, near the apex of the conus medullaris it becomes enlarged, and assumes the shape of an inverted ⊥. This enlargement is known as the **ventriculus terminalis.** From this point it is prolonged for some distance into the filum terminale, and it ends in a closed extremity. In the cervical and thoracic regions the central canal is nearer the anterior surface of the cord than the

sterior, but in the lumbar region it occupies the centre. In the nus medullaris it is near the posterior surface.

The canal is lined with ciliated columnar epithelium, the columnar lls being known as *ependymal cells*.

The central canal represents the lumen of the neural tube of ectoderm from ich the spinal cord is developed.

White Matter of the Spinal Cord.—The white matter forms the ter part of the cord, and is arranged in three columns—anterior, teral, and posterior. The **anterior column** is situated between the terior median fissure and the anterior horn of grey matter, and tends as far as the most lateral fasciculi of the anterior nerve-roots. therefore includes the superficial coating of the anterior horn, where is traversed, over an area of some breadth, by the scattered fasciculi the anterior nerve-roots. The **lateral column** is situated between the terior and posterior horns of grey matter, in the concavity of the escent. Its superficial limits are the most lateral fasciculi of the terior nerve-roots and the fasciculi of the posterior nerve-roots at e postero-lateral sulcus. The **posterior column** is situated between e posterior median sulcus and the posterior horn of grey matter, its perficial limit being the fasciculi of the posterior nerve-roots at the stero-lateral sulcus.

The white matter increases in quantity from below upwards, and pta of pia mater and neuroglia fibres pass into it at various points.

hief Distinguishing Characters of the Spinal Cord in Different Regions, as seen in Transverse Sections.

Cervical Region.	Thoracic Region.	Lumbar Region.
Transversely oval.	1. Circular.	1. Almost circular.
Anterior Horn, short, broad, and blunt. Posterior Horn, long, narrow, and tapering.	2. Anterior and Posterior Horns, both narrow, posterior more so than anterior.	2. Anterior and Posterior Horns, both broad, anterior more so than posterior.
Formatio Reticularis, well marked.	3. Formatio Reticularis, not very distinct.	3. Formatio Reticularis, absent.
Lateral Horn, merged into anterior, except above fourth cervical vertebra.	4. Lateral Horn, conspicuous, especially in upper part	4. Lateral Horn, merged into anterior.
White Matter, large in amount.	5. White Matter, less in amount, but large in proportion to Grey Matter.	5. White Matter, small in amount, and Grey Matter, large.
. Central Canal, nearer the ventral than the dorsal surface.	6. Central Canal, nearer the ventral than the dorsal surface.	6. Central Canal, in the centre.
. Postero - intermediate Sulcus and Septum of pia mater, well marked.	7. Postero - intermediate Sulcus, absent, but Septum of pia mater recognizable.	7. Postero - intermediate Sulcus and Septum of pia mater, absent.

Minute Structure of the Spinal Cord—Grey Matter.—The grey matter consists of nerve-cells, nerve-fibres, and neuroglia, and is very vascular.

The **nerve-cells** are present in great numbers, and are multipolar. Each cell sends off at various points several protoplasmic processes, one of which becomes the axis-cylinder of a nerve-fibre, and is called the *axis-cylinder process*, or *axon*. The other processes are known as the *protoplasmic processes* (*of Deiters*), or **dendrites,** and, after successive branchings, they terminate in free extremities. There are no anastomoses between the dendrites of the same cell, nor between those of contiguous cells. A multipolar nerve-cell, with its axon and dendrites, constitutes a **neuron.** The multipolar cells form longitudinal columns of various lengths, and, as seen in transverse sections of the cord, they are arranged in groups which occupy particular regions. These

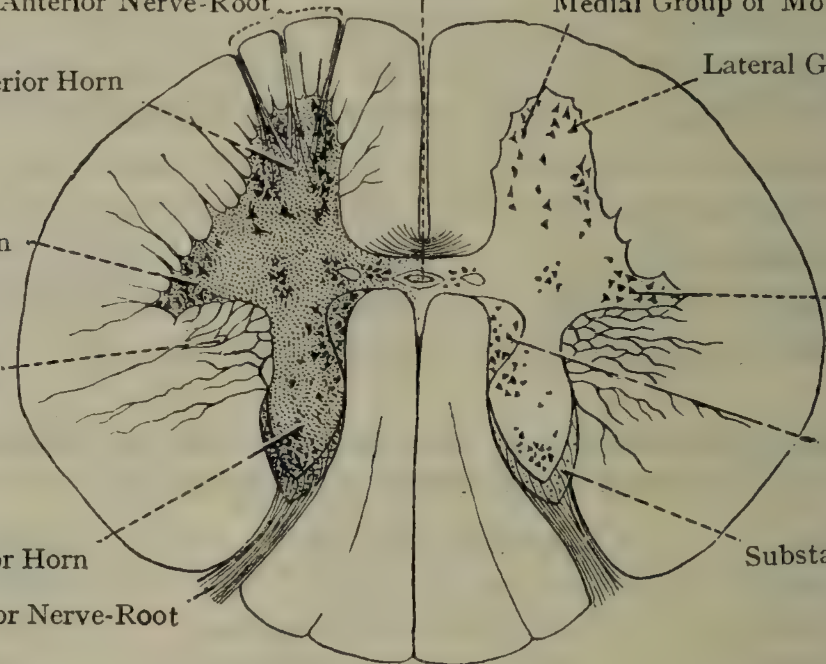


Fig. 868.—Transverse Section of the Spinal Cord in the Upper Thoracic Region, showing the Arrangement of the Grey Matter and Cells (Semi-diagrammatic) (after Poirier).

cell-columns or groups are three in number—namely, anterior or ventral, in the anterior horn of grey matter; lateral, in the lateral horn of grey matter; and posterior, constituting the **thoracic nucleus** (or posterior vesicular column of Lockhart Clarke), and being very conspicuous in the medial portion of the cervix of the posterior grey horn in the thoracic region. Besides these main columns or groups, other nerve-cells are present, which are scattered irregularly throughout the other portions of the grey matter.

The **anterior** or **ventral cell-column** is situated, as stated, in the anterior horn of grey matter, and extends throughout the whole length of the spinal cord. Its cells are of large size and very conspicuous, and their axons, which are at first non-medullated, become medullated, and then constitute the fasciculi which emerge to form the anterior nerve-roots. These cells are therefore the sources from which the

ferent or motor nerve-fibres proceed, and the ventral column is nsequently spoken of as the **motor column.** The ventral or motor lls of this column are arranged in two groups, medial and lateral. ne *medial group* occupies the medial part of the anterior grey horn, nd the *lateral group* is situated in its outer part. In the cervical and mbar enlargements of the cord the cells of the lateral group are very imerous, and are arranged in two sub-groups, ventro-lateral and orso-lateral.

The **intermedio-lateral cell-column** is situated, as stated, in the teral horn of grey matter, and the cells constitute a column known the **intermedio-lateral nucleus.**

The **thoracic cell-column** is situated in the medial part of the rvix of the dorsal cornu of grey matter. This extends throughout ne entire thoracic region of the cord, and for a short distance into ne cervical and lumbar enlargements. The cells make an elongated icleus (often termed **Clarke's column**), and are of large size. This olumn exists chiefly in the thoracic portion of the cord, whence the ame **thoracic nucleus.**

The cells of the grey matter differ as regards their axons, some having short, nd others long, axons.

The **cells with short axons** have their axons confined to the grey matter, which they ramify not far from the parent-cells. They serve to bring contigu- is cells into relation with one another.

The **cells with long axons** are partly *root-cells* and partly *association-cells,* nd their axons travel for some distance from the parent-cells. The axons of ne root-cells leave the cord in the fibres of the ventral or motor nerve-roots. he axons of the association-cells constitute *association-fibres,* which are dis- osed in two ways: (1) Some enter the white matter of the same side of the ord, in which they divide into ascending and descending branches. Eventually ney re-enter the grey matter, and terminate in arborizations at some distance om the parent-cells. (2) Other association-fibres cross to the opposite side the ventral or white commissure. Some of these end in arborizations around ne cells of the grey crescent, whilst others enter the white matter, in which ney are disposed as on the side from which they have crossed.

Destination of Axons of Cells of Grey Matter.

Cells of Ventral Horn.—(1) Many axons become the axis-cylinder processes f the efferent fibres of the ventral nerve-roots. (2) Other axons constitute ssociation-fibres, which cross to the opposite side in the ventral or white com- nissure. After crossing, some end in arborizations around the cells of the entral **horn;** others enter the white matter; and a few are regarded by some uthorities as entering the ventral nerve-roots of the side to which they have rossed.

Cells of Lateral Horn.—The axons of the cells of the intermedio-lateral nucleus ass to the efferent fibres of the ventral nerve-roots, and they are regarded as irnishing the *white rami communicantes* of the sympathetic system.

Cells of Dorsal Horn.—The axons of the cells of the dorsal horn have various irections: (1) Some pass to the ventral horn and ventral or white commissure. 2) The axons of the cells of the thoracic nucleus pass to the lateral column, and re usually regarded as entering the dorsal cerebellar and ventro-lateral cere- ellar tracts. (3) The axons of the cells of the substantia gelatinosa pass partly the lateral column, adjacent to the dorsal horn, where they divide into ascend- ig and descending branches, and partly into the posterior marginal bundle of

Lissauer. (4) The axons of other cells in the lateral part of the cervix of th dorsal horn pass to the lateral and ventral horns, the ventral or white commissure and the lateral column. (5) The axons of the cells of the caput cornu posteriori pass to the lateral column of the same side, and a few are regarded as passing to the opposite side in the ventral or white commissure.

Dorsal or Grey Commissure.—This commissure lies at the bottom of the dorsal median septum. It consists of (1) grey matter, con-taining a few small nerve-cells, and (2) medullated nerve-fibres. These fibres pass across from one side to the other, and later on diverge in each grey crescent. They serve as association fibres which bring the cells of opposite sides into relation with one another. This commissure contains the central canal of the cord, which for the most part is nearer the ventral portion of the commissure than the dorsal. The part of the commissure surrounding the central canal is called the *substantia gelatinosa centralis*. It consists of neuroglia, a few nerve-cells, and nerve-fibres; and it is invaded by processes derived from the deep ends of the ciliated columnar epithelial cells which line the central canal.

Summary of the Gelatinous Substances of the Grey Matter. — These are (1) The *substantia gelatinosa*, which forms a cap for the caput cornu posterioris, (2) the *substantia gelatinosa centralis*, which surrounds the central canal of the cord; and (3) the *substantia gelatinosa externa*, which forms the glial sheath of the cord beneath the pia mater.

White Matter.—The white matter of the cord consists of longi-tudinal medullated nerve-fibres, traversed by septa of the pia mater, and embedded in neuroglia. The fibres have no primitive sheath or neurilemma.

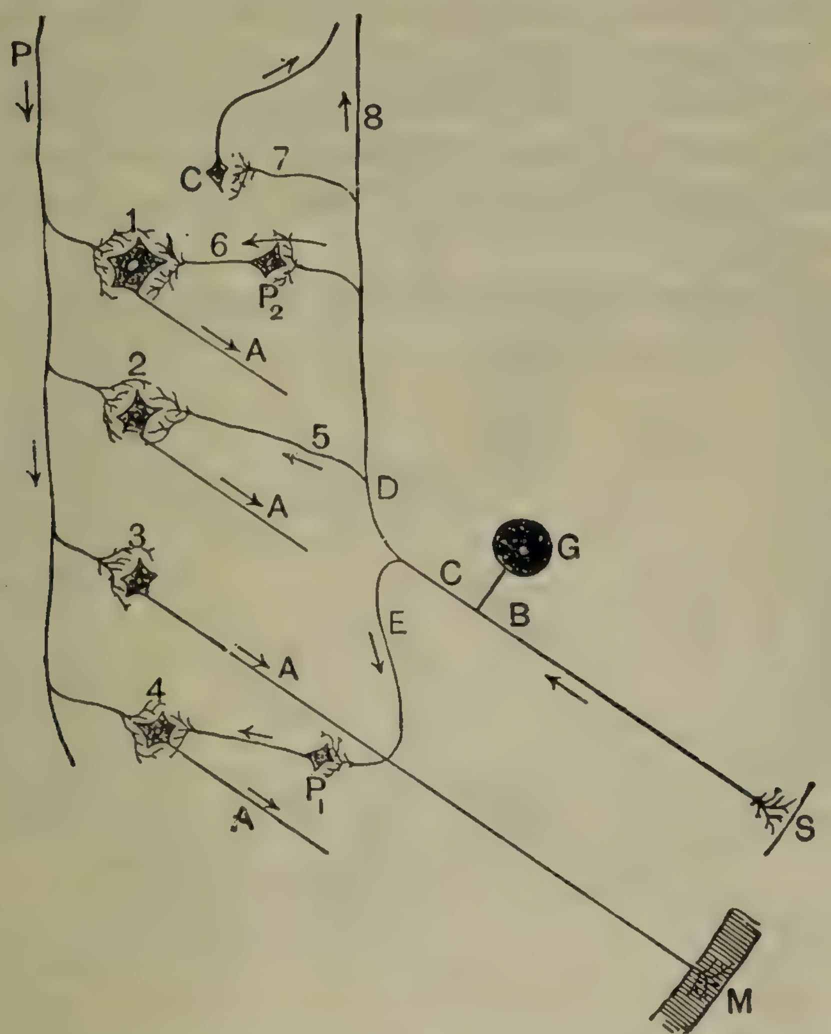
Ventral or White Commissure.—This commissure lies at the bottom of the ventral median fissure, and it is separated from the central canal of the cord by a part of the dorsal or grey commissure. It consists of medullated nerve-fibres, destitute of a neurilemma, some of which pass transversely, but most of them decussate, entering the com-missure ventrally on one side, and leaving it dorsally on the opposite side. The fibres, after crossing, enter the grey crescent and the ventral column. They are derived from (1) the anterior cerebro-spinal tract, (2) the processes of root-cells and of association cells, and (3) the fibres of the spino-thalamic tract, to be presently described.

Fibres of Roots of Spinal Nerves—Ventral or Anterior Nerve-Roots.—The fibres of the ventral nerve-roots arise *within* the cord from several sources. (1) Many of them are axons of the *medial cells* of the **ventral horn** of grey matter of the same side. (2) Some are axons of the *lateral cells* of the **ventral horn.** (3) Others are axons of the cells of the thoracic nucleus of the same side. (4) A few are axons of cells in the **dorsal horn** of grey matter of the same side. (5) A few are regarded as being axons of the *medial cells* of the ventral and inter-mediate grey matter of the *opposite side*, which cross in the ventral or white commissure. All the axons receive their medullary sheaths near the parent cells, and they form funiculi, which leave the white matter of the ventral column over an area corresponding to the *caput*

the ventral horn of grey matter, after which each fibre acquires its imitive sheath or neurilemma.

Most of the axons of the fibres of the ventral nerve-roots belong to the ntral (motor) cells of the ventral horn of grey matter of the same side.

Dorsal or Posterior Nerve-Roots.—The fibres of the dorsal nerve-ots arise from the unipolar (orginally bipolar) cells of the spinal nglia. The single pole or process of each of these cells is T-shaped. ne half of the horizontal limb of the T is *central,* and *enters* the cord



'IG. 869.—COURSE OF NERVE-FIBRES IN THE SPINAL CORD (FROM HALLIBURTON'S 'HANDBOOK OF PHYSIOLOGY' (AFTER SCHÄFER).

P. Cerebro-spinal Tract
1, 2, 3, 4. Anterior Cornual Cells
, A, A, A. Axons of Anterior Cornual Cells
M. Muscular Fibre
G. Unipolar Cell of a Spinal Ganglion, giving Origin to a Fibre of a Posterior Nerve-Root
B. Peripheral Branch of Fibre
S. Skin
(lower C) Central Branch of Fibre, passing into the Spinal Cord
. Descending Branch of Fibre in the Spinal Cord
D. Ascending Branch of Fibre in the Spinal Cord
P1, P2. Posterior Cornual Cells
C (upper C). Cell of Clarke's Column or Thoracic Nucleus
5. Collateral, passing directly to arborize around an Anterior Cornual Cell (2).
6. Collateral, with an Intermediate Cell-Station in a Posterior Cornual Cell (P_2).
7. Collateral, arborizing around a Cell of Clarke's Column (upper C).
8. Continuation of Main Ascending Branch of Fibre.

t the dorso-lateral sulcus between the dorsal and lateral columns of vhite matter. The other half of the horizontal limb is *peripheral,* and asses *outwards* in the course of the nerve.

Within the cord a few lateral fibres enter the marginal bundle of Lissauer, and the dorsal horn of grey matter, but most of them pass nto the *postero-lateral column* (Burdach) close to the dorsal horn of grey matter. Within this column the fibres divide into two branches—*ascending* and *descending.* The descending branches, after a short

course, enter the dorsal horn. These descending fibres are usually regarded as forming the 'comma tract.' The ascending branches are longer than the descending, and, at various levels, they also enter the dorsal horn. The ascending branches of the fibres of the dorsal roots of the lower spinal nerves enter the postero-medial column.

The ascending and descending branches give off numerous collateral fibrils, which enter the dorsal grey column. These collaterals have the following destinations: (1) The dorsal horn of the same side, and that of the opposite side through the dorsal or grey commissure; and (2) the ventral and lateral horns of the same side. In each case they come into close relation with the corresponding nerve-cells—*e.g.*, the cells of the dorsal horn, including the thoracic nucleus, the ventral or motor cells of the ventral horn, and the cells of the thoracic nucleus in the lateral horn.

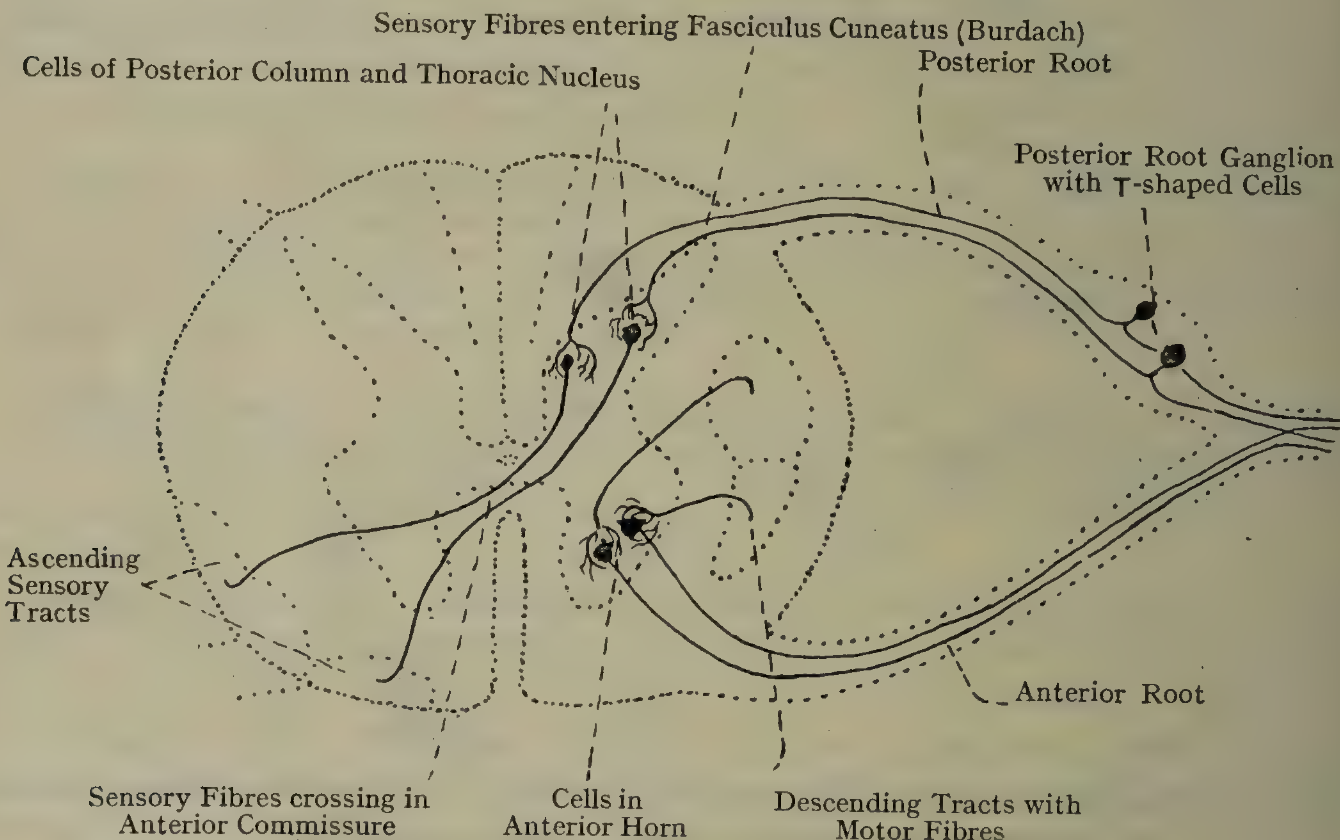


FIG. 870.—SIMPLE SCHEME OF FIBRES IN CORD.

Spinal Ganglia.—These are situated on the *posterior* roots of the spinal nerves in the intervertebral foramina, and outside the theca, though invested by a prolongation from it. Each ganglion is oval, and consists of unipolar nerve-cells. The single pole of each cell divides into two processes, one of which is *centripetal* and forms part of the posterior nerve-root, whilst the other is *centrifugal* and passes into the spinal nerve. The pole and its inward and outward processes resemble the letter T. In early life the cells are bipolar.

The fibres of the posterior nerve-roots have their deep origins in the unipolar cells of the spinal ganglia, and they *grow into* the spinal cord. On the other hand, the fibres of the anterior nerve-roots have their deep origins within the spinal cord, where they arise as the axons of the multipolar nerve-cells of the anterior column of grey matter, and they *grow outwards*.

Tracts of the Spinal Cord.

Posterior Column.—The tracts of this column are *ascending* and *scending*, and they are as follows:

Ascending Tracts.

Fasciculus gracilis (Fig. 871, 1).
Fasc. cuneatus (Fig. 871, 2).
Postero-lateral tract (of Lissauer) (Fig. 871, 3).

Descending Tracts

Semilunar (comma) tract (Fig. 871, 9).
Septo-marginal bundle (Fig. 871, 10).

Lissauer's tract also belongs to the lateral column.

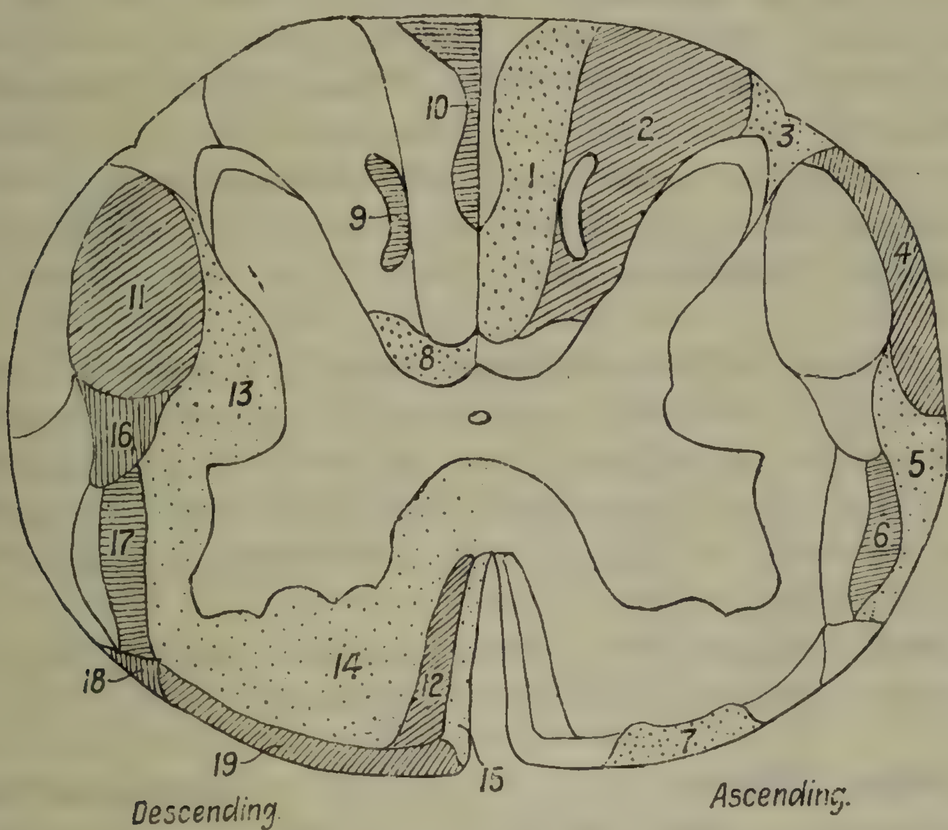


FIG. 871.—THE TRACTS OF THE SPINAL CORD.

ASCENDING.

:. Fasciculus gracilis (Goll's column).
:. Fasciculus cuneatus (Burdach's column).
. Fasciculus postero-lateralis (Lissauer's tract).
. Posterior spino-cerebellar fasciculus (Flechsig's tract).
5. Anterior spino-cerebellar fasciculus (Gower's tract).
5. Lateral spino-thalamic tract.
7. Anterior spino-thalamic tract.
3. Intersegmental tract (fasciculus proprius: ground bundle).

DESCENDING.

9. Semilunar (or comma) tract.
10. Septo-marginal bundle.
11. Lateral cerebro-spinal fasciculus (crossed pyramidal tract).
12. Anterior cerebro-spinal fasciculus (direct pyramidal tract).
13. Lateral intersegmental tract.
14. Anterior intersegmental tract.
15. Sulco-marginal tract.
16. Rubro-spinal tract (Monakow's bundle).
17. Tecto-spinal tract.
18. Olivo-spinal tract (Helweg's tract).
19. Vestibulo-spinal tract.

Ascending Tracts.—The **fasciculus gracilis (tract of Goll)** is situated ose to the posterior median septum. Its fibres are derived from the orsal roots of the coccygeal, sacral, lumbar, and lower thoracic nerves. hey are at first contained in the cuneate tract, but as they ascend ey are gradually displaced medially, and so form a special tract. he fibres terminate superiorly in connection with the cells of the *ucleus gracilis* of the medulla oblongata.

The **fasciculus cuneatus (tract of Burdach)** is situated on the lateral ide of the tract of Goll next to the dorsal horn of grey matter.

Above the mid-thoracic region it is separated from Goll's tract by the dorsal intermediate or paramedian furrow and a septum of pia mater. Its fibres are derived from the dorsal nerve-roots. Above the mid-thoracic region they are derived from the dorsal roots of the upper thoracic and cervical spinal nerves, and these fibres terminate superiorly in connection with the cells of the *nucleus cuneatus* of the medulla oblongata. Below the mid-thoracic region the fibres are derived from the lower dorsal nerve-roots, and these, being displaced inwards into the gracile tract, terminate in connection with the cells of the *nucleus gracilis*.

The **postero-lateral fasciculus** (**Lissauer's tract**) is close to the outer surface of the cord. It embraces the contiguous parts of the posterior and lateral columns, and occupies the region of the dorso-lateral sulcus where the funiculi of the dorsal nerve-roots enter the cord. It lies between the substantia gelatinosa and the surface of the cord. Its fibres are derived from the dorsal nerve-roots, and they ascend close to the *substantia gelatinosa*, in which they terminate at different levels.

Descending Tract.—The **semilunar tract** (comma) is situated in the cuneate fasciculus. Its fibres are usually regarded as being derived from the descending branches of the fibres of the dorsal nerve-roots, in which case they are *exogenous*. The other view, however, is that the fibres are *intrinsic* or *endogenous*, and spring from the cells of the dorsal cornu of grey matter.

Antero-lateral Column.—The tracts of this column are arranged into descending and ascending, and are as follows:

Descending Tracts.

1. Lateral cerebro-spinal (crossed pyramidal) tract (Fig. 871, 11).
2. Anterior cerebro-spinal (direct pyramidal) tract (Fig. 871, 12).
3. Intersegmental tract (Fig. 871, 13 and 14).
4. Rubro-spinal tract (Fig. 871, 16).
5. Vestibulo-spinal tract (Fig. 871, 19).
6. Olivo-spinal tract (Fig. 871, 18).
7. Tecto-spinal tract (Fig. 871, 17).

Ascending Tracts.

1. Dorsal spino-cerebellar tract (Fig. 871, 4).
2. Ventral spino-cerebellar tract (Fig. 871, 5).
3. Anterior spino-thalamic tract (Fig. 871, 7).
4. Lateral spino-thalamic tract (Fig. 871, 6).
5. Spino-tectal tract (Fig. 871, 6).

Descending Tracts.—The *crossed pyramidal* or **lateral cerebro-spinal tract** (*fasciculus spinalis lateralis*, Fig. 871, 11) is a long descending tract of large size, which is situated deeply in the dorsal part of the lateral column directly in front of the dorsal cornu of grey matter. It is separated from the outer surface of the cord by the dorsal spino-cerebellar (or direct cerebellar) tract. It diminishes in size as it descends, and in the lumbar region it becomes superficial. At about the level of the third sacral nerve it ends. The fibres of this tract have their origin in the pyramidal cells of the motor area of the cortex of the cerebral hemisphere of the *opposite side*. From this origin they descend through (1) the internal capsule of the corpus striatum, (2) the crus

erebri, and (3) the pons. On leaving the pons they enter the pyramid f the medulla oblongata on the side from which they have arisen. t the lower part of the pyramid they cross to the opposite side and ake up their position deeply in the dorsal part of the lateral column f the spinal cord. The fibres of the crossed pyramidal tract of one de therefore come from the cerebral hemisphere of the opposite side, nd they form the *inner* and *larger part* of the pyramid of the medulla blongata, also of the opposite side. As this tract descends, fibres ave it in each segment of the cord. These fibres enter the ventral orn of grey matter, and end in close relation with the ventral or notor cells, the axons of many of which form the axis-cylinder pro-esses of the fibres of the ventral or motor nerve-roots.

The *direct pyramidal* or **anterior cerebro-spinal tract** is of small size, nd is situated in the anterior column, where it lies close to the ventral nedian fissure. It diminishes in size as it descends, and usually erminates about the centre of the thoracic region, but fibres have been raced as low as the fourth sacral nerve. The fibres of this tract, like hose of the crossed pyramidal tract, have their origin in the pyramidal ells of the motor area of the cortex of the cerebral hemisphere, but in his case of the *same side*. The fibres of the direct pyramidal tract of ne side therefore come from the cerebral hemisphere of the same side. hey pursue a similar downward path as low as the pyramid of the nedulla oblongata of the same side, of which they form the *smaller art*. They take no part, however, in the decussation of the pyramids, s do the fibres of the crossed pyramidal tract. Their course is directly ownwards into the corresponding half of the spinal cord, where *most f them* take up their position in the anterior column close to the ventral nedian fissure. The fibres of the direct pyramidal tract, though they ake no part in the decussation of the pyramids, cross to the opposite ide at regular intervals as they descend in the anterior column of he cord. The crossing takes place in the ventral or white commissure, nd, having entered the ventral horn of grey matter of the opposite ide, the fibres end, like those of the crossed pyramidal tract of that ide, in close relation with the ventral or motor cells, the axons of nany of which pass to the ventral or motor nerve-roots.

Most of the pyramidal fibres therefore cross from the side on which hey arise to the opposite side. In the case of the crossed pyramidal ract the crossing takes place in the lower part of the medulla ob-ongata. In the case of the direct pyramidal tract the crossing takes lace in the ventral median fissure of the spinal cord along the course f the tract.

The **ground-bundle** or **intersegmental tracts** (*fasciculus proprius nterior*, Fig. 871, 14; *lateralis*, Fig. 871, 13; and *posterior*, Fig. 871, 8) ontain association fibres linking together various parts of the cord. he fasciculus proprius anterior is continued up into the medulla as he posterior longitudinal bundle, but the ground-bundles, as a whole, re regarded as descending tracts.

The **vestibulo-spinal tract** (*fasciculus vestibulo-spinalis*, Fig. 871,

19) is situated in the anterior column, where it lies superficially. It forms a communication between the vestibular structures, through Deiters' nucleus, with the motor cells of the cord.

The *prepyramidal* or **rubro-spinal tract** (Fig. 871, 16) is situated in the lateral column on the ventral aspect of the crossed pyramidal tract. Its fibres are chiefly derived from the *red nucleus* of the tegmentum or dorsal part of the crus cerebri of the *opposite side*, and they are regarded as terminating in the dorsal part of the ventral grey matter.

The **tecto-spinal tract** (*fasciculus tecto-spinalis*, Fig. 871, 17) runs from the superior corpus quadrigeminum of the opposite side to the motor cells, and lies in front of the rubro-spinal tract.

The *bulbo-spinal* or **olivo-spinal tract,** or *bundle of Helweg* (Fig. 871) 18), is confined to the cervical region of the cord, and is triangular. Its fibres are regarded as arising in the medulla oblongata behind the olive, but their mode of termination is not known. They lie near the surface of the cord external to the anterior nerve-roots.

Ascending Tracts.—The **dorsal spino-cerebellar tract,** or **direct cerebellar tract** (**of Flechsig**) (Fig. 871, 4), is situated in the lateral column. It lies in front of the dorso-lateral sulcus, between the crossed pyramidal tract and the outer surface of the cord. It commences in the lower part of the thoracic region, and superiorly it traverses the lower part of the medulla oblongata on its lateral aspect, after which it enters the restiform body, by which it is conducted to the *vermis* of the cerebellum. Its fibres are usually regarded as being derived from the *thoracic nucleus* or column of Clarke.

The **ventral spino-cerebellar tract,** or **tract of Gowers** (Fig. 871, 5), is situated chiefly in the lateral column, in front of the dorsal cerebellar tract, close to the outer surface of the cord. It is comma-shaped in section, its dorsal part being broad, but as it extends forwards between the funiculi of the ventral nerve-roots it tapers and enters the ventral column superficially. It begins near the lumbar region of the cord. Superiorly it extends through the medulla oblongata and pons, and afterwards passes along the superior cerebellar peduncle into the cerebellum, terminating in the *vermis*. It therefore takes an indirect course as compared with that of the dorsal spino-cerebellar tract. Its fibres are crossed and are usually regarded as being derived from the thoracic nucleus and posterior horn of the opposite side. The ventral spino-cerebellar tract contains the spino-thalamic and spino-tectal tracts.

The **spino-thalamic tract** (Fig. 871, 6) consists of fibres which arise as the axons of cells of the dorsal grey matter, around which cells the fibres of the dorsal nerve-roots have terminated. The spino-thalamic fibres cross to the opposite side in the ventral or white commissure, thus giving rise to a *spinal inferior sensory decussation* or *spino-thalamic decussation*, as distinguished from the *superior sensory decussation* in the bulb, called the *decussation of the fillets*, which is produced by the *deep arcuate fibres* which arise from the cells of the nucleus gracilis and

ucleus cuneatus. The spino-thalamic fibres, having crossed in the entral white commissure, ascend in the tract of Gowers, and after raversing the bulb and pons they terminate in the **optic thalamus** f the side to which they have crossed as a cell-station. It is important ɔ note that there are *two sensory decussations*—lower or spinal, and pper or bulbar. In unilateral lesions of the spinal cord there would nly be *partial* anæsthesia on the opposite side; whereas in unilateral esions of the bulb, involving both the fillet-fibres and the spino-thalamic bres, there would be *complete* anæsthesia on the opposite side.

The **spino-tectal tract** (Fig. 871, 6) is also an ascending tract. Its bres are connected with the cells of the ventral cornu of grey matter. 'hey ascend in conjunction with the ventral spino-cerebellar tract, and ass through the formatio reticularis of the bulb and pons. After nis they decussate with those of the opposite side, forming the *fountain ecussation (of Meynert)*, which lies between the two *red nuclei*, to 'hich nuclei the spino-tectal fibres furnish collaterals. After the ecussation the fibres of either side pass to the corresponding *superior olliculus* of the **corpora quadrigemina.**

The tracts of the antero-lateral column may be otherwise arranged s follows:

Ventral Column.	Lateral Column.
nterior cerebro-spinal tract (descending) (12).	Lateral cerebro-spinal tract (descending) (11).
nterior intersegmental (descending) (14).	Rubro-spinal tract (descending) (16).
ulco-marginal tract (descending) (15).	Tecto-spinal tract (descending) (17).
'estibulo-spinal tract (descending) (19).	Olivo-spinal tract (descending) (18).
nterior spino-thalamic tract (ascending) (7).	Dorsal cerebellar tract (ascending) (4).
	Anterior spino-cerebellar tract (Gowers, ascending) (5).
	Posterior spino-thalamic and spino-tectal tracts (ascending) (6).
	Lateral intersegmental (descending) (13).

The **spino-thalamic** and **spino-tectal tracts** (ascending) are contained ı the ventral spino-cerebellar tract. A part of the **postero-lateral asciculus** (Lissauer's tract) lies superficially in the dorsal part of the ıteral column, and it has been described in connection with the **dorsal olumn.**

Association Fibres of Antero-lateral Column—Intersegmental Fasciculi.—The art of the antero-lateral column which is not occupied by the descending and scending tracts is adjacent to the grey matter, and it constitutes the **antero-teral ground-bundle.** It is divided into two parts—anterior and lateral.

The **anterior intersegmental group** is situated in the ventral column in front the ventral cornu of grey matter, and has been already described.

The **lateral group** occupies the lateral column ventral and medial to the crossed yramidal tract.

The portion of the ventro-lateral ground-bundle adjacent to the grey matter, ıd almost surrounding it, is known as the *limiting zone.*

The fibres of the entire antero-lateral ground-bundle are *association* or *ngitudinal commissural* fibres, which serve to connect the grey matter of suc-

cessive segments of the spinal cord. They are derived from the cells of the gre matter of the same side, and also of the opposite side, the latter crossing in th ventral or white commissure.

Arteries of the Spinal Canal and Spinal Cord—Arteries of the Spina Canal.—These vessels enter the spinal canal through the intervertebra and sacral foramina. In the cervical region they are branches of th vertebral, deep cervical, and superior intercostal arteries; in th thoracic and lumbar regions they are derived from the dorsal branche of the intercostal lumbar and ilio-lumbar arteries; and in the sacra region they come from the lateral sacral arteries. Within the spina canal each **spinal artery** divides into three branches—neural or central and anterior and posterior parietal. The *neural* or *central branc* pierces the theca of the spinal cord. It supplies the coverings of th cord and the nerve-roots, and it anastomoses with the anterior an posterior spinal arteries on the cord. This branch is sometimes spoke of as the *lateral spinal artery*. The parietal branches divide and joi again with one another in such a way that they form five anastomoti chains in the spinal canal outside the dura mater; of these, one i antero-median, two antero-lateral, and two postero-lateral.

Arteries of the Spinal Cord.—These are: (1) the anterior spina artery; (2) the posterior spinal arteries, right and left; and (3) th lateral spinal arteries, right and left (neural or central branches jus described in connection with the spinal canal).

The **anterior spinal artery** is formed by the union of the *anterio spinal branches*, right and left, of the vertebral arteries. It descend along the front of the cord in the median line, and is reinforced a regular intervals by the lateral spinal arteries. In this manner a anterior longitudinal anastomotic chain is formed, which descend for some distance on the filum terminale.

The anterior spinal branches of the vertebral arteries are seldom of equa size, and often only one is present.

The **posterior spinal arteries** are two in number, right and left, an each is a branch of the corresponding vertebral artery. Each vesse descends on the side of the cord in two branches, one being in fron of and the other behind the posterior nerve-roots. These are reinforce by branches from the lateral spinal arteries, and the lateral longitudina anastomotic chains formed in this manner extend over the entire lengt of the cord. It will thus be seen that there are five anastomoti chains inside the dura mater in relation to the cord, though they hav not quite the same distribution as the extradural; one is antero-median and two on each side postero-lateral. Of these two, one lies in fron of and the other behind the posterior nerve-roots.

It is only under very favourable conditions that all these arteries ar injected equally.

Veins of the Spinal Column and Spinal Cord—Veins of the Spina Column.—These veins form two plexuses, extra- and intra-spinal, whic for convenience are divided into five groups from behind forward

) posterior extraspinal, (2) posterior intraspinal, (3) veins of the ertebral bodies, (4) anterior intraspinal, (5) anterior extraspinal.

The **dorsal spinous venous plexus** is situated deeply upon the super-cial surface of the neural arches of the vertebræ under cover of the ultifidus spinæ muscle. It receives its tributaries from the integu-ent and muscles of the back, and it communicates with the posterior ngitudinal intraspinal plexus by branches which pierce the ligamenta ava. In the neck the blood is conveyed away from the plexus by eins which open into the vertebral venous plexus around the vertebral tery of each side; in the thoracic region by veins which join the dorsal anches of the intercostal veins; and in the lumbar region by veins hich join the dorsal branches of the lumbar veins.

The **veins of the bodies of the vertebræ (venæ basis vertebræ)** are ntained within the cancellated tissue of the vertebral bodies. They mmunicate in front with the anterior extraspinal veins, and posteriorly ey terminate in two venous trunks which, emerging through the

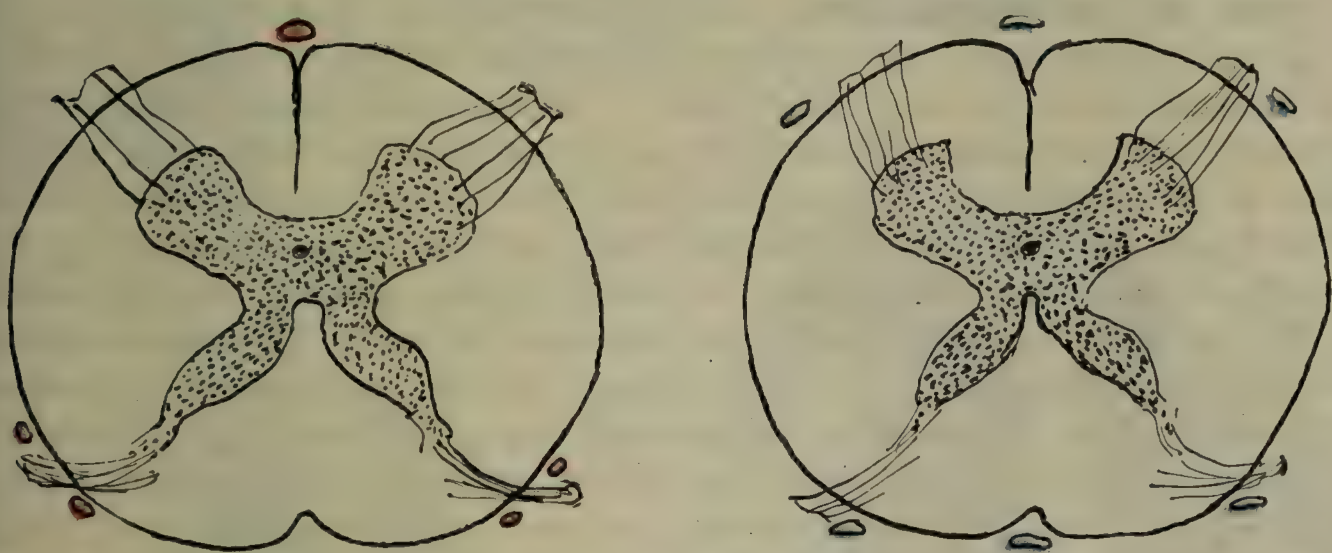


FIG. 872.—SCHEMATIC SECTIONS TO SHOW POSITIONS OF LONGITUDINAL ARTERIAL AND VENOUS CHANNELS.

vo foramina on the posterior surface of each vertebral body, open ito the transverse communicating branch between the two anterior ngitudinal intraspinal veins.

The **anterior longitudinal intraspinal veins** form two anastomotic hains, which are situated on the posterior surfaces of the bodies of he vertebræ, one on either side. They communicate with each other pposite the centre of each body by transverse branches which receive he terminal trunks of the venæ basis vertebræ. These transverse ranches pass between the posterior longitudinal ligament and the odies of the vertebræ. Superiorly the anterior intraspinal veins ommunicate with the vertebral and the transverse or basilar plexuses f veins, and laterally an offset passes outwards through each inter-ertebral foramen, which, with that of the posterior intraspinal vein, orms a plexus around the adjacent spinal nerve.

The **posterior longitudinal intraspinal veins** are situated in front of he laminæ, one on either side, and they are connected at frequent itervals by transverse branches. They communicate with the dorsal

spinous venous plexus by branches which pierce the ligamenta flava. Superiorly they communicate with the marginal sinuses on either side of the foramen magnum and vermiform fossa, which by their union form the occipital sinus. With the marginal sinuses and the anterior intraspinal veins they form a venous ring at the foramen magnum. Laterally each vein sends outwards through the corresponding intervertebral foramen an offset, which, with that of the anterior intraspinal vein, forms a plexus around the adjacent spinal nerve.

The anterior and posterior intraspinal veins are situated between the theca of dura mater and the wall of the spinal canal.

The **anterior extraspinal veins** form a plexus along the anterior aspect of the bodies of the vertebræ, which is most copious in the neck. On either side it communicates with the vertebral plexus around the vertebral artery in the neck, the intercostal veins in the thoracic region, and the lumbar veins in the lumbar region. It is also connected with the venæ basis vertebræ.

Veins of the Spinal Cord.—These vessels lie within the substance of the pia mater, and are disposed as venous chains, one being in front, one behind, and two on either side. The anterior vessel lies over the anterior median fissure beneath the anterior spinal artery; the posterior vessel is also medially placed; and the two lateral vessels are situated one in front of and the other behind the posterior nerve-roots (Fig. 872). Besides these principal chains the veins form a plexus on the surface of the cord. Laterally branches emerge through the intervertebral foramina, which, along with the offsets of the anterior and posterior intraspinal veins, form plexuses around the spinal nerves. From these plexuses the blood is conveyed on either side into the vertebral plexus and deep cervical vein in the neck, and into the intercostal and lumbar veins in the corresponding regions.

Lymphatics.—There are no lymphatic vessels in the spinal cord. Their place is taken by spaces in the outer coat of the arteries, called **perivascular spaces,** which are in communication with the subarachnoid space.

Development of the Spinal Cord.

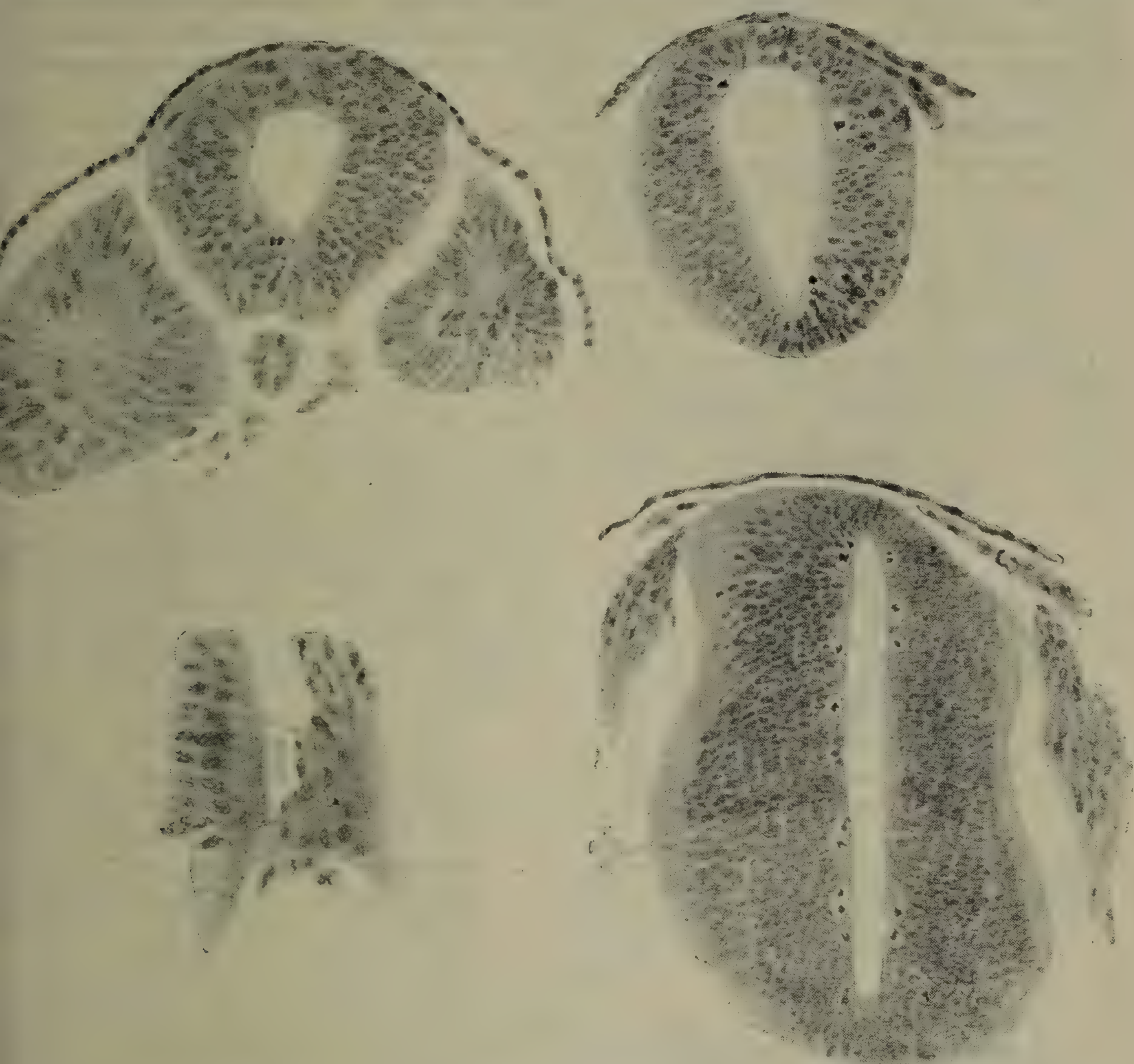
The formation of the neural tube from the neural plate and groove is described on pp. 34 and 39. A short general account of the formation of the cord from the tube, and of the spinal nerves, is given on p. 53. Further details are given in the following paragraphs.

The proliferating cells of the early neural tube become confluent and form a syncytium, which is evident in the growing cord to a comparatively late stage. Exhibiting this syncytial character, the ectodermic cells of the wall of the tube undergo proliferation, the wall becomes thickened, and it consists of two kinds of cells—namely, (1) sustentacular or supporting cells, and (2) nerve-cells proper. The former make the **ependyma** and **neuroglia** of the spinal cord, and the latter give rise to the **grey** and **white matter.** The loosely arranged syncytial network is known as the *myelospongium*. This myelospongium becomes condensed internally and externally, and these condensed layers form the *internal* and *external limiting membranes*. The wall of the young neural tube is arranged in three layers or zones—namely, (1) inner or ependymal, (2) intermediate or mantle zone, and (3) outer or marginal zone.

The **ependymal zone** consists of a single layer of elongated cells, connected

th the internal limiting membrane. Their bases are directed towards the nen of the neural tube, and from their apices delicate *radial fibres* pass out-rds to the external limiting membrane. Amongst them there are some con-cuous cells, called *germinal cells*. These lie close to the wall of the neural be, and by their proliferation they give rise to ependymal cells and neuroblasts. e latter migrate outwards into the mantle zone.

The **mantle layer** consists mainly of neuroblasts derived from the lining layer ependymal cells, but smaller **neuroglial cells** are scattered among these, and whole is supported by a network of spongioplasm, in which, in fact, the



G. 873.—Three Sections from Different Levels of Cord in Embryo of 4·9 Mm.

ft lower figure, under higher power, shows nerve-fibres leaving ventro-lateral wall.

clei may be said to be embedded. Neuroglial fibres develop from the neuro-al cells, and extend throughout the thickness of the cord, ramifying and joining hin the spongy basis.

The **marginal zone** is the peripheral and outlying part of the spongy net-rk, forming a definite layer superficial to the mantle zone. It is a region ich will be occupied by the tracts of nerve-fibres as these form, acting as scaffolding or support for them; it increases enormously in thickness as the asion by fibres progresses.

As just said, the *white matter* of the cord is made by nerve-fibres growing

in the marginal zone, the *grey matter* is formed from the mantle zone, and th ependymal layer, when it has ceased to proliferate and give off the cells of th mantle zone, becomes the lining cell layer of the *central canal.* The cana itself is the remains of the ventral part of the original cavity of the neural tube

Neuroglial cells have many branches, and are spoken of as *glia-cells* or *spide cells.* The **neuroglial fibres** are fibrillations of the peripheral protoplasm of th cells, from which they become differentiated.

The **neuroblasts** lie in groups within the mantle layer, and they give ris to the **nerve-cells** of the spinal cord. Each cell is primarily unipolar and pear shaped. It has a prominent nucleus, and the body is prolonged into a proces or pole, which represents the *axon* or *axis cylinder process* of a nerve-fibre. Sub sequently the pear shape is lost, due to the formation of secondary processes o dendrites, the cell being now multipolar.

Formation of the Cord.—The number of neuroblasts within the mantl zone increases rapidly, the multiplication being due to frequent division of th germinal cells in the ependymal zone.

The division of germinal cells is apparently very extensive and rapid There is doubt, however, as to further addition by division of the nucle within the mantle zone; if there is such division, it is probably amitotic as the occurrence of mitotic figures in this zone is very exceptional.

Whatever may be the origin of all the nuclei, they soon show a tendency t gather more particularly in dorsal and ventral thickenings on each side. Thu there occur longitudinal bulgings on eacl side, showing not only on the oute surface, but also markedly on the in ternal surface, making the prominence known as the **dorsal** (or **alar**) and **ventra** (or **basal**) **laminæ** (Fig. 874) which affec the form of the contained cavity. A interlaminar sulcus runs down the sid wall of the cavity between these tw laminæ.

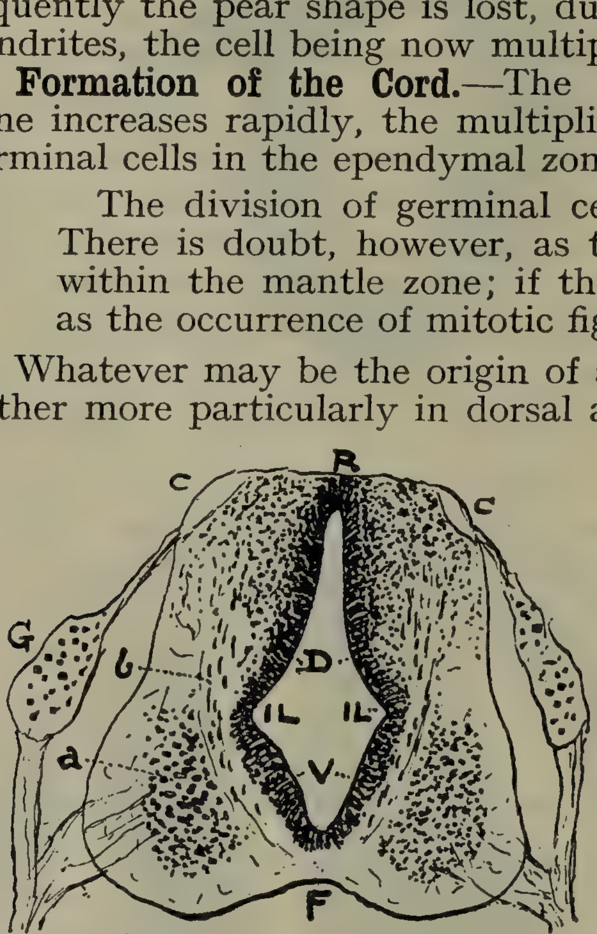


FIG. 874.—SECTION ACROSS CORD, SEMI-DIAGRAMMATIC, ABOUT END OF FIRST MONTH.

(Explanation in text.)

A semidiagrammatic sectio across the cord of an embryo a the end of the first month is give in Fig. 874 to illustrate thes points. The main collections o neuroblasts in the mantle zon make the ventral (V) and dorsa (D) laminæ, separated by th sulcus (IL). A floor-plate, (F) connects the two sides and is composed of a thinner ependymal layer with a fairly thick marginal zone; a roof plate (R) is practically only ependymal. The neural crest, described on p. 53, lies beside the tube on each side, and is represented here by a mass of neuroblasts which will become the posterior root ganglion (G); the interganglionic parts of the neural crest (p. 54) have disappeared by this time, leaving the ganglionic masses in position. Differential disposition of neuroblasts in the mantle zone has begun already.

General Formation.—The neuroblasts of the *basal lamina* make the cells of the *anterior grey column,* and the fibres of the afferent roots pass out directly from them. Those of the *dorsal lamina* are utilized in forming the matter of the *posterior grey column.* The spinal ganglia send nerve-fibres (posterior roots) into the dorsal region of the cord, the ganglia, as seen, being outside the cord from the beginning. The marginal zone carries fibres from the neuroblasts, and thus increases in depth gradually and continuously; in this way the *white matter* of the cord is laid down round the grey substance. The cavity, becoming relatively smaller, remains only as the *central canal;* there is some reason to think

ıat the dorsal portion of the original cavity is actively obliterated by fusion ɛtween its walls. The ependymal zone, after its germinal functions have ceased : the end of the second month, becomes the *ependymal lining of the canal.*

The **ventral lamina** differentiates ore quickly than the dorsal part, ıd can be described first. In Fig. ʼ4 it can be seen that a tract of ıclei (*b*) is present, having a distinct ɔrso-ventral direction and passing edial to the main ventral or ventro-teral neuroblastic mass (*a*). This tract comes early. Its appearance ggests at first a dorso-ventral igration, but such migration is rtainly not present, and the ar-ngement seems only due to the rection of early fibrils in this tract path, directed towards the floor-ate, where they cross to the other le.

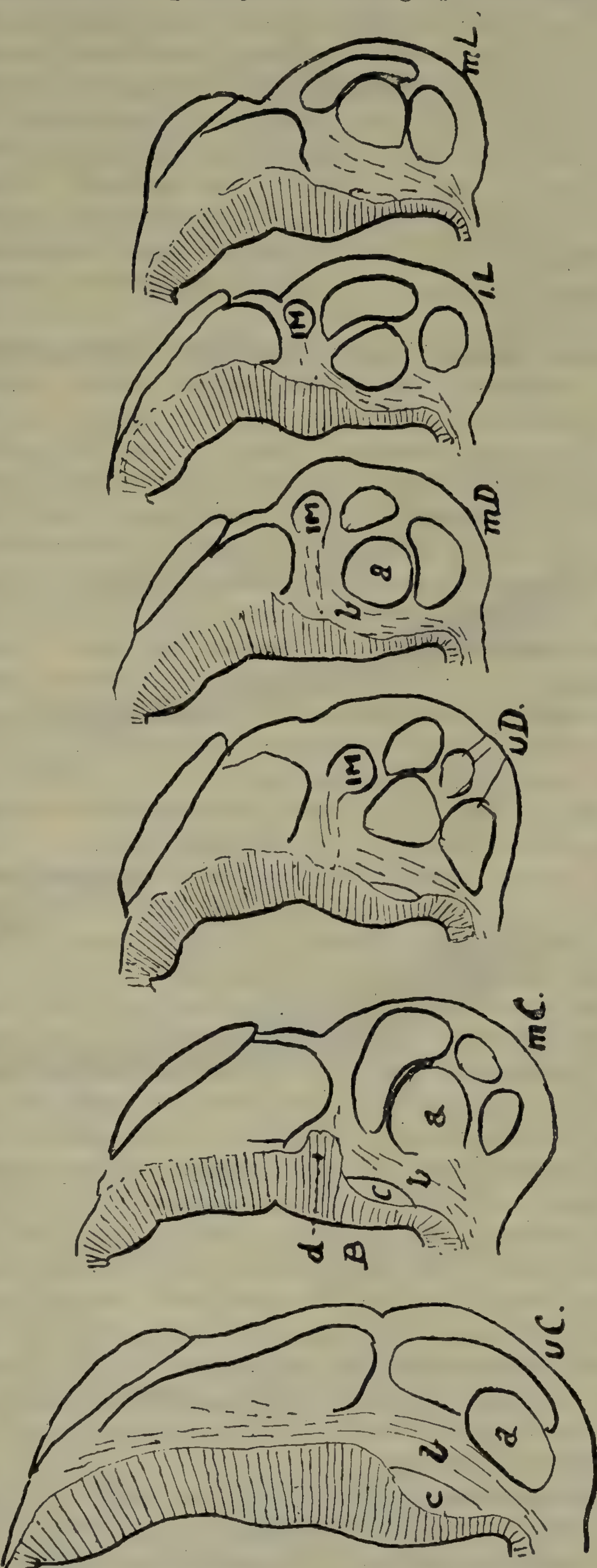


Fig. 875.—Tracings of Sections. (15 Mm.) (See text for description.)

This early indication of decussation is of interest. For some fundamental but not very evident reason, the passage of impulses—afferent or efferent—to the opposite side seems to be of basic importance, and a glimpse at the drawings given already will make it clear that the floor-plate is the decussating region; the roof-plate does not seem to provide the necessary marginal zone, and is in fact stretched into a transparent cellular layer higher up, so that the commissural fibres have only the floor-plate for their passage. So far, then, as the primary neural tube extends, all commissural fibres pass ventrally, and the tract *b* might even be spoken of as a ʻ lateral commissure path ʼ; such a name, however, would not take account of certain other characters, which might be summed up perhaps in a ʻ path of least resistance,ʼ so that, for instance, vessels tend to enlarge and lie in this path. Without labouring the matter further, it will be enough to direct attention to this ʻ path,ʼ to which reference will be made from time to time.

Grouping of Ventral Neuroblasts.—Fig. 875 gives tracings from different ʼels of the cord at 15 mm., showing the modifications found at this period the ventro-lateral group (*a* of Fig. 874). The groups are not so clearly marked, course, as indicated in the tracings, but are nevertheless quite evident; uC d mC are upper and middle cervical levels, uD and mD are upper and middle

thoracic, and iL and mL are first and middle lumbar levels. The ' commissura path ' already mentioned is shown at *b*, and the grouping of neuroblasts seems t correspond well with the condition in the adult cord; hence the arrangements i the ventral grey column appear to be attained at an early stage. The group *c*, i the cervical and upper thoracic sections, increases in size as it is traced upward It is composed of neuroblasts originating from the ependymal zone at the sam level of origin as the *a* group, but separated from this last collection by the pat *b*; this suggests that it might be looked on as of the same morphological value a the *a* group, but of later development. Whether this way of regarding it i justifiable or not, the group is responsible for supplying the hypoglossal nucleu and (possibly) that of the sixth nerve, while the *a* group, at the hypoglossal leve is apparently taken into the formation of the olive; this will be dealt with in th proper place.

Dorsal Lamina and Associated Formations.—The neuroblasts of the dorsa lamina increase and differentiate slowly, forming a massive but apparentl undifferentiated collection in the second month, when the ventral formation (Fig. 875) are evident. There is at first very little marginal zone over thi dorsal collection, but about the end of the first month the fibrils growing i from the ganglionic mass, beside the cord, begin to collect as a small bundl (C, Fig. 874) on the dorso-lateral aspect of the neuroblastic mass. This bundl is the earliest sign of the *posterior white column*, and increases rapidly in size, a the same time extending medially. The bundle is to be identified with th **cuneate fasciculus.** The medial extension no doubt helps to form the **gracil fasciculus,** but this may have some separate formation as well. The **postero lateral tract** (Lissauer's zone) begins to form a little later, as the entering fibre of the posterior root increase in number.

The method of elongation of the posterior horn is not clear; doubtless th increasing depth of the surrounding white columns has something to do with it but the other factors are not apparent.

The *deposition of fibrils* within the **marginal zone** to make the **white column** goes on, seemingly, throughout fœtal life; they can be recognized in the firs part of the second month at least, and perhaps earlier than this. It may b assumed that the shorter fibres are formed first, and occupy the marginal zon close to the neuroblasts; thus we get the short intersegmental fibres clothin the grey matter. The subsequently developed longer fibres are laid down o these short ones, and the latest developed would be the most superficial; thu we find long fibres reaching the mid-brain and thalamus, and superficial to these although mixed with them to some extent, fibres running to the cerebellum a later formation. This, in a general way, agrees with what is known about th position of such tracts in the cord.

The downward-running tracts doubtless follow a comparable regulation i their disposal, but the matter of decussation is important here. The cerebro-spinal fibres, for example, decussate for the most part immediately before entering the cord, and thus pass at once into the *b* path mentioned above; following this, they reach the space ventral to the posterior horn and Lissauer's tract, in which they lie as the **lateral cerebro-spinal** or *crossed pyramidal tract.* The uncrossed fibres ultimately cross and also enter the *b* path, from which they reach the anterior horn.

Myelinization.—The tracts are at first made up of **axis cylinders** alone, and these acquire **myelin sheaths** subsequently. The time when this occurs differs in the various tracts. The process begins about the fourth or fifth month in the *root* fibres, and after this appears in the tracts more or less in the order of their formation as laid down above. The *pyramidal* fibres do not begin to develop their sheaths till about the time of birth, and the process is said to continue until after puberty.

Caudal End of Spinal Cord.—This undergoes certain modifications. It can be seen in Fig. 877 that a tail process, bent dorsally, represents the atrophied remnant, in the early part of the second month, of the large ' tail ' of younger stages. This tail process contains a prolongation from the neural tube; it

emains up to about the 18 mm. stage, when the atrophied filament vanishes, arrying with it the included neural prolongation. Fig. 876 shows two median ongitudinal sections of the end of the cord in embryos of 16 and 35 mm. re- pectively, the tail remnant being present in the younger specimen, although ıst about to disappear. The neural cell-layers in this remnant are continued ıto a canal (*c*), the walls of which are continuous with the ependymal layers f the cord. A second canal (*vc*) is seen on its ventral side, the cavity of which pens into the central cavity of the cord (the continuity is not very clear in ıedian section). The central cavity of the cord ends in a dilated *ventricle*, hich seems to be a normal condition at this stage. That part of the neural ıbe which corresponds with the *quondam* tail is evidently disappearing, shows regular growth, and is represented by remnants.

In the 35 mm. embryo the tail has gone, and the caudal neural remnant shows coccygeal **vestigial cyst** (*cyst*) where the caudal portion has separated, the

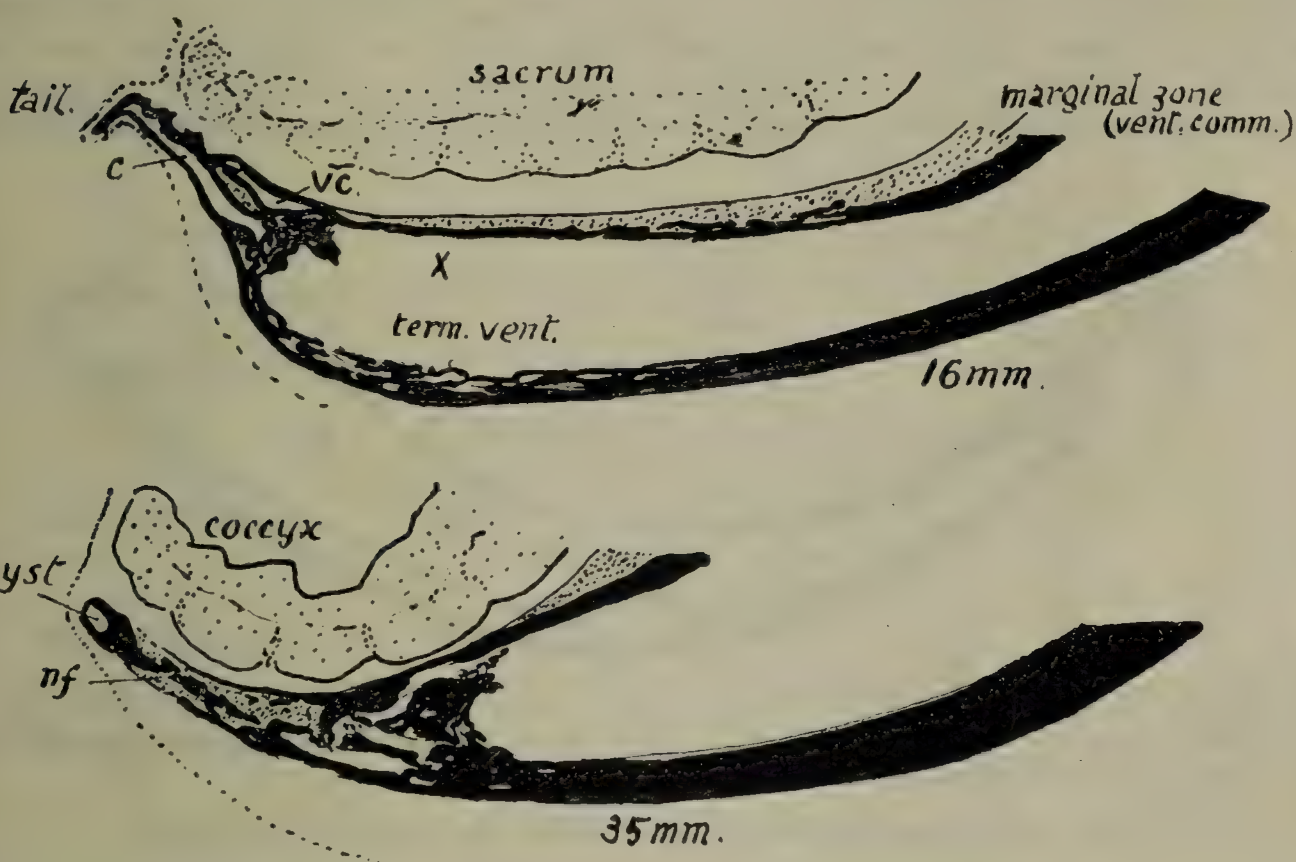


FIG. 876.—MEDIAN SAGITTAL SECTIONS OF ENDS OF CORDS IN SIXTH AND NINTH WEEKS.

Ependymal tissue shown in black. Description in text.

yst lying very near the surface. Some nerve-fibres have developed in connection ith this (*nf*) and pass to the cord itself. Remnants of this canal are seen ırther forward, and the ventral canal is seen opening into the ventral part of ıe terminal ventricle, as in the younger stage.

After this stage the cord does not grow in length at the same rate as the ertebral column, so that its caudal end gets farther and farther away from the occygeal region. Hence, the vestigial cyst remaining *in situ* with a superficial ttachment, the intervening cell-strands are drawn out in a lengthening con- ection. The main cell masses caudal to the ventricle are drawn up with it, ıaking the nervous elements found in the upper end of the *filum terminale*; ıe rest of the filum is composed of *drawn-out pia mater*, the included and retched nerve-tissue having disappeared.

The coccygeal vestigial cyst enlarges somewhat and develops nerve-tissue ound it, but disappears during the later fœtal months; it is a possible cause, y persistence, of certain congenital cysts found near the coccyx.

Membranes of Spinal Cord.—The membranes—namely, pia mater, arachnoic and dura mater (theca)—are developed from the mesoderm which invests th neural tube.

Growth of Spinal Cord.—The cord originally occupies the entire length o the spinal canal of the vertebral column. The vertebral column, however grows more rapidly than the cord, so that at the period of birth the cord does no extend lower than the level of the third or fourth lumbar vertebra. Sub sequently its lower limit is the intervertebral disc between the bodies of th first and second lumbar vertebræ. This produces a change in the course o the lumbar, sacral, and coccygeal nerves. In order to reach the level of th intervertebral foramina through which they emerge from the spinal cana they descend almost vertically, and constitute the bundles of nerves known a the cauda equina.

A linear reconstruction of the **coccygeal** portion of the cord in a 15 mm embryo is given in Fig. 877. It shows the atrophying tail-remnant, with it included piece of neural tissue, but also shows, proximal to this, a portion o nerve-tube truly coccygeal in nature and position, from which take origin four (? or more) nerves behind the coccygeal nerve. These *post-coccygea nerves*, which have double roots, join with each other and with the coccygea

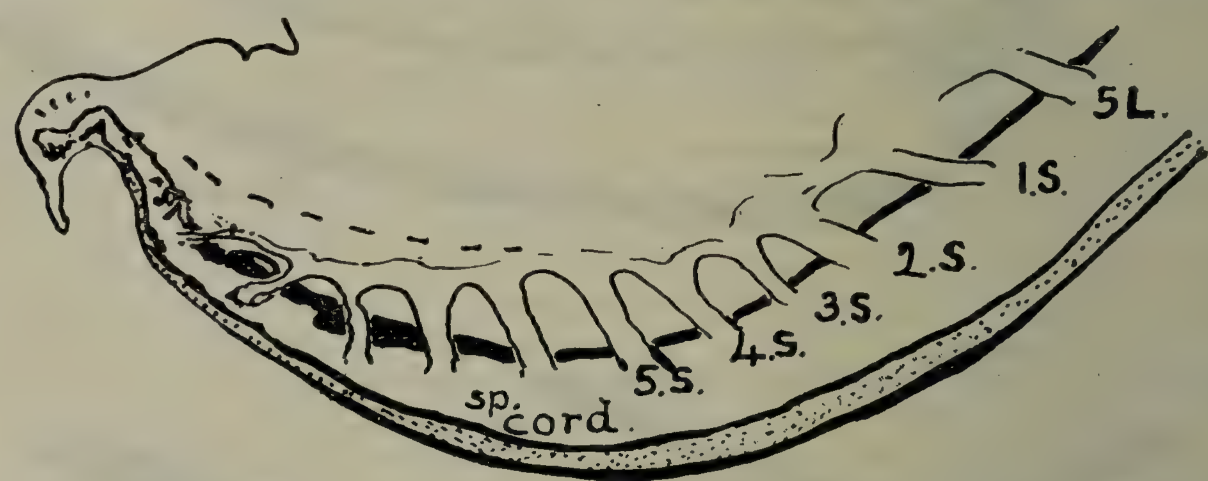


FIG. 877.—LINEAR RECONSTRUCTION OF CAUDAL END (15 MM.), SHOWING THE PROLONGATION OF CORD INTO THE TAIL FILAMENT, AND THE PRESENCE OF FOUR NERVES BEYOND THE COCCYGEAL.

The vertebral levels of the spinal nerves are indicated.

nerve in a series of ill-defined loops. They emerge between the rudimentary vertebræ caudal to the sacrum. The broken-up post-coccygeal portion of the cord is in part carried up with the persisting coccygeal portion, and in par left behind; the intermediate part is drawn out with the filum terminale. Som nervous matter still persists at the upper end of this structure. The post coccygeal nerves atrophy and disappear, but Rauber has described remains of ganglia and nerves beside the upper part of the filum, which may repre sent remnants of the upper post-coccygeal nerves, drawn up with the cord.

THE ENCEPHALON.

The encephalon is the part of the cerebro-spinal axis which is contained within the cranial cavity. It is composed of the medulla oblongata, pons Varolii, cerebellum, and cerebrum. In the embryo it consists of three hollow vesicles.

$$\textbf{Encephalon} = \begin{cases} \textbf{Prosencephalon} \text{ or Fore-brain.} \\ \textbf{Mesencephalon} \text{ or Mid-brain.} \\ \textbf{Rhombencephalon} \text{ or Hind-brain.} \end{cases}$$

The subdivisions of the prosencephalon are the telencephalon and he thalamencephalon or diencephalon; the mesencephalon remains ındivided; and the subdivisions of the rhombencephalon are the met-ncephalon and the myelencephalon.

Fore-brain or **Prosencephalon**	=	**Telencephalon.** **Thalamencephalon** or **Diencephalon.**
Mid-brain or **Mesencephalon**	=	**Mesencephalon.**
Hind-brain or **Rhombencephalon**	=	**Metencephalon.** **Myelencephalon.**

Che various parts of the encephalon which are developed from these ubdivisions will be made evident from the following table:

Telencephalon	=	Cerebral Hemispheres. Lateral Ventricles. Anterior Part of Third Ventricle. Interventricular Foramina. Olfactory Lobes.
Thalamencephalon or **Diencephalon**	=	Posterior Part of Third Ventricle. Optic Thalami and Corpora Geniculata. Pineal Body. Interpeduncular Structures. Pituitary Body. Optic Nerve and Retina.
Mesencephalon	=	Corpora Quadrigemina. Crura Cerebri. Aqueduct (of Sylvius).
Metencephalon	=	Cerebellum. Pons (Varolii). Pontine Part of the Fourth Ventricle.
Myelencephalon	=	Medulla Oblongata (or Bulb). Bulbar Part of Fourth Ventricle.

General Description of the Base and Superior Surface of the Encephalon.

The inferior aspect of the encephalon is known as the **base.** In the following general description of the parts which it presents the order pursued is, as nearly as possible, from behind forwards and upwards.

The **medulla oblongata** (or **bulb**) lies on the under aspect of the cerebellum in the median line, occupying the vallecula which separates the two cerebellar hemispheres. The surface exposed is the ventral surface, which presents (1) the anterior median sulcus, crossed at its lower part by the decussation of the pyramids; (2) the pyramid, on either side of this sulcus; and (3) the olivary body, external to each pyramid.

The **hemispheres of the cerebellum** lie one on either side of the medulla oblongata, and they conceal from view the posterior parts of the cerebral hemispheres and the posterior part of the great longitudinal fissure. They are characterized by the laminated arrangement of their nervous matter, the laminæ being curved and separated from

each other by fissures. Posteriorly the hemispheres are separated fror each other by the posterior notch. When the medulla oblongata i raised, and the cerebellar hemispheres slightly separated from each other the **vallecula** is fully exposed, and the **inferior vermis** is seen lyin deeply in it, with the *sulcus valleculæ* on either side of it.

The **pons** (**pons Varolii**) forms a prominent elevation above th medulla oblongata, the surface exposed being the ventral surface. I the median line this surface presents a longitudinal groove, which i

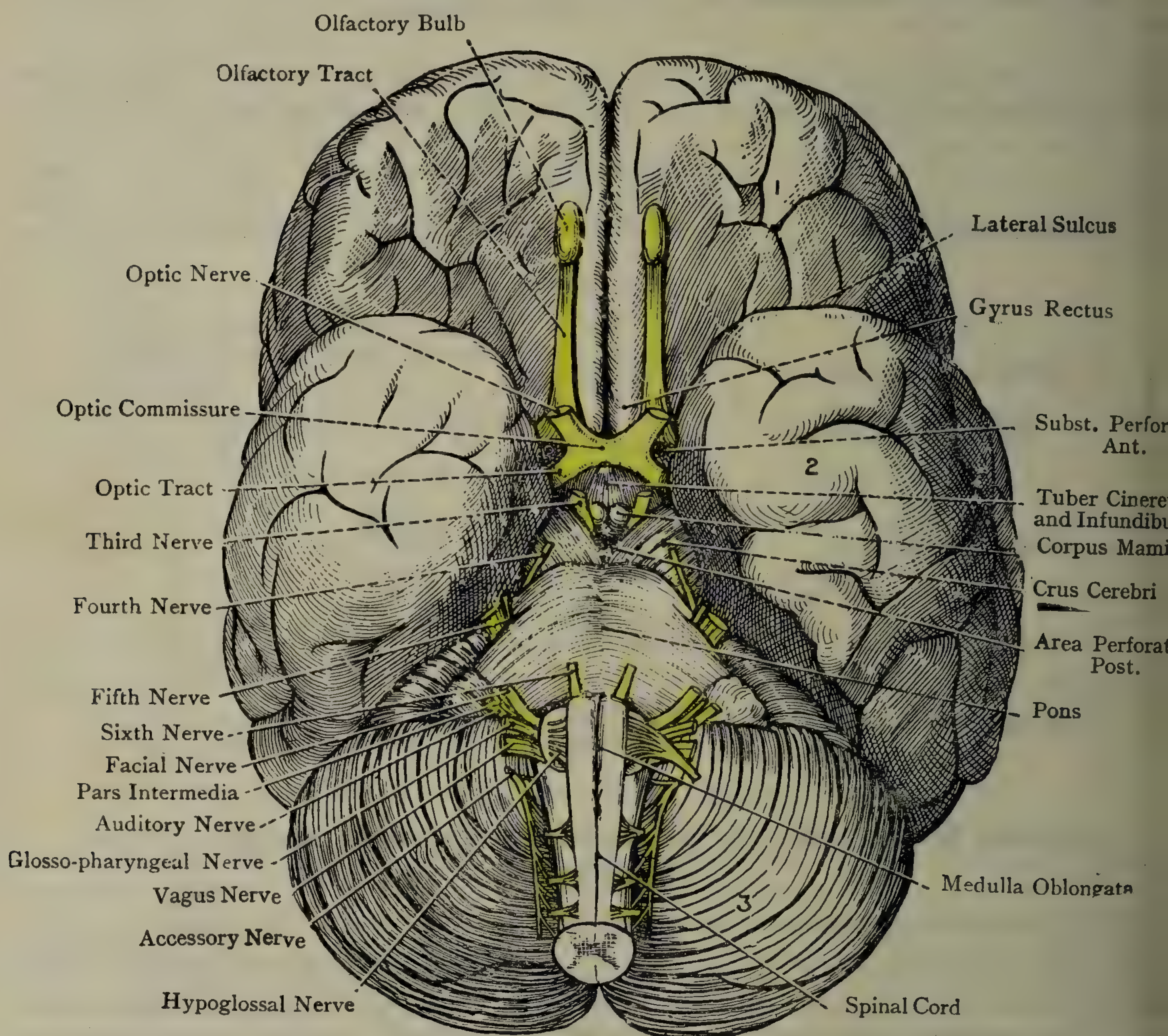


FIG. 878.—THE BASE OF THE ENCEPHALON, AND THE CRANIAL NERVES. 1, frontal lobe (orbital surface); 2, temporal lobe; 3, cerebellum.

occupied by the basilar artery. On either side the pons becomes the **middle peduncle of the cerebellum,** passing outwards and backward into the cerebellar hemisphere.

The **temporal lobes of the cerebrum** are situated in front of the cerebellar hemispheres, and are conspicuous by their prominence Each terminates anteriorly in a projecting extremity, called the **temporal pole.**

The **stem** of the **lateral sulcus** lies immediately in front of the

emporal lobe, and is occupied by the middle cerebral artery. At the ıner end of the stem of the fissure is the depression often referred to s the *vallecula Sylvii* or *vallecula cerebri.*

The **frontal lobes of the cerebrum** lie in front of the stem of the teral fissure. The exposed parts are the orbital surfaces, each of hich is separated from its fellow of the opposite side by the great ngitudinal fissure. Each orbital surface presents a straight fissure, alled the **olfactory sulcus,** which is situated near the great longitudinal ssure, and is parallel to it. This sulcus is occupied by the **olfactory act** and **olfactory bulb.**

The **crura cerebri,** or **peduncles,** right and left, appear at the upper order of the pons, and soon diverge from each other as they pass rwards and upwards to sink into the cerebral hemispheres.

The **optic tract** of each side winds round the outer and ventral spects of the corresponding crus cerebri. Its course is forwards and ıwards towards its fellow of the opposite side.

The **optic commissure,** or **chiasma,** connects the two optic tracts fter their convergence.

The **optic nerves,** right and left, leave the front of the commissure, nd pass forwards and outwards to the optic foramina.

The **interpeduncular space** is situated in front of and above the ons. It is somewhat diamond-shaped, and its boundaries are as ollows: posteriorly, the divergence of the crura at the upper border f the pons; anteriorly, the optic commissure; and, laterally, the crus erebri and optic tract from behind forwards. The following parts e within this space, in the order named, from behind forwards: (1) the rea perforata posterior; (2) the corpora albicantia or mamillaria; nd (3) the tuber cinereum, with the infundibulum. The structures ccupying the interpeduncular space form for the most part the *floor f the third ventricle.*

The **area perforata posterior** or **posterior perforated substance** orresponds to the posterior median angle of the diamond-shaped interpeduncular space, and it lies in a deep depression, called the **interpeduncular fossa** (or *fossa Tarini*). The grey matter which forms it is erforated by openings for the passage of the postero-medial branches f the posterior cerebral arteries.

The **corpora mamillaria** are situated directly in front of the area erforata posterior, and present the appearance of small, white, peake bodies lying close to the median line.

The **tuber cinereum** extends from the mammillary bodies to the ptic commissure, and is composed of grey matter. The **infundibulum** connected with the tuber cinereum close behind the optic comissure, and passes downwards to the posterior part of the pituitary ody.

The **area perforata anterior** or **anterior perforated substance** of each de coincides with the vallecula at the inner end of the stem of the teral fissure. It lies outside the interpeduncular space, close to the uter aspect of the optic commissure. It consists of grey matter, which

is perforated by openings for the passage of a few antero-medial branches of the anterior cerebral artery, and numerous antero-lateral branches of the middle cerebral artery. These branches are destined for the nucleus caudatus and nucleus lenticularis of the corpus striatum, the grey matter of which nuclei comes to the surface of the brain at the anterior perforated substance.

The medulla oblongata and pons occupy the basilar groove of the interior of the base of the skull; the cerebellar hemispheres occupy the cerebellar fossæ of the occipital bone; the temporal lobes of the cerebrum sink deeply into the lateral divisions of the middle fossa of the base of the skull; the orbital surfaces of the frontal lobes occupy the lateral divisions of the anterior fossa; the stem of the lateral fissure faces the posterior border of the small wing of the sphenoid; the optic commissure lies above the olivary eminence and optic groove of the sphenoid; and the olfactory bulb rests upon one half of the cribriform plate of the ethmoid bone. The **olfactory bulb** and **olfactory tract,** essential parts of the brain, occupy the olfactory sulcus on the orbital surface of the frontal lobe near the great longitudinal fissure; and the olfactory filaments pass through the foramina of the cribriform plate of the ethmoid bone on their way from the olfactory cells of the olfactory mucous membrane to the olfactory bulb. Posteriorly the olfactory tract divides into two roots, medial and lateral. The *medial root* curves inwards behind the ' area of Broca ' to the callosal gyrus. The *lateral root* passes backwards and laterally across the outer part of the area perforata anterior. The triangular area of grey matter, which is situated between the diverging roots of the olfactory tract, is called the *trigonum olfactorium.* It is sometimes spoken of as the *middle* or *grey root* of the olfactory tract. The **area of Broca** is situated in front of the medial (inner) root of the olfactory tract, and is continuous with the callosal gyrus.

Superficial Origins of the Cranial Nerves.

The **first** or **olfactory nerve** is represented by the filaments which, as has been seen already, have their superficial origin from the lower surfaces of the olfactory bulbs and pass through the cribriform plate.

The **second** or **optic nerve** is connected with the lateral extremity of the front part of the optic commissure.

The **third** or **oculo-motor nerve** emerges through the oculo-motor sulcus on the inner aspect of the crus cerebri, just above or in front of the pons, and close to the posterior perforated substance.

The **fourth** or **trochlear nerve,** having emerged from the upper part of the superior medullary velum, makes its appearance in the interval between the crus cerebri internally and the temporal lobe externally.

The **fifth** or **trigeminal nerve** consists of two roots, which emerge close together from the lateral aspect of the ventral surface of the pons. The *sensory* root is large, and the *motor* root, which is small, lies above and slightly medial to the sensory root.

The **sixth** or **abducent nerve** appears at the lower border of the pons ust lateral to the pyramid of the medulla oblongata.

The **seventh** or **facial nerve** emerges at the lower border of the pons n front of the restiform body of the medulla oblongata.

The **eighth** or **auditory nerve** likewise appears at the lower border of he pons in front of the restiform body of the medulla oblongata. It lies on the outer side of the facial nerve.

The *N. intermedius* is a small nerve which appears between the facial and auditory nerves. It is regarded as the **sensory root** of the facial nerve.

The **ninth** or **glosso-pharyngeal nerve** emerges, in the form of about six fasciculi, from the postero-lateral sulcus of the medulla oblongata, between the olivary body and the restiform body, immediately below the facial nerve.

The **tenth** or **vagus nerve** lies directly below the glosso-pharyngeal nerve, and emerges by several fasciculi from the postero-lateral sulcus of the medulla oblongata in front of the restiform body.

The **eleventh** or **accessory nerve** has several roots which lie below the fasciculi of the vagus nerve. These rise (*a*) from the medulla oblongata and (*b*) the upper part of the lateral column of the spinal cord as low as the level of the fifth cervical nerve. The first is the *cranial* origin of the nerve, the second its *spinal* root. They lie below the fasciculi of the vagus nerve, and external to, or in front of, the posterior roots of the adjacent cervical spinal nerves.

The **twelfth** or **hypoglossal nerve** emerges by several fasciculi through the antero-lateral sulcus of the medulla oblongata between the pyramid and the olivary body. These fasciculi lie in line with the sixth nerve superiorly.

Arteries at the Base of the Encephalon.—The arteries which supply the brain are the two vertebral and the two internal carotid arteries.

The **vertebral arteries** incline medially as they ascend on the ventral aspect of the medulla oblongata, and at the lower border of the pons they unite to form the basilar artery. The branches of each vertebral artery to be noted are as follows: (1) the *posterior spinal branch*, which arises from the main vessel immediately after it has pierced the dura mater, and descends upon the side of the medulla oblongata to the spinal cord; (2) the *anterior spinal branch*, which arises higher up than the preceding, and passes downwards and inwards on the ventral aspect of the medulla oblongata to unite with its fellow and form the *anterior spinal artery*; and (3) the *posterior inferior cerebellar branch*, of large size, which arises from the main vessel near the pons, and passes backwards round the medulla oblongata to enter the vallecula of the cerebellum.

The **basilar artery** extends from the lower border of the pons to the upper border, occupying the basilar groove on its ventral surface. It is formed by the union of the two vertebral arteries, and terminates by dividing into the two posterior cerebral arteries. The branches of the basilar artery to be noted on either side are as follows: (1) the

transverse arteries of the pons; (2) the *internal auditory artery*, which accompanies the auditory nerve through the meatus auditorius internus; (3) the *anterior inferior cerebellar artery*, which arises from the basilar about its centre, and passes backwards to the inferior surface of the cerebellar hemisphere; (4) the *superior cerebellar artery*, which arises from the basilar near its termination, and passes laterally close to the

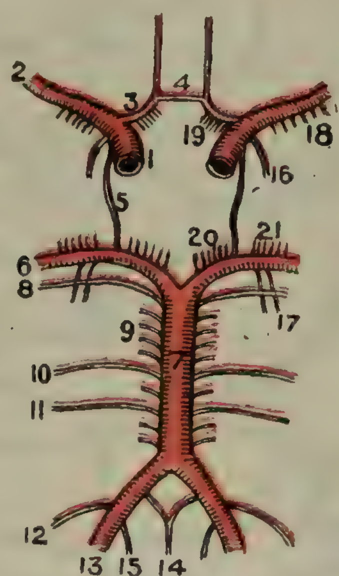
FIG. 879.—ARTERIES ON BASE OF BRAIN.

upper border of the pons, and then round the outer side of the crus cerebri to the superior surface of the cerebellar hemisphere; and (5) the *posterior cerebral artery*, which arises from the termination of the basilar, and passes laterally parallel to the superior cerebellar artery, and then round the crus cerebri to the inferior surface of the occipital lobe. The posterior cerebral and superior cerebellar arteries are separated from

each other by the third and fourth cranial nerves. The branches of the posterior cerebral artery are: (1) *postero-medial,* which pass to the posterior perforated substance; (2) *postero-lateral,* which pass round the crus cerebri; and (3) *posterior choroidal,* which pass to the upper part of the choroidal fissure.

The **internal carotid artery** of each side appears at the vallecula cerebri, and there divides into the anterior and middle cerebral arteries. Near its termination it gives off the **posterior communicating artery,** which passes backwards to join the posterior cerebral artery. It also gives off the **anterior choroidal artery,** which passes backwards and outwards between the crus cerebri and the uncinate gyrus to the lower and anterior part of the choroidal fissure.

The **anterior cerebral artery** passes forwards and inwards between the optic nerve and the medial root of the olfactory tract, and enters the great longitudinal fissure. As it is about to enter that fissure it is connected with its fellow of the opposite side by the **anterior communicating artery,** which is short, but of fairly large size. Amongst other branches the following are to be noted arising from the anterior cerebral artery: (1) *antero-medial,* few and inconstant; and (2) *antero-lateral,* both of which pass to the anterior perforated substance.



1. Internal Carotid
2. Middle Cerebral
3. Anterior Cerebral
4. Anterior Communicating
5. Posterior Communicating
6. Posterior Cerebral
7. Basilar
8. Superior Cerebellar
9. Transverse Pontine
10. Internal Auditory
11. Anterior Inferior Cerebellar
12. Posterior Inferior Cerebellar
13. Vertebral
14. Anterior Spinal
15. Posterior Spinal
16. Anterior Choroid
17. Posterior Choroid
18. Central or Ganglionic
19. Central or Ganglionic
20. Central or Ganglionic (Postero-mesial)
21. Central or Ganglionic (Postero-lateral)

FIG. 880.—THE ARTERIES AT THE BASE OF THE BRAIN, AND THE CIRCULUS ARTERIOSUS.

The **middle cerebral artery,** of large size, sinks into the lateral fissure, which it traverses in an outward direction. Before disappearing into the fissure *antero-lateral ganglionic branches* are to be noted arising from it, which are arranged in two sets, *medial* and *lateral striate,* for the corpus striatum and internal capsule.

Circulus Arteriosus.—This is an important communication between the vertebral and internal carotid arterial systems at the base of the brain, which is situated around the interpeduncular space. It is not actually a circle, though so named, but is a heptagon—that is to say, it has seven angles and seven sides.

Beginning at the median line posteriorly, and proceeding forwards on either side to the median line in front, at the great longitudinal fissure, the component arteries of the circle are: (1) the basilar, (2) the posterior cerebral, (3) the posterior communicating, (4) the internal carotid, (5) the anterior cerebral, and (6) the anterior communicating. These communications serve to insure a uniform supply of arterial blood to the brain in cases of obstruction to one or other of the principal arterial trunks. The communications also serve to equalize the circu-

lation of blood through the different parts of the brain, an arrangement which, though doubtless advantageous, cannot be essential, since one or both of the posterior communicating arteries are often very small and sometimes absent.

Superior Surface of the Brain.—The brain is ovoid superiorly, its greatest breadth corresponding to the positions of the parietal eminences of the parietal bones. In the median line it presents a deep cleft, called the **longitudinal fissure,** which extends from the front to the

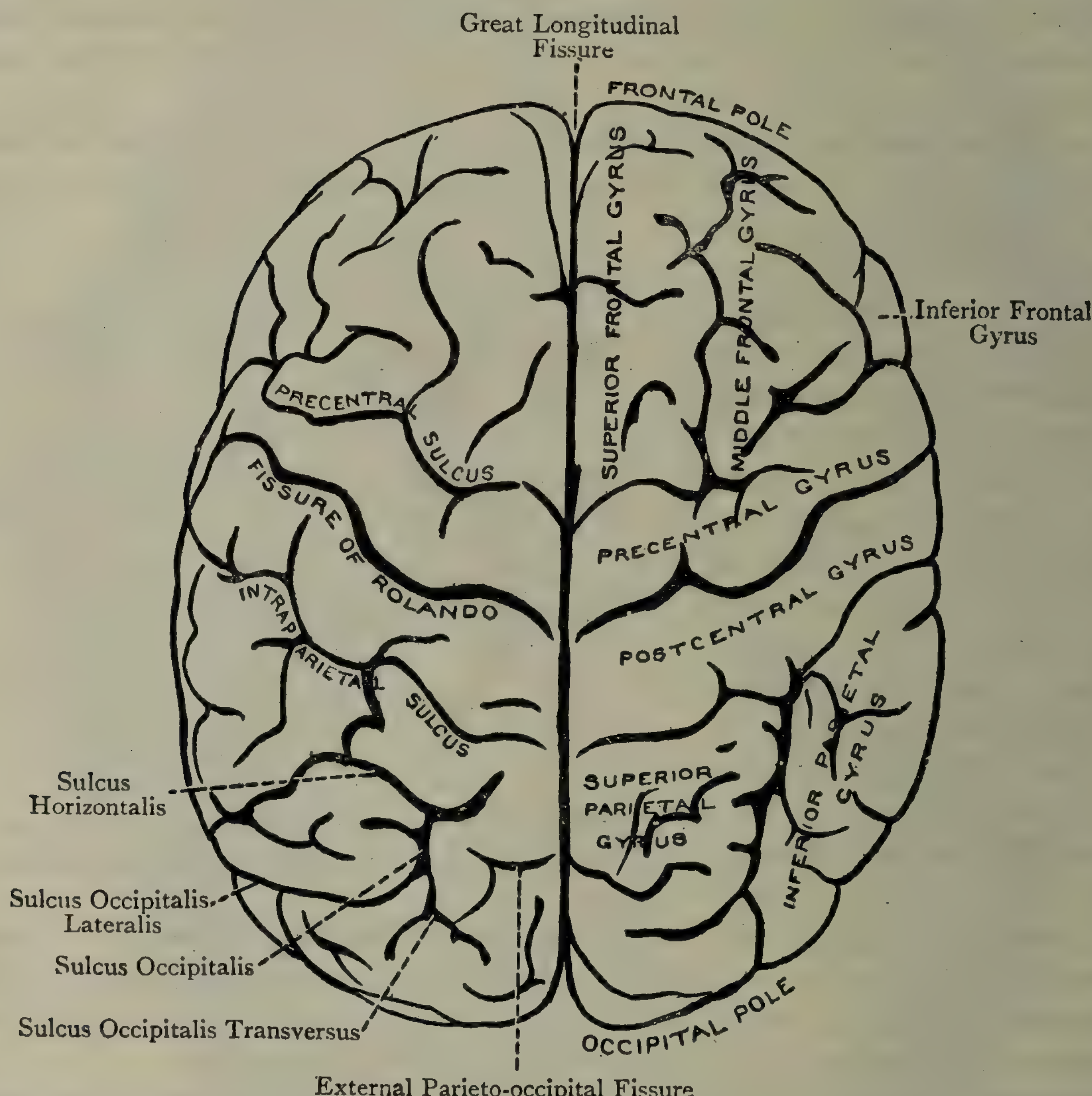


FIG. 881.—THE CEREBRAL HEMISPHERES (SUPERIOR VIEW).
Fissure of Rolando=central fissure.

back, and divides it into two **hemispheres,** right and left. This fissure is occupied by a process of the dura mater, called the **falx cerebri,** and the corpus callosum lies at its deep part. In front of the corpus callosum the fissure extends down to, and is visible on, the base of the brain, but behind the corpus callosum it only extends to the level of the *tentorium cerebelli*, which separates the cerebellum from the posterior parts of the cerebral hemispheres. The fissure, therefore, in this situation is not visible inferiorly until the cerebellum and the tentorium cerebelli have been removed.

Each **hemisphere** is semi-ovoid, its medial surface being flat. The anterior and posterior extremities are rounded, the former being the thicker of the two. The anterior extremity is known as the **frontal pole,** and the posterior extremity forms the **occipital pole.** The surface of each hemisphere consists of grey matter, which is spoken of as the **cerebral cortex.** Superiorly and externally it is convex in adaptation to the concavity of the vault of the cranium. It is broken up into a number of tortuous eminences, called **gyri** or **convolutions,** and these are separated from each other by clefts, called **sulci** or **fissures.** The surfaces of the gyri which bound the sulci are covered with grey matter, like their exterior. The pia mater closely covers the gyri, and also dips into the sulci, so as to cover the opposed surfaces of the gyri. The arachnoid membrane, however, does not dip into the sulci, but passes over them. The sulci are of various depths, but the average depth is about ½ inch.

RHOMBENCEPHALON.

I. The Medulla Oblongata.

The **medulla oblongata** (or *bulb*) is continuous with the spinal cord, and extends from the lower margin of the foramen magnum of the occipital bone to the lower border of the pons. Its direction is upwards and forwards, and it measures I inch in length, ¾ inch in breadth at the widest part, and fully ½ inch in thickness. Inferiorly its girth corresponds with that of the spinal cord, but it widens superiorly, so that it is somewhat pyramidal. Its *ventral surface* faces the basilar groove of the occipital bone, and its *dorsal surface* is directed towards the vallecula of the cerebellum.

The bulb is composed of two symmetrical halves, its bilateral symmetry being indicated superficially by upward prolongations of the ventral or anterior sulcus and dorsal or posterior median septum of the spinal cord. The *anterior median fissure* extends as high as the lower border of the pons, where it expands slightly and forms a blind recess, called the *foramen cæcum.* In its lower part this fissure is interrupted and crossed by bundles of nerve-fibres, which are derived from the inner three-fourths of each pyramid, the decussation thus formed being known as the **decussation of the pyramids,** or **motor decussation.** The *posterior median septum* only extends along the lower half of the bulb, and it terminates superiorly at the point of divergence of the margins of the fourth ventricle.

Each half of the bulb presents two grooves. The *antero-lateral sulcus* is situated between the pyramid and the olivary body, and along this sulcus the roots of the hypoglossal nerve emerge in line with the ventral roots of the spinal nerves. Whilst, however, the latter are spread over a certain area, the hypoglossal roots emerge along a straight line corresponding to the ventro-lateral sulcus of the bulb. This sulcus is not represented on the surface of the spinal cord. The *postero-lateral sulcus* lies on the dorso-lateral aspect of the olivary body. Along

this sulcus, in order from above downwards, there are (1) the roots of the glosso-pharyngeal nerve, (2) the funiculi of the vagus nerve, and (3) the funiculi of the *bulbar part* of the accessory nerve.

The bulb in its *lower half* contains a prolongation of the central canal of the spinal cord. This part of the bulb is spoken of as the *closed part*, and it extends as high as the level of the lower point of the ventricle. In the *upper half* of the bulb the central canal opens out at this level into the fourth ventricle, and the dorsal aspect of the bulb forms the lower or bulbar half of the floor of the fourth ventricle. The upper half of the bulb is therefore spoken of as the *open part*.

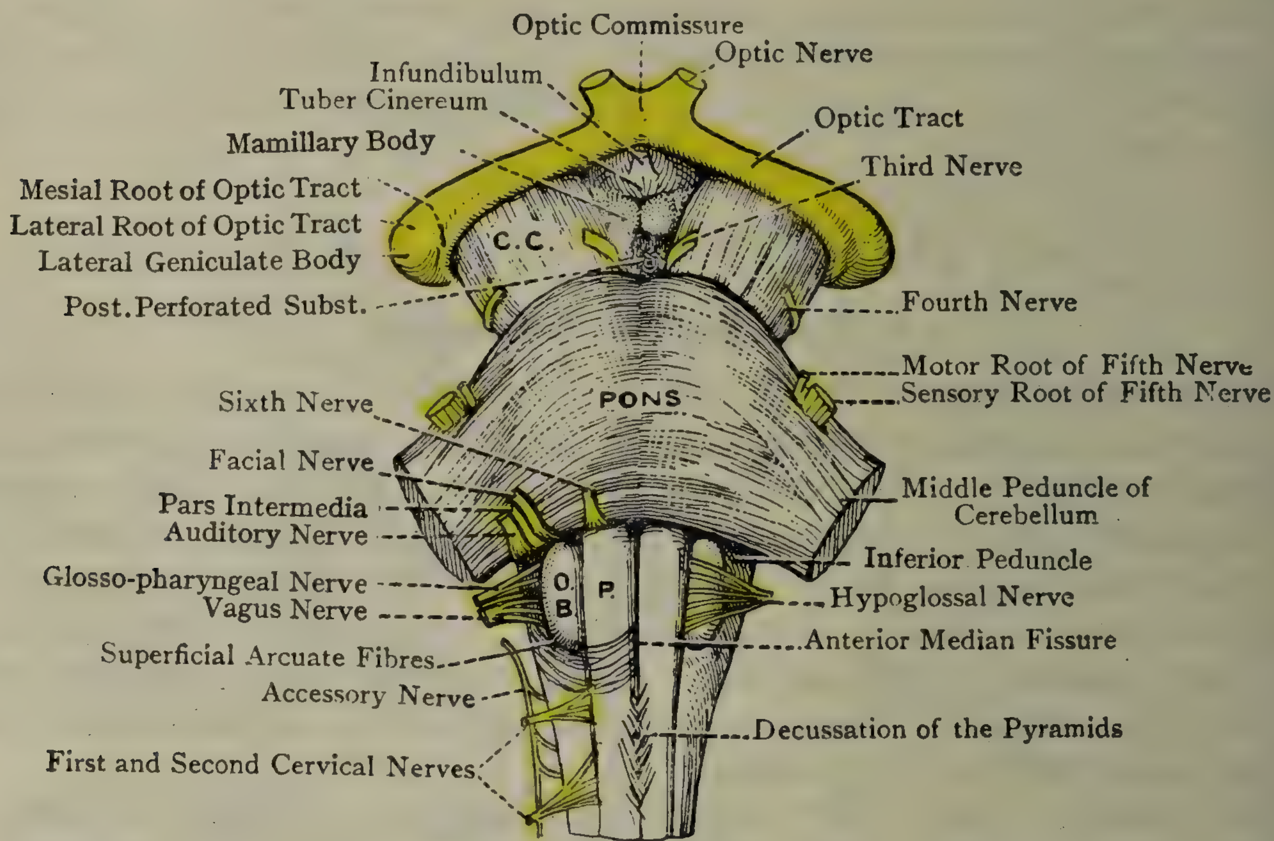


FIG. 882.—THE MEDULLA OBLONGATA, PONS, AND INTERPEDUNCULAR REGION.
C.C., crus cerebri; P., pyramid; O.B., olivary body.

The surface of each half of the bulb is divided into three areas by the above-mentioned sulci, with the corresponding nerve funiculi. These surface areas are ventral, lateral, and dorsal.

Ventral or Anterior Area.—This superficial area is situated between the median and the antero-lateral sulcus, along which the funiculi of the hypoglossal nerve emerge. It constitutes the **pyramid** of the bulb. The two pyramids, right and left, represent the motor tracts of the bulb. As regards position, the pyramid is like the anterior column of the spinal cord, and it consists of bundles of nerve-fibres disposed longitudinally. Inferiorly it is somewhat narrow, but it widens superiorly. At the lower border of the pons it undergoes a slight constriction, after which it sinks into the pons. As it traverses the pons its funiculi become separated into several strata, and these are gathered together at the upper border of the pons into the crus cerebri of the corresponding side.

Inferiorly each pyramid is disposed in two parts—medial and lateral. The *medial portion* represents as a rule the inner three-fourths, and its fibres cross to the opposite side in the lower part of the ventral median sulcus of the bulb. Thereafter they sink deeply into the dorsal part of the lateral column of the spinal cord on the side to which they have crossed, where they constitute the **crossed pyramidal** or **lateral cerebro-spinal tract.** The intercrossing of fibres which takes place in the lower part of the ventral median fissure of the bulb is called the **decussation of the pyramids,** or the **motor decussation,** and, as stated, it usually involves the fibres of the inner three-fourths of the pyramid.

The *lateral portion* of the pyramid represents as a rule the lateral fourth, and its fibres take no part in the decussation. The path of most of them is downwards into the *anterior column* of the spinal cord of the same side, where they lie close to the anterior median fissure of the cord and constitute the **direct pyramidal** or **anterior cerebro-spinal tract.** A few of them, however, descend into the lateral column of the same side, and constitute the **uncrossed lateral pyramidal tract.**

The pyramid of the bulb, therefore, only corresponds topographically with the anterior column of the spinal cord. The direct cerebro-spinal tract of the anterior column of the cord forms the greater part of the lateral fourth of the corresponding pyramid of the bulb; and the crossed cerebro-spinal tract of the lateral column of the cord forms the medial three-fourths of the pyramid of the opposite side. The remainder of the anterior column of the cord sinks deeply into the bulb and lies on the dorsal aspect of the pyramid.

The ventral surface of each pyramid is crossed above the level of the decussation of the pyramids by the *anterior superficial arcuate fibres,* which emerge from the ventral median fissure and take an arched course outwards and then backwards to the inferior cerebellar peduncle.

The sixth cranial nerve emerges close to the lower border of the pons, immediately lateral to the pyramid, and in line with the funiculi of the hypoglossal nerve as these leave the ventro-lateral sulcus.

Lateral Area of the Medulla Oblongata.—This superficial area is situated behind the funiculi of the hypoglossal nerve. *Superiorly* the oval eminence, called the **olive,** is included in it. *Inferiorly* it has the appearance of being a prolongation of the lateral column of the spinal cord, but this is not the case. The crossed cerebro-spinal tract of the lateral column of the cord sweeps obliquely across to the opposite side, where it forms the greater part of the pyramid of that side. The parts, therefore, of the lateral column of the cord which form the lateral area of the bulb *below the olive* are (1) the dorsal or direct spino-cerebellar tract, (2) the ventral spino-cerebellar tract, and (3) the lateral intersegmental bundle. The dorsal spino-cerebellar tract, as it ascends, soon inclines obliquely backwards to join the inferior peduncle. The ventral spino-cerebellar tract and intersegmental bundle ascend until they reach the lower end of the olive. They then in part sink deeply, and ascend to the pons on the dorsal or deep aspect of the olive. Most

of the cerebellar fibres, however, remain on the surface, and ascend in the small interval which lies between the outer part of the olive and the funiculi of the glosso-pharyngeal and vagus nerves.

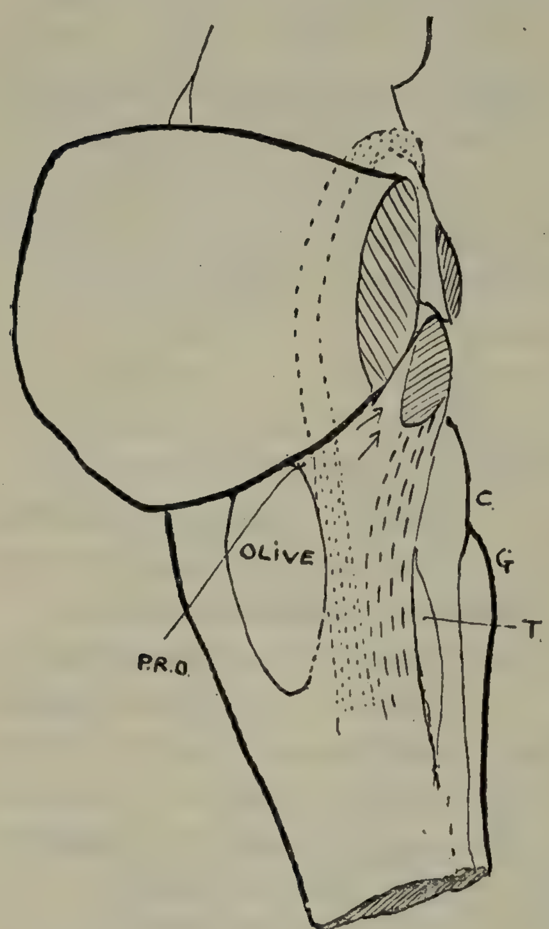


FIG. 883.—A SKETCH TO SHOW THE DISPOSITION OF SPINO-CEREBELLAR FIBRES IN LATERAL REGION OF MEDULLA.

The dorsal fibres (interrupted lines) run to inferior peduncle, therefore have a dorsal tendency as they ascend, covering in the spinal root of fifth nerve, which is making a slight prominence, the tuberculum gelatinosum (T). The ventral fibres (Gowers' tract) are dotted. The arrows indicate many fibres from other parts (olives, etc.), helping to complete the peduncle. C, G, cuneate and gracile tubercles; P.R.O., position of pallido-rubro-olivary tract.

The lateral area of the bulb below the olive thus represents the dorsal or direct spino-cerebellar tract, ventral spino-cerebellar tract, and, deeply, the lateral ground-bundle of the lateral column of the spinal cord of the same side (Fig. 883).

Superiorly, as stated, the lateral area presents an oval eminence, called the **olive.** It lies between the funiculi of the hypoglossal nerve on the one hand, and the funiculi of the glosso-pharyngeal and vagus nerves on the other, with the intervention of some ascending fibres belonging to the ventral spino-cerebellar tract. Its long axis is placed vertically, and in this direction it measures about $\frac{1}{2}$ inch. Superiorly it is separated from the pons by a deep transverse groove, and inferiorly the anterior superficial arcuate fibres arch over its lower part.

At the lower border of the pons, lateral to the upper end of the olive, the facial and auditory nerves make their appearance. The facial nerve is in line with the roots of the glosso-pharyngeal nerve. The auditory nerve appears *lateral* to the facial nerve, and between the two is the small *pars intermedia* (*of Wrisberg*).

Dorsal or Posterior Area of the Medulla Oblongata.—This superficial area is limited in front by the sulcus containing the funiculi of the glosso-pharyngeal, vagus, and *bulbar part* of the spinal accessory nerves. Posteriorly its lower half extends as far as the dorsal median fissure, and its upper half extends only as far as the lateral boundary of the lower or bulbar half of the floor of the fourth ventricle. Inasmuch as this area belongs to both the closed and open part of the bulb, it will be considered in two sections—lower and upper.

Lower Portion of Posterior Area.—This, it has been shown, is limited behind by the dorsal median fissure, and it is in direct continuity with the dorsal column of the spinal cord of the same side, which is composed

f the gracile and cuneate columns. It presents three longitudinal minences—namely, the funiculus gracilis, funiculus cuneatus, and uniculus gelatinosus.

The **funiculus gracilis** is a prolongation of the column of the spinal ord, and lies close to the dorsal median fissure. The **funiculus cuneatus** s a prolongation of the column of the cord, and lies lateral to the uniculus gracilis, from which it is separated by an upward continuation f the dorsal intermediate or paramedian furrow of the cord.

At the lower level of the ventricle each of these two funiculi ecomes enlarged and terminates in a prominence or bulb. The enargement formed by the funiculus racilis is called the **clava,** or **gracile ubercle,** and that formed by the funiulus cuneatus is termed the **cuneate ubercle.** The two clavæ, right and left, ie on either side of the lower angle of he fourth ventricle, and as the bulb pens out dorsally at this level to form he lower or bulbar half of the floor of he fourth ventricle each clava is displaced laterally. An angular interval iow separates the two clavæ, and the prolongation of the central canal of the pinal cord through the lower or closed art of the bulb opens into the fourth entricle in the angle between the two lavæ.

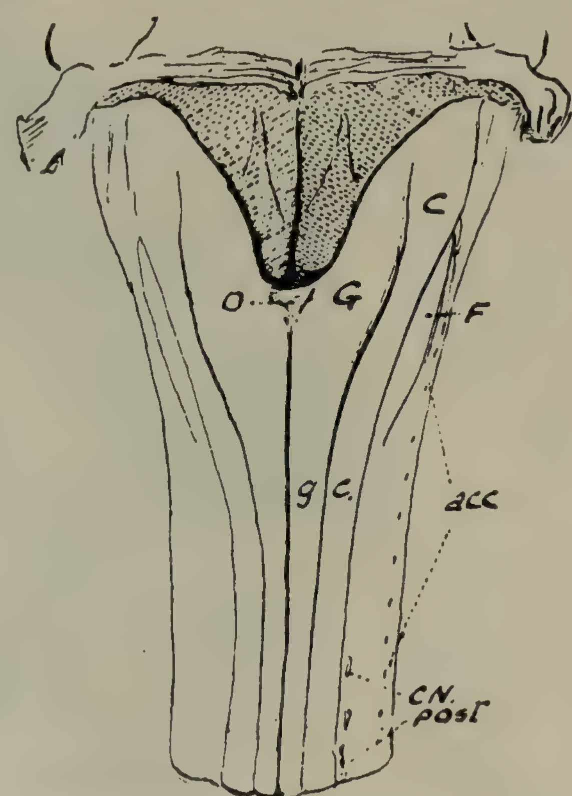


FIG. 884.—POSTERIOR VIEW OF MEDULLA.

G, C, gracile and cuneate tubercles; *g*, *c*, corresponding tracts; F, gelatinous tubercle; O, obex.

The funiculus gracilis, with its tuercle, and the funiculus cuneatus, with ts cuneate tubercle, are to a large exent produced by the collections of grey natter which they contain—namely, the *ucleus gracilis* and *nucleus cuneatus.*

The **funiculus gelatinosus** is situated n the outer side of the funiculus cuneatus, between it and the funiuli of the bulbar part of the spinal accessory nerve. It is produced y the substantia gelatinosa (of the spinal cord), which is close to the urface in the lower or closed part of the bulb. Inferiorly the funiculus s narrow, but it widens as it ascends, and superiorly it terminates n an enlarged extremity, called the **spinal tract of the trigeminal** or **uberculum gelatinosum.**

The funiculus and tubercle are covered by a thin layer of longiudinal nerve-fibres which represent the **spinal** or descending **sensory oot of the fifth cranial nerve.**

Upper Portion of Posterior Area.—This belongs to the upper or open art of the bulb, and extends as far as the lateral boundary of the ower or bulbar half of the floor of the fourth ventricle. It presents prominent round tract, called the *restiform body,* which is situated

between the lower half of the floor of the fourth ventricle and the funiculi of the vagus and glosso-pharyngeal nerves. Its direction is upwards, outwards, and backwards, and it enters the corresponding hemisphere of the cerebellum. It is otherwise known as the **inferior cerebellar peduncle.**

The inferior peduncle succeeds to the funiculus gracilis and funiculus cuneatus of the lower portion of the posterior area of the bulb, but it is quite distinct from these funiculi, and receives no fibres from them. The sources of its fibres will be given in connection with the internal structure of the bulb (see p. 1463). Meanwhile, it is

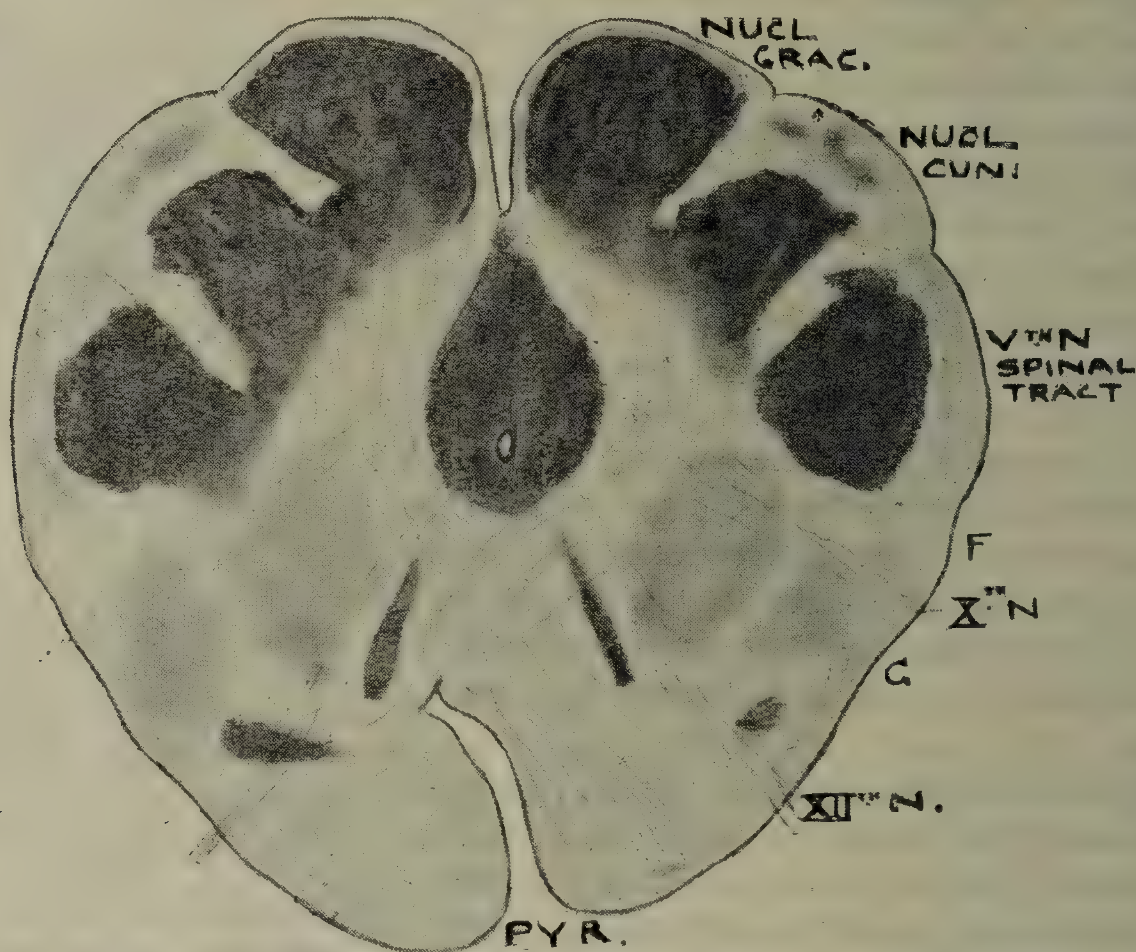


FIG. 885.—SECTION THROUGH MEDULLA JUST ABOVE DECUSSATION OF PYRAMIDS: SHOWS THE PROMINENCE OF SPINAL TRACT OF FIFTH NERVE.

F is the dorsal spino-cerebellar tract immediately ventral to this, and G is the ventral tract.

clear that it constitutes the great tract of connection between the cerebellar hemisphere, the bulb, and the spinal cord.

The restiform body becomes conspicuous above the level of the cuneate tubercle, and forms the lateral boundary of the lower or bulbar half of the floor of the fourth ventricle.

Internal Structure of the Medulla Oblongata.—Each half of the bulb is composed of grey nervous matter and tracts of white nervous matter.

Grey Matter.—The grey matter lies largely in the interior. Over the dorsal aspect of the upper or open part of the bulb, however, it comes to the surface, and covers the lower or bulbar half of the floor of the fourth ventricle.

As compared with the grey matter of the spinal cord, it presents mportant modifications, and its component parts are as follows:

1. Substantia or formatio reticularis.
2. A thick layer of grey matter around the central canal in the lower or closed part of the bulb.

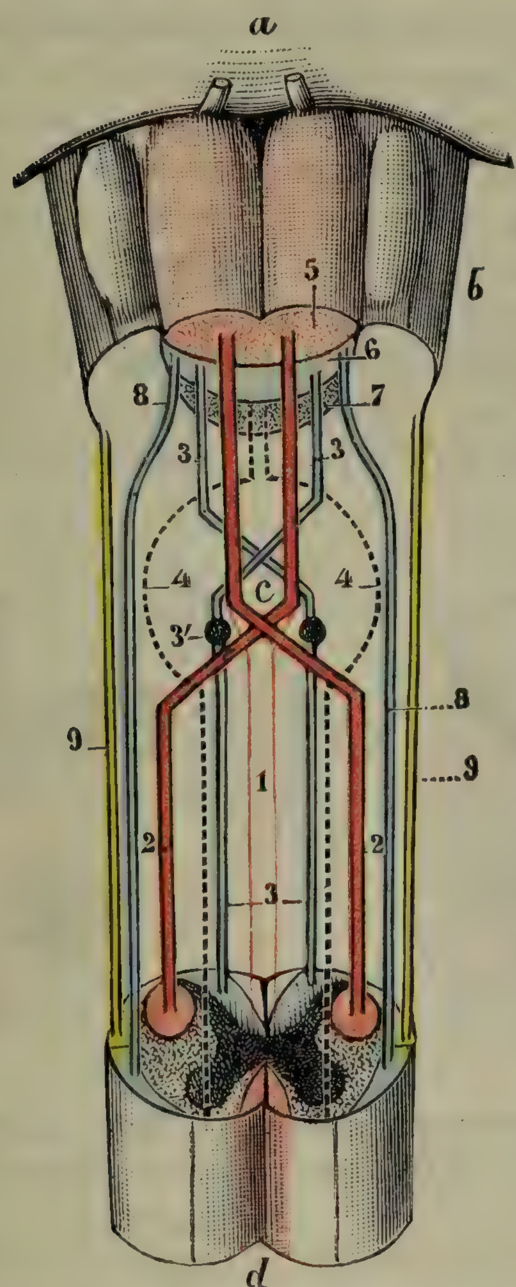


Fig. 886.—The Decussation of the Pyramids: Scheme representing the Passage of the Various Tracts from the Spinal Cord to the Medulla (L. Testut's 'Anatomie Humaine').

a. Pons
b. Medulla Oblongata (anterior aspect)
c. Decussation of the Pyramids
d. Section of the Cervical Spinal Cord
1. Anterior Cerebro-spinal Tract
2. Lateral Cerebro-spinal Tract
3. Sensory Tract
3′. Nucleus Gracilis et Nucleus Cuneatus
4. Antero-lateral Intersegmental Tract
5. Anterior Pyramid
6. Fillet or Lemniscus
7. Posterior Longitudinal Bundle
8. Ventral Cerebellar Tract
9. Dorsal Cerebellar Tract

3. A thick layer of grey matter over the floor of the fourth ventricle in the upper or open part of the bulb.
4. Substantia gelatinosa (nucleus of spinal tract, N. V.).
5. Nuclei of grey matter.

The modifications undergone by the grey matter of the bulb in ts lower or closed part are brought about by the decussation of the

pyramids. The nerve funiculi of the lateral cerebro-spinal tract of the spinal cord, on one side as they are *traced upwards*, pass through the base of the **ventral grey column** of that side, and then cross in the lower part of the ventral median fissure of the bulb to the pyramid of the opposite side, of which they form the inner and larger part. The nerve funiculi of the tract of the other side are disposed in a similar manner. The ventral grey column of either side is thus broken up by the corresponding crossed pyramidal tract. Its *basal part* remains on the ventral and lateral aspects of the central canal, but its *caput* is detached and displaced laterally by the pyramid and olive of the same side (see Fig. 887).

The **dorsal horn** of grey matter is gradually displaced laterally and ventralwards, in the lower or closed part of the bulb, by the funiculus gracilis and funiculus cuneatus. Its *basal part* remains on the dorsal and lateral aspects of the central canal; its *cervix* is broken up into a network by intersecting nerve-fibres; and its *caput* is thereby detached.

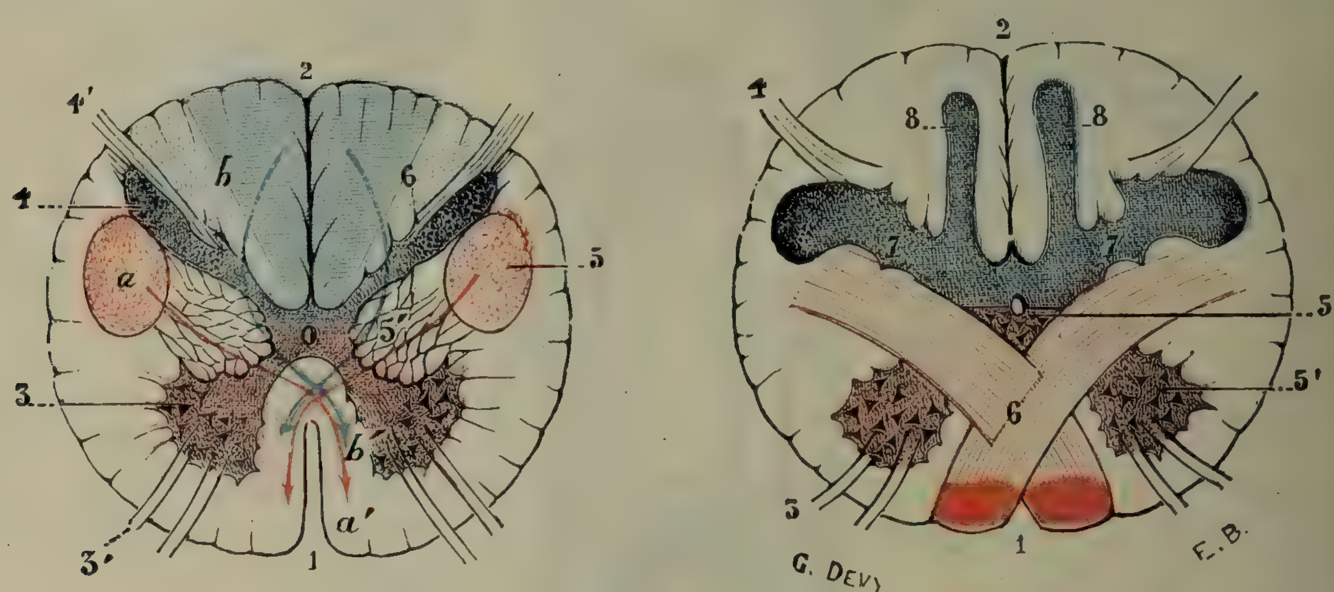


FIG. 887.—SCHEMATIC SECTIONS SHOWING DECUSSATION OF PYRAMIDS WITH THE DESTRUCTION OF BASE OF VENTRAL GREY COLUMN (TESTUT).

The caput lies close to the detached caput of the ventral grey matter, but does not blend with it.

Substantia or Formatio Reticularis.—The grey matter of the detached caput of the ventral grey cornu is broken up into a network by intersecting nerve-fibres, which run longitudinally and transversely. This reticulum, augmented by the network formed in the cervix of the dorsal grey cornu, constitutes the **substantia** or **formatio reticularis** of the bulb. It lies deeply within the bulb, dorsal to the olive and pyramid of the same side, and it consists of grey matter, longitudinal and transverse nerve-fibres, and some nerve-cells.

The funiculi of the hypoglossal nerve, as they pass forwards to the ventro-lateral sulcus of the bulb, divide the formatio reticularis into two parts—lateral and medial (Fig. 891). The *lateral portion* is situated behind the olive, and is called the **formatio reticularis grisea,** from the large amount of grey matter, with nerve-cells, which it contains. The *medial portion* is situated behind the pyramid, and is

alled the **formatio reticularis alba.** It contains little grey matter nd few nerve-cells.

Central Grey Matter.—The grey matter which surrounds the entral canal in the lower or closed part of the bulb is derived from he basal portions of the ventral and dorsal grey columns of the upper art of the spinal cord. In the upper or open part of the bulb this entral grey matter spreads out and forms a thick layer over the wer or bulbar part of the floor of the fourth ventricle. The *medial art* of this layer represents the basal part of the *ventral* grey horn, nd it contains the hypoglossal nucleus. The *lateral part* represents he basal part of the *dorsal* grey horn, and it contains vagus, glosso-haryngeal, and vestibular nuclei.

The hypoglossal nucleus is frequently spoken of as 'morphologically continuous with' or 'representing' the ventral grey column above the cervical nerves. This continuity, however, is not an actual anatomical fact; it exists only in the site of ependymal zone origin of the neuroblasts concerned in forming the nuclei. The ordinary motor cells of the ventral grey column in the cord have been derived from the lower part of the ependymal zone, from which they have migrated to form the ventral portion of the marginal zone. Later, when the collections of neuroblasts in the ventral horn have already settled into something approaching their final arrangements, a secondary output of neuroblasts frees itself from the ependymal zone in the same region, but does not migrate any further; this, then, might be looked on as of the same ependymal or original value as the ventral cells, although not anatomically continuous with them. It is from this secondary formation, which is found in the cervical and hind-brain regions, that the hypoglossal nucleus is formed; possibly the sixth nucleus owns a like origin, but this cannot be said with certainty. The other nuclei mentioned in the preceding paragraph are not concerned in this development in any way.

Substantia Gelatinosa (Fig. 885).—This caps the detached and splaced caput of the dorsal horn of grey matter. Having increased amount owing to the presence of root-fibres of the fifth nerves d lying close to the surface, it gives rise to the *tuberculum gelatinosum*, metimes referred to simply as the 'spinal tract of the fifth nerve.'

Nuclei of Grey Matter.—The nuclei, which will be considered in is place, are as follows:

1. Nucleus gracilis.
2. Nucleus cuneatus.
3. Olivary nuclei.
4. Arcuate nucleus.
5. Nucleus lateralis.

The **nucleus gracilis** is a collection of grey matter within the funicus gracilis. For the most part it is connected with the grey matter

on the dorsal and lateral aspects of the central canal, and it may be regarded as being in large part an extension from the basal par of the dorsal grey cornu. It is elongated, and increases in size a it ascends. It gives rise to the prominence of the funiculus gracili and to the clava, and the fibres of the funiculus gracilis, as they ascend terminate at intervals around the cells of the nucleus (see Fig. 885).

The **nucleus cuneatus** is a collection of grey matter within th funiculus cuneatus. It is a direct extension from the basal part o

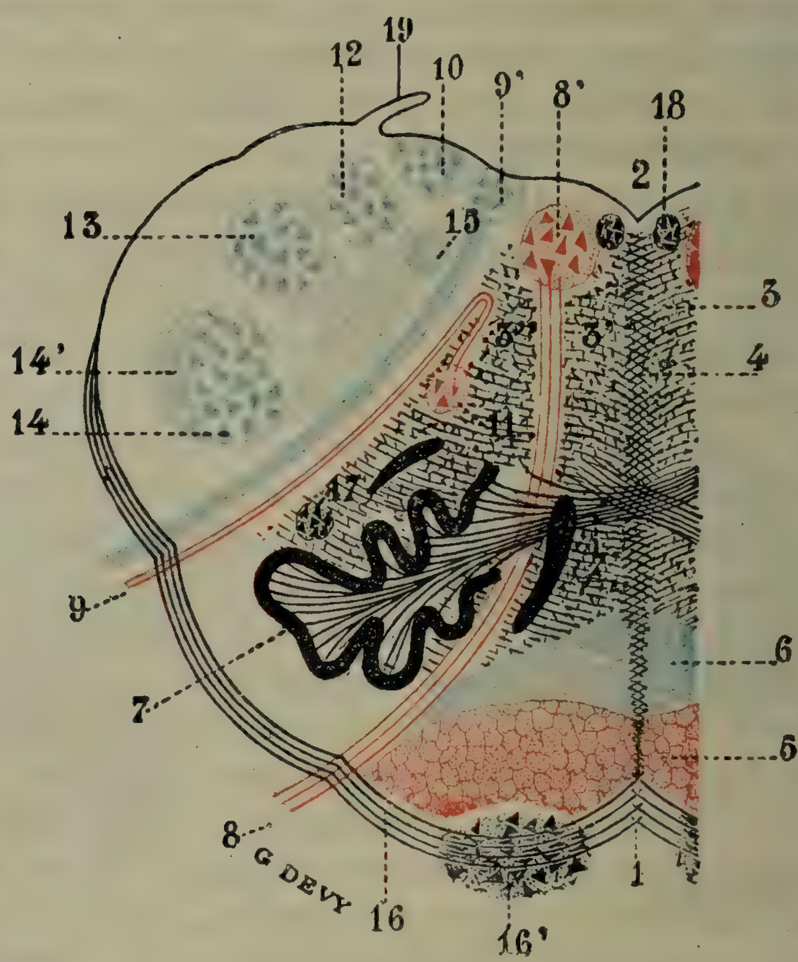


FIG. 888.—THE FORMATIO RETICULARIS OF THE MEDULLA OBLONGATA, SHOWN BY A HORIZONTAL SECTION PASSING THROUGH THE MIDDLE OF THE OLIVARY BODY (DEMI-SCHEMATIC) (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Anterior Median Fissure
2. Fourth Ventricle
3. Formatio Reticularis
3'. Reticularis Alba
3''. Reticularis Grisea
4. Raphé
5. Anterior Pyramid
6. Lemniscus
7. Inferior Olive with the two Accessory Nuclei
7'. Peduncle of Olivary Body
8. Hypoglossal Nerve
8'. Hypoglossal Nucleus
9. Vagus Nerve
9'. Terminal Nucleus of Vagus Nerve
10. External Dorsal Vestibular Nucleus
11. Nucleus Ambiguus
12. Nucleus Gracilis
13. Nucleus Cuneatus
14. Caput of Posterior Cornu
14'. Lower Sensory Root of Fift Nerve
15. Fasciculus Solitarius
16. External Anterior Arcuat Fibres
16'. Arcuate Nucleus
17. Lateral Nucleus

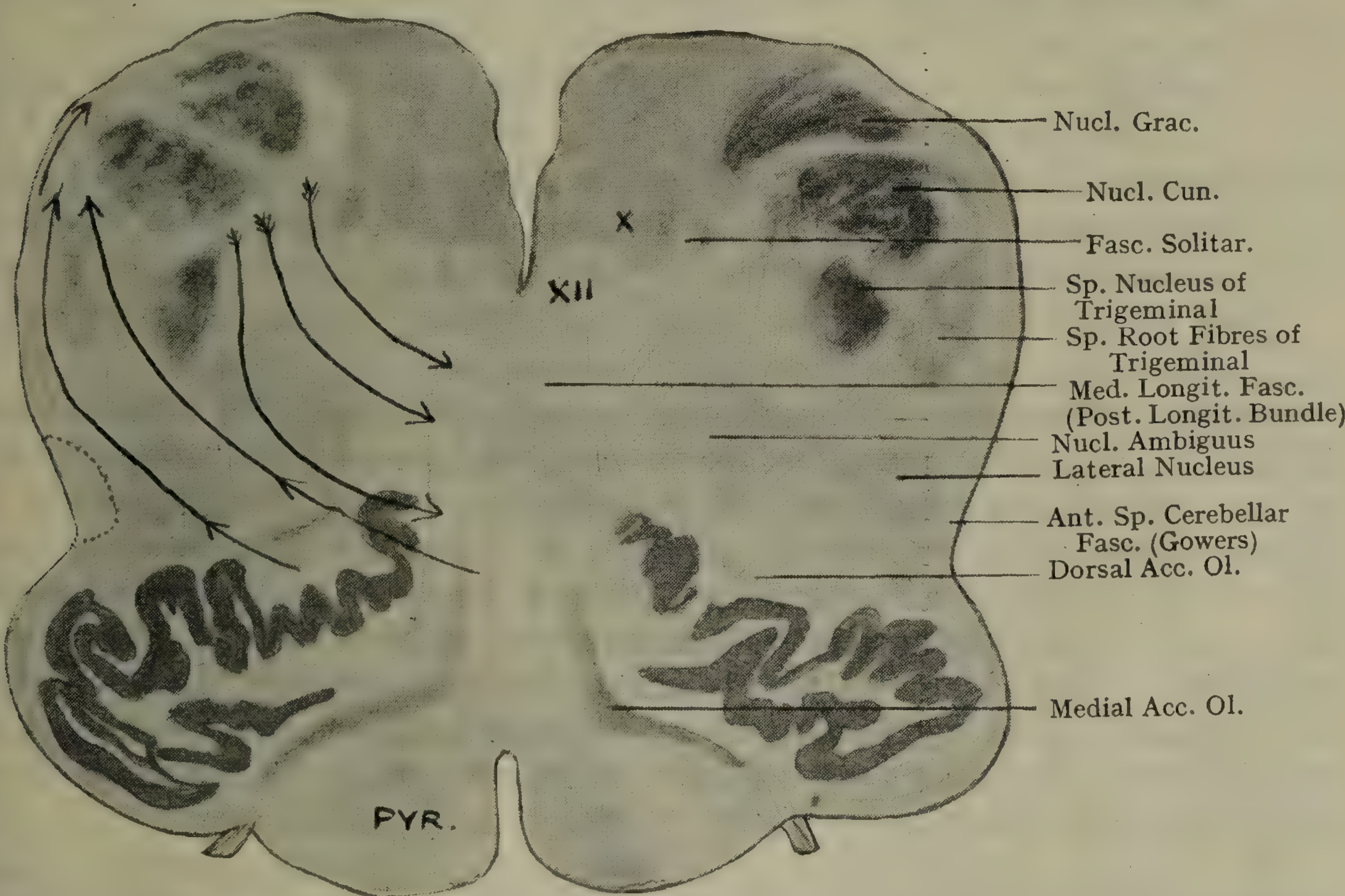
the dorsal grey cornu, which lies on the dorsal and lateral aspect of the central canal. Like the nucleus gracilis it is elongated, and increases in size as it ascends. It gives rise to the prominence o the funiculus cuneatus and to the cuneate tubercle, and the fibre of the funiculus cuneatus, as they ascend, terminate at interval around the cells of the nucleus.

Lateral to the nucleus cuneatus there is a small collection of grey matter which is known as the *external* or *accessory cuneate nucleus*. It is on a highe level than the decussation of the pyramids, and it may be regarded as a detache portion of the substantia gelatinosa.

The **olivary nuclei** are associated with the olive, and are three in umber—inferior, and two accessory (medial and dorsal).

The superior olivary nucleus is situated in the dorsal or tegmental part of e pons, and is not developmentally associated with those now dealt with.

The **inferior olivary nucleus,** which is the chief nucleus, is situated thin the olive. As seen in transverse sections through the olive, appears (Fig. 889) as a wavy lamina of grey matter, curved in such a anner as to form an incomplete capsule, which encloses white matter.



IG. 889.—SECTION THROUGH THE LOWER HALF OF INFERIOR OLIVE (SHOWS ALSO THE MEDIAL AND DORSAL ACCESSORY OLIVES).

racile and cuneate nuclei are seen in position, but spinal tract of fifth is separated from surface by fibres passing to inferior peduncle; these are dorsal spino-cerebellar and fibres from olive from opposite side; some fibres from olive pass between the nucleus and the nerve tract. Arrows show the direction of fibres on one side. The upper ones come from the dorsal nuclei and fifth nucleus, and run ventrally to decussate. The lower fibres are running dorsally, and come mainly from opposite olive, and some from same side.

he open part of the capsule is called the *hilum*, and is directed wards the median line, but it stops short of either end of the nucleus. great many nerve-fibres pass through the hilum, some inwards nd others outwards, and these form what is known as the *olivary eduncle.* The wavy lamina is traversed by nerve-fibres.

The *medial accessory* and *dorsal accessory olivary nuclei* are situated n the medial and dorsal aspects respectively of the inferior or chief livary nucleus, from which, however, they are distinct. Each consists of a band of grey matter, and the upper part of the medial ccessory nucleus lies opposite the hilum of the chief nucleus.

Structure of Inferior Olivary Nucleus.—The wavy lamina consists of many small nerve-cells and nerve-fibres which traverse it. The axons of the nerve-cells leave the nucleus as nerve-fibres, and pass to the raphé of the bulb. Some of the nerve-fibres which traverse the wavy grey lamina terminate in connection with its cells, and other fibres pass through it (see Fig. 889).

There are at least two fibre tracts (in addition to those passing into the inferior peduncle) which connect the inferior olive with more distant parts of the nervous system, and are recognizable in sections; little is actually known about them otherwise. The smaller one (olivo-spinal or Helweg's tract) lies on the surface of the lower medulla and cord immediately in front of the ventral spino-cerebellar fibres. The upper tract, much larger and longer, is the tractus pallido-rubro-olivaris, a name describing its apparent connections.

The structure of the two accessory olivary nuclei corresponds to that of the chief or inferior olivary nucleus.

Arcuate Nucleus.—This nucleus (seen in Fig. 889) consists of a lamina of grey matter which lies upon the ventral aspect of the pyramid of the bulb above the level of the decussation of the pyramids, and beneath the anterior superficial arcuate fibres as they arch outwards over the pyramid after emerging from the ventral median fissure. Superiorly it lies over the medial aspect of the pyramid close to the ventral median fissure. It contains small nerve-cells, in connection with which some of the anterior superficial arcuate fibres terminate, whilst others arise as axons of the cells, and many of them pass over the nucleus without entering it.

Fibres of various sorts, which may be termed in general *circumolivary*, may be found turning over the lower part of the olive. Some are superficial arcuate fibres, as just described, but others may come apparently from the pyramid, and others again, associated with the ponto-bulbar body, may be really of the nature of *aberrant pontine* fibres.

Nucleus Lateralis.—This is a special collection of nerve-cells in that portion of the formatio reticularis grisea which lies on the dorso-lateral aspect of the olive. It is situated deeply between the olive and the substantia gelatinosa (see Fig. 889).

White Matter of the Medulla Oblongata.—The white matter is situated chiefly on the surface. Over the dorsal aspect of the upper or open part of the bulb, however, the grey matter comes to the surface, and covers the lower or bulbar half of the floor of the fourth ventricle. The white matter is disposed in tracts or strands which are chiefly longitudinal, but a few run transversely in an arched manner. The tracts are as follows:

1. Pyramidal tract (cerebro-spinal tract).
2. Dorsal spino-cerebellar tract (direct cerebellar tract).
3. Ventral spino-cerebellar tract (tract of Gowers).

4. Restiform body (inferior cerebellar peduncle).
5. Funiculus cuneatus.
6. Funiculus gracilis.
7. Medial or posterior longitudinal bundle.
8. Tecto-spinal tract.
9. Rubro-spinal tract.
10. Spino-tectal tract.
11. Superficial arcuate tract.
12. Deep arcuate tract.
13. Fillet (lemniscus).
14. Vestibulo-spinal tract.
15. Olivo-cerebellar tract.

The **pyramid** of either side and the decussation of the pyramids have been already described. It may, however, be again stated that the path of their motor nerve-fibres is *downwards* into the spinal cord.

The pyramidal tract has descended from the pons.

Posterior (or Direct) Spino-cerebellar Tract.—This tract extends *upwards* from the lateral column of the spinal cord. It traverses the lower part of the lateral area of the bulb nearly as high as the lower part of the olive, and immediately anterior to the tuberculum gelatinosum, after which it passes backwards and upwards into the inferior peduncle, of which it forms a part (Fig. 883).

Anterior Spino-cerebellar Tract.—This tract, like the dorsal or direct spino-cerebellar tract, extends *upwards* from the lateral column of the spinal cord. It is situated chiefly on the dorsal aspect of the olive, but some of its fibres appear close to the outer side of that body. Whilst the dorsal spino-cerebellar tract passes into the restiform body, and so reaches the cerebellar hemisphere *directly*, the ventral spino-cerebellar tract is continued upwards into and beyond the pons before reaching the cerebellar hemisphere.

Restiform Body.—The restiform body, or **inferior peduncle of the cerebellum,** is situated on the dorsal aspect of the bulb in its upper or open part, the funiculus gracilis and funiculus cuneatus occupying the dorsal aspect in its lower or closed part. It succeeds to the clava and cuneate tubercle, in which these two funiculi respectively end, but it receives no nerve-fibres from the funiculi. It makes its first appearance in relation to the nucleus cuneatus, and above the cuneate tubercle it is a conspicuous massive bundle, which forms the lateral boundary of the lower or bulbar half of the floor of the fourth ventricle. Its course is upwards, outwards, and then suddenly backwards. It sinks into the corresponding hemisphere of the cerebellum.

This peduncle is composed of fibres which are derived from the following sources:

1. The **olivo-cerebellar fibres** of the **inferior olivary nucleus** of the *opposite side.*
2. The **posterior cerebellar tract** of the lateral column of the spinal cord of the *same side.*

3. The **anterior superficial arcuate fibres** from the **nucleus gracilis** and **nucleus cuneatus** of the *opposite side.*
4. The **posterior arcuate fibres** from the **nucleus gracilis** and **nucleus cuneatus** of the *same side.*
5. **Vestibular fibres** from the **vestibular nuclei** of the **vestibular division** of the **auditory nerve.**

The restiform body, from its composition, serves as an important means of connection between the cerebellar hemisphere superiorly and the medulla oblongata and spinal cord inferiorly.

Funiculus Cuneatus and Funiculus Gracilis.—These tracts are prolonged *upwards* from the posterior column of the spinal cord. As stated, each contains a grey nucleus, around the cells of which the corresponding sensory nerve-fibres terminate at intervals as they ascend. Towards the clava and cuneate tubercle the fibres become few and are spread over the clava and cuneate tubercle, finally ending in connection with the cells of the grey nuclei which give rise to these prominences (Fig. 885).

Posterior Longitudinal Bundle.—The fibres of this bundle (*fasciculus longitudinalis medialis*), when followed downwards into the anterior column of the spinal cord on the same side, represent the fibres of the ventral intersegmental tract. As these fibres are followed into the lower part of the bulb they form a bundle, which lies close to the median raphé and directly dorsal to the corresponding pyramid. This strand represents the longitudinal bundle in the lower part of the bulb. The deep arcuate fibres, to be presently described, pass obliquely through it to the median line, where they decussate with those of the opposite side. This decussation takes place in the interval between the right and left dorsal longitudinal bundles. Having now reached the other side, the deep arcuate fibres take an upward course, close to the median line, as the *medial lemniscus.* The dorsal longitudinal bundle and fillet are therefore now closely related to one another in the lower part of the bulb, both lying dorsal to the pyramid, the fillet lying close to the raphé.

In the upper part of the bulb the two tracts become distinct. The posterior longitudinal bundle is displaced dorsalwards during the formation of the fillet, and it comes into contact with the grey matter on the floor of the fourth ventricle, whilst the lemniscus lies on the dorsal aspect of the pyramid.

The posterior longitudinal bundle is prolonged into the ventral column of the spinal cord on the same side, where it is represented, as has been said, by the ventral intersegmental fibres.

A *ventral* or *anterior longitudinal bundle* (tecto-spinal tract) is described as lying on the ventral aspect of the dorsal or posterior longitudinal bundle. This bundle, however, is not well defined. It descends into the anterior column of the spinal cord, and is accompanied by the *ponto-spinal tract,* the fibres of which spring from the cells of the formatio reticularis of the pons.

Arcuate Tracts.—These tracts form two goups—superficial and deep.

The **superficial arcuate fibres** are arranged in two sets—anterior and posterior.

The *anterior superficial arcuate fibres* arise from the nucleus gracilis and nucleus cuneatus of the *opposite side*, and a few arise from the arcuate nucleus of the same side. At the median line they decussate with those of the opposite side, and emerge at the ventral median fissure, where many of them arch over the medial and ventral aspects of the pyramid. Others pierce the pyramid, whilst some emerge at the ventro-lateral sulcus between the pyramid and olive. The fibres now pass outwards and dorsalwards, some arching over the lower part of the olive, and finally enter the restiform body.

The *posterior superficial arcuate fibres* arise from the nucleus gracilis and nucleus cuneatus of the *same side*, and they enter the restiform body also of the same side.

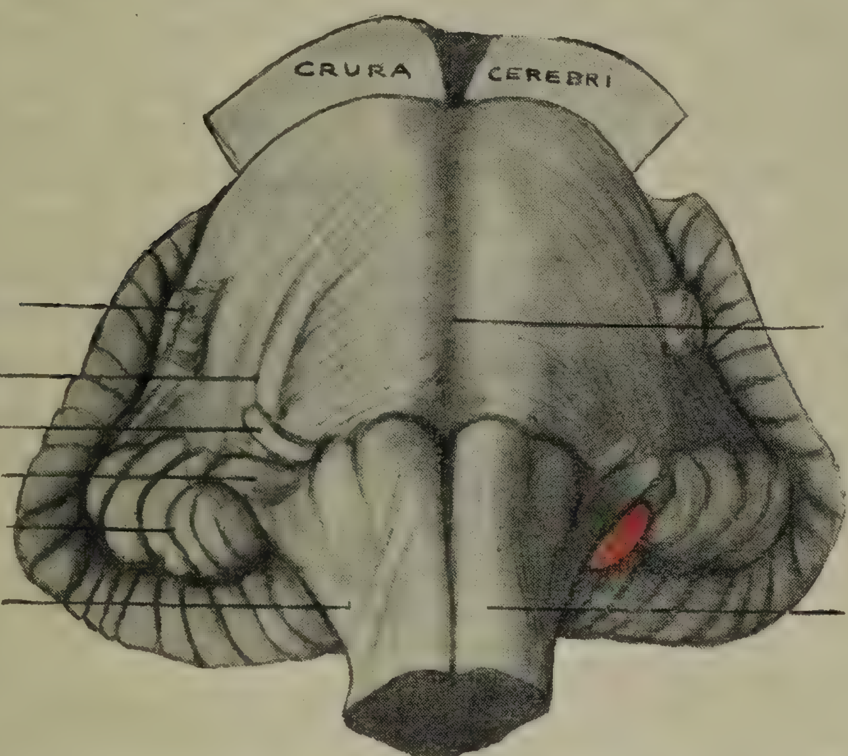


FIG. 890.—FRONT ASPECT OF PONS AND MEDULLA, SHOWING OBLIQUE FIBRES OF PONS AND ARCUATE FIBRES ON MEDULLA.

The **deep arcuate fibres** are disposed in two sets—lemniscal and olivo-cerebellar. The *lemniscal deep arcuate fibres* arise from the nucleus gracilis and nucleus cuneatus of the *same side*. They sweep forwards and inwards (Fig. 889) towards the raphé, passing obliquely through the dorsal longitudinal bundle. At the median line they decussate with those of the opposite side above the level of the decussation of the pyramids. Having reached the opposite side, the deep arcuate fibres change their course, and now pass *upwards* The ascending tract thus formed constitutes the **medial lemniscus** (or medial fillet).

The decussation which takes place between the deep arcuate fibres in the median line, immediately above the decussation of the pyramids, is called the **decussation of the lemnisci** (*decussatio lemniscorum*), or the **superior sensory decussation,** as distinguished from

the inferior sensory or spino-thalamic decussation, which takes place in the spinal cord.

The *olivo-cerebellar deep arcuate fibres* arise from the inferior olivary nucleus of *one side*. Emerging through the hilum, they pass across the median line to the opposite side. They then pass over or through the inferior olivary nucleus of that side, on the dorsal aspect of which they are collected into a distinct tract. This tract, arching backwards, applies itself to the restiform body on its deep aspect, and is thereby conducted to the cerebellar hemisphere. Its fibres terminate in the cortex of the vermis and cerebellar hemisphere. The olivo-cerebellar arcuate fibres constitute the *olivo-cerebellar tract*, which connects the inferior olivary nucleus of *one side* with the cerebellar hemisphere of the *opposite side*.

Lemniscus.—The *lemniscus* (or fillet), as seen in the bulb, is a well-marked tract of fibres which lies on the dorsal aspect of the pyramid close to the raphé. As just stated, its fibres are derived from the lemniscal deep arcuate fibres of the *opposite side*. In the lower part of the bulb the fillet and posterior longitudinal bundle are closely related. In the upper part of the bulb, however, as already said, the posterior longitudinal bundle is displaced dorsalwards by the developing fillet, and the fillet, now distinct from the longitudinal bundle, lies on the ventral aspect of that bundle, and on the dorsal aspect of the pyramid. The ventral region of the bulb is thus traversed by four longitudinal tracts, all of which lie close to the median line. These tracts are related to each other in the following order from before backwards (ventro-dorsally):

Pyramid.
Fillet.
Tecto-spinal.
Posterior longitudinal bundle.

Olivo-cerebellar Tract.—This tract has already been described in connection with the olivo-cerebellar deep arcuate fibres.

Raphé of the Medulla Oblongata.—The raphé of the bulb occupies the median plane above the decussation of the pyramids, and is composed of fibres which, for the most part, cross obliquely from one side to the other. These fibres represent (1) the anterior superficial arcuate fibres, (2) the lemniscal deep arcuate fibres, and (3) the olivo-cerebellar deep arcuate fibres. A few fibres pass ventro-dorsally, and some are disposed longitudinally. The fibres are therefore arranged in an intersecting manner.

Central Canal of the Medulla Oblongata.—The central canal of the spinal cord is prolonged upwards through the lower or closed part of the bulb. As it ascends it is gradually displaced backwards, first by the decussation of the pyramids, and afterwards by the decussation of the lemnisci. It is surrounded by a thick layer of grey matter, which is derived from the basal portions of the ventral and dorsal grey horns of the spinal cord. Superiorly, at the level of the obex,

it opens into the lower part of the fourth ventricle in the angle between the two diverging clavæ. The grey matter which surrounds the canal is now spread out, and forms a thick covering over the lower part of the ventricular floor, as has been said already.

Areas of Flechsig.—These areas involve the whole substance of the bulb, and are mapped out by the funiculi of the hypoglossal and vagus nerves. Seen in transverse section, these funiculi lie near each other as they arise from their nuclei in the grey matter of the lower part of the floor of the fourth ventricle. As the funiculi of the hypoglossal nerve pass forwards and those of the vagus nerve outwards they diverge from each other, and the substance of the bulb is thereby divided into three segments, which constitute the *areas of Flechsig*—ventral, lateral, and dorsal (see Fig. 891).

FIG. 891.—PLAN TO ILLUSTRATE THE THREE AREAS OF FLECHSIG, SHOWING THE MAIN STRUCTURES IN EACH OF THESE.

The **ventral area** lies between the raphé of the bulb and the funiculi of the hypoglossal nerve. Throughout its thickness this area contains the following structures:

The pyramid and arcuate nucleus (Fig. 891, P).
The lemniscus, decussating (L).
The posterior longitudinal bundle (B).
The formatio reticularis alba.

The **lateral area** lies between the funiculi of the hypoglossal nerve and those of the vagus nerve. Throughout its thickness this area contains the following structures:

The olive and inferior olivary nucleus.
The nucleus lateralis (NL).
The nucleus ambiguus (to be afterwards described) (NA).
The formatio reticularis grisea.

The **dorsal area** is the region behind the funiculi of the vagus nerve. Throughout its thickness this area contains the following structures:

The inferior peduncle.
The upper part of the cuneate nucleus (C).
The descending root of the vestibular nerve } To be afterwards described.
The fasciculus solitarius (S)
The spinal root of the fifth cranial nerve (V)
The substantia gelatinosa (G).

Course of Chief Nerve Funiculi of Spinal Cord through Medulla Oblongata.

Spinal Cord.	Medulla Oblongata.
Posterior Column.	
Column of Goll (fasciculus gracilis).	Funiculus gracilis and nucleus gracilis.
Column of Burdach (fasciculus cuneatus).	Funiculus cuneatus and nucleus cuneatus.
Lateral Column.	
(Crossed) lateral cerebro-spinal tract.	Inner three-quarters of opposite pyramid.
Anterior cerebro-spinal tract.	Outer one-quarter of pyramid of same side.
Dorsal (or direct) spino-cerebellar tract.	Lateral area below olive, and inferior peduncle.
Ventral (or indirect) spino-cerebellar (tract of Gowers). Prepyramidal or rubro-spinal tract. Lateral intersegmental.	Lateral area below olive, and formatio reticularis.
Anterior Column.	
Anterior cerebro-spinal tract. Tecto-spinal tract.	Outer one-quarter of pyramid of same side.
Ventral intersegmental. Anterior marginal bundle (of Lowenthal).	Posterior longitudinal bundle.

Development of Medulla Oblongata.—The bulb is developed from the **myelencephalon,** which is the caudal division of the **rhombencephalon.**

2. The Pons.

The **pons (Varolii)** is situated above the medulla oblongata, and between the hemispheres of the cerebellum. With the exception of the inferior peduncles, all parts of the medulla oblongata are prolonged into it. The pons presents two surfaces (ventral and dorsal) and two borders (upper and lower). The **ventral surface** (Fig. 890) rests upon the upper part of the basilar groove of the occipital bone and the dorsum sellæ of the sphenoid. It is convex from side to side, and from above downwards, and has a transversely striated appearance, due to the disposition of its superficial fibres. Along the median line it presents the *basilar groove,* which extends from the lower to the upper border, and lodges the basilar artery. On either side of this groove the ventral surface is rendered prominent by the prolongation upwards of the pyramids of the medulla oblongata, and the basilar groove is chiefly due to this circumstance. The sensory and motor roots of the fifth nerve, lying close together, appear on the lateral aspect of the ventral surface, the small motor root being the upper of the two. The portion external to these two nerve-roots constitutes the middle peduncle of the cerebellum. It is composed of the transverse fibres of the pons, which pass backwards and laterally into the corresponding cerebellar hemisphere.

The **dorsal surface** is directed towards the cerebellum. It presents a triangular area which is covered with grey matter. This area is continuous with the dorsal surface of the upper or open part of the medulla oblongata, and it forms the upper or pontine part of the floor of the fourth ventricle. On either side it is bounded by the superior peduncle of the cerebellum as it passes upwards and inwards.

The **upper border** is slightly depressed at the centre, and on either side of the median depression it slopes outwards and downwards towards the middle peduncle of the cerebellum. The crura cerebri, right and left, sink into the pons at the upper border.

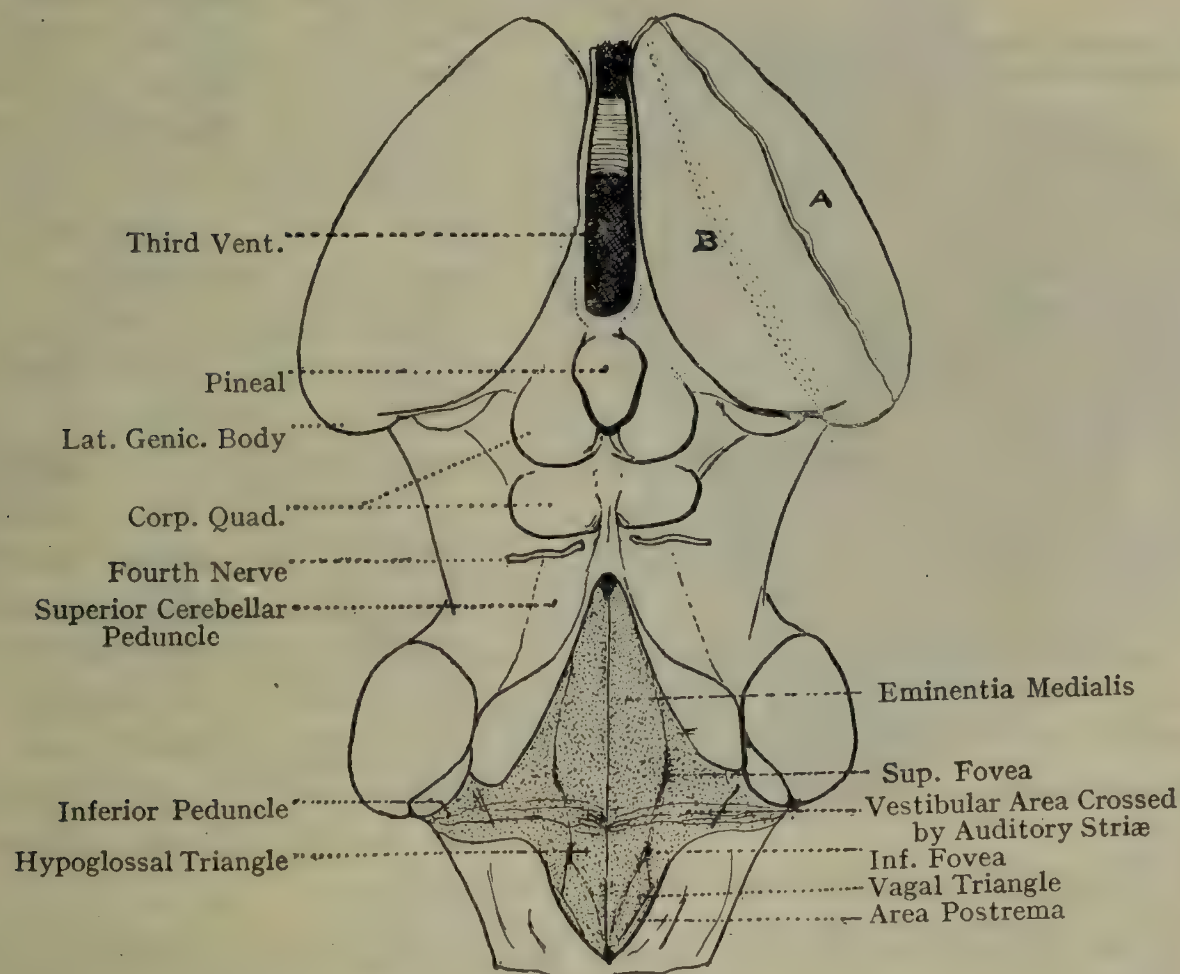


FIG. 892.—POSTERIOR ASPECT OF MID- AND HIND-BRAINS.

Internal Structure of the Pons.—The pons is composed of a large ventral and a small dorsal part.

Ventral Part.—This portion consists of (1) bundles of transverse fibres, (2) bundles of longitudinal fibres, and (3) a large amount of grey matter.

The **bundles of transverse fibres** intersect the bundles of longitudinal fibres, and on either side they are collected into the middle peduncle of the cerebellum, which enters the corresponding cerebellar hemisphere. Some of the transverse fibres arise in the cortex of the cerebellum as the axons of the 'cells of Purkinje,' and these terminate in the pons in arborizations round the cells of the *nucleus pontis*, mostly on the opposite side to that on which they arise. Other transverse fibres arise in the pons as the axons of the cells of the nucleus pontis on one side. They then cross to the other

side, and enter the cerebellar hemisphere of that side, where they terminate in arborizations in the cortex. The fibres, therefore, of which the middle peduncle of the cerebellum is composed may be regarded as being of two kinds—namely, efferent and afferent. The efferent fibres arise in the cerebellar cortex and terminate in the pons, whilst the afferent fibres arise in the pons and terminate in the cerebellar cortex.

The **bundles of longitudinal fibres** in each half of the ventral part of the pons are derived from the breaking up of the *crusta* or basis pedunculi of the corresponding **crus cerebri,** which enters the pons at its upper border. Most of these bundles are collected together at the lower border of the pons, and form the **pyramid** of the medulla oblongata on the same side. Certain of the fibres of the basis pedunculi, however, terminate in the pons as follows: (1) some end in arborizations around the cells of the motor nucleus of the fifth cranial nerve, the nucleus of the sixth cranial nerve, and the nucleus of the seventh cranial or facial nerve; and (2) others end in arborizations around the cells of the nucleus pontis, all of the same side.

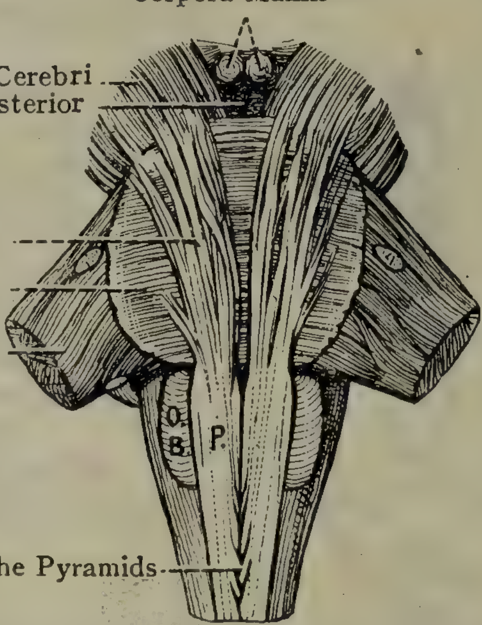


FIG. 893.—DISSECTION OF THE PONS, SHOWING THE COURSE OF THE PYRAMIDAL TRACTS OF THE MEDULLA OBLONGATA (HIRSCHFELD AND LEVEILLÉ).

P., right pyramid; O.B., right olivary body.

> The fibres to cranial motor nuclei may run a more aberrant course, leaving the basis pedunculi in the mid-brain and running in the tegmentum of the pons to decussate and reach their objectives. Some also run a recurrent course, leaving the pyramid below the pons and turning upwards deeply.

The **grey matter** of the pons, which is large in amount, occupies the intervals between the intersecting transverse and longitudinal bundles, and contains small multipolar nerve-cells. It is known as the *nucleus pontis,* and is continuous with the arcuate nuclei of the medulla oblongata.

Corpus Trapezoides or Trapezium.—The trapezium is a fairly thick layer of transverse fibres on either side, which have no connection with the corresponding middle peduncle of the cerebellum. The fibres are situated in the lower part of the pons dorsal to the pyramidal bundles. Within the trapezium are large multipolar cells, which constitute the *nucleus of the trapezium.* The fibres of the trapezium arise chiefly as the axons of the cells of the ventral cochlear

nucleus, and also of the dorsal cochlear nucleus (or tuberculum acusticum), in which nuclei the fibres of the cochlear division of the auditory nerve terminate. Some of the fibres arise from the superior olivary nucleus; others are the axons of the cells of the nucleus of the trapezium; whilst a third set (*auditory striæ*) arise from the tuberculum acusticum of the opposite side. Certain of the fibres

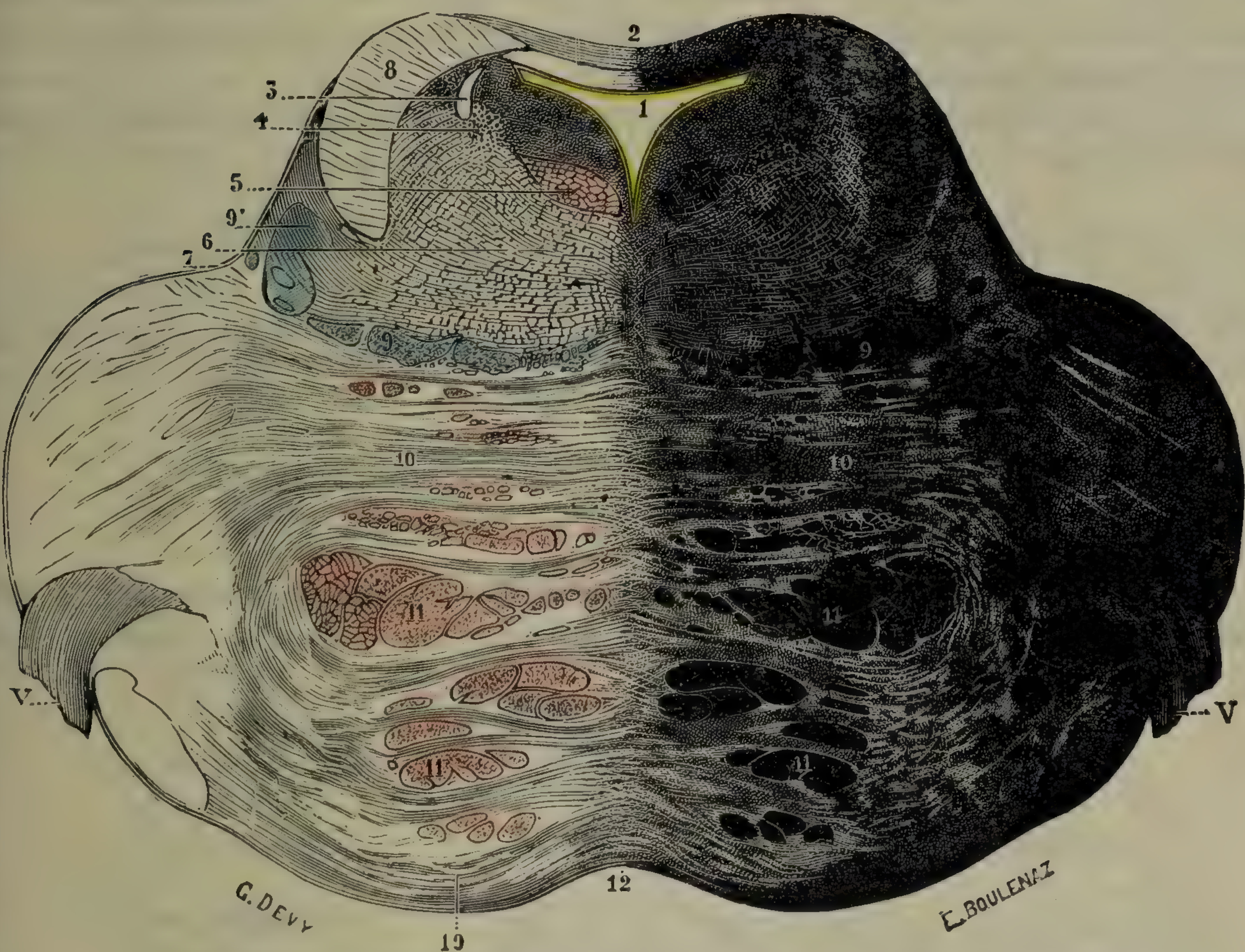


FIG. 894.—VERTICAL TRANSVERSE SECTION THROUGH THE UPPER PART OF THE PONS AND FOURTH VENTRICLE (FROM L. TESTUT'S 'ANATOMIE HUMAINE,' AFTER STILLING).

1. Fourth Ventricle
2. Superior Velum
3. Superior Root of Fifth Nerve
4. Nerve-cells which accompany this Root
5. Posterior Longitudinal Bundle
6. Formatio Reticularis
7. Lateral Fissure of Isthmus
8. Section of Superior Cerebellar Peduncle

9, 9. Medial and Lateral Portions of the Lemniscus
10, 10. Transverse Fibres of the Pons
11, 11. Longitudinal Fibres of the Pons
12. Raphé
V. Fifth Nerve

of the trapezium terminate in the superior olivary nucleus, but the majority cross the median plane, where they decussate with those of the opposite side. Having crossed to the opposite side, they become longitudinal, and form a well-marked ascending tract in the dorsal part of the pons, called the **lateral lemniscus**, which lies on the outer side of the main or medial fillet.

Dorsal or Tegmental Part of the Pons.—This portion is divided into two symmetrical halves by a median raphé, which is continuous with that of the upper or open part of the medulla oblongata. It consists of formatio reticularis, which is continued upwards from the formatio reticularis of the bulb. The formatio reticularis of the

dorsal part of the pons contains certain tracts of nerve-fibres and nuclei, with which important nerves are connected. These are so complicated that it is convenient to divide the dorsal part of the pons into two regions—lower and upper.

Lower Region.—This region corresponds to the level of the trapezium in the ventral part of the pons, and succeeds the upper end of the bulb. The inferior peduncle of the bulb lies for a short distance on the lateral aspect of this region, but soon passes backwards and sinks into the hemisphere of the cerebellum.

The tracts and nuclei of the formatio reticularis of the lower region, which will be described in this place, are as follows:

1. Spinal sensory root of the fifth cranial nerve.
2. Motor nucleus of the facial nerve.
3. Superior olivary nucleus.
4. Nucleus of the sixth cranial nerve.
5. Posterior longitudinal bundle.
6. Rubro-spinal tract.
7. Tecto-spinal tract.
8. Lemniscus.

The **funiculi of the spinal or descending sensory root of the fifth cranial nerve** appear ventro-medial to the mass of the inferior cere-

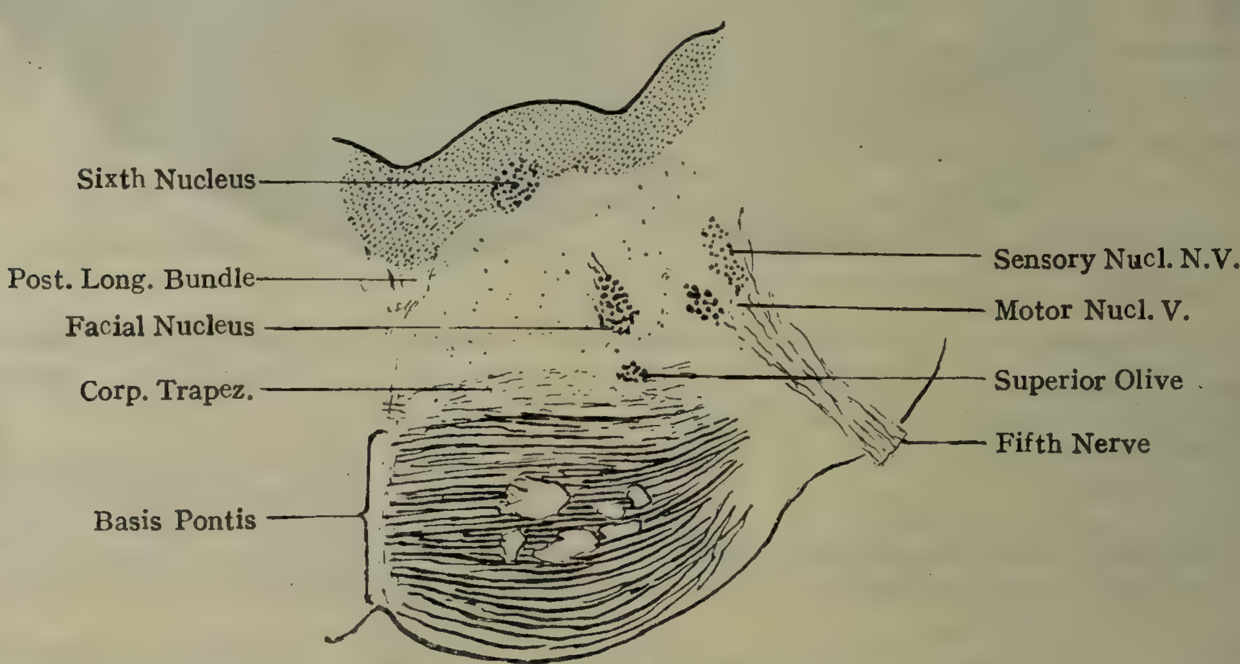


Fig. 895.—Nuclear Positions in Pons (Schematic).

bellar peduncle. Close to the inner side of this root, and accompanying it in its downward course, there is the **inferior sensory nucleus** of the fifth nerve, around the cells of which the fibres of the spinal or descending root of that nerve terminate at intervals. The inferior sensory nucleus is an upward prolongation of the substantia gelatinosa, and inferiorly it extends to about the level of the second cervical spinal nerve (see Fig. 885).

The **motor nucleus of the facial nerve** is internal to the funiculi of the spinal root of the fifth nerve. It lies deeply in the lower region of the dorsal part of the pons on the dorsal aspect of the superior

livary nucleus. The motor fibres of the facial nerve arise as the xons of the cells of this nucleus (see Fig. 896).

The **superior olivary nucleus** is situated on the ventral aspect of he facial nucleus, and is close to the lateral part of the trapezium, he fibres of which arch round its ventro-lateral aspect. Some of hese fibres terminate in the superior olivary nucleus, whilst others rise from its cells.

In connection with the superior olivary nucleus three other nuclei are lescribed: (1) an accessory superior olivary nucleus on the medial side of the rincipal nucleus; (2) a lateral pre-olivary nucleus on the ventral aspect of the rincipal nucleus; and (3) a medial pre-olivary nucleus on the ventral aspect of he nucleus of the trapezium.

The **nucleus of the sixth cranial nerve** lies immediately beneath he grey matter of the pontine part of the floor of the fourth ventricle, nd on the lateral side of the dorsal longitudinal bundle which separates he nucleus from the median raphé. It corresponds to that portion

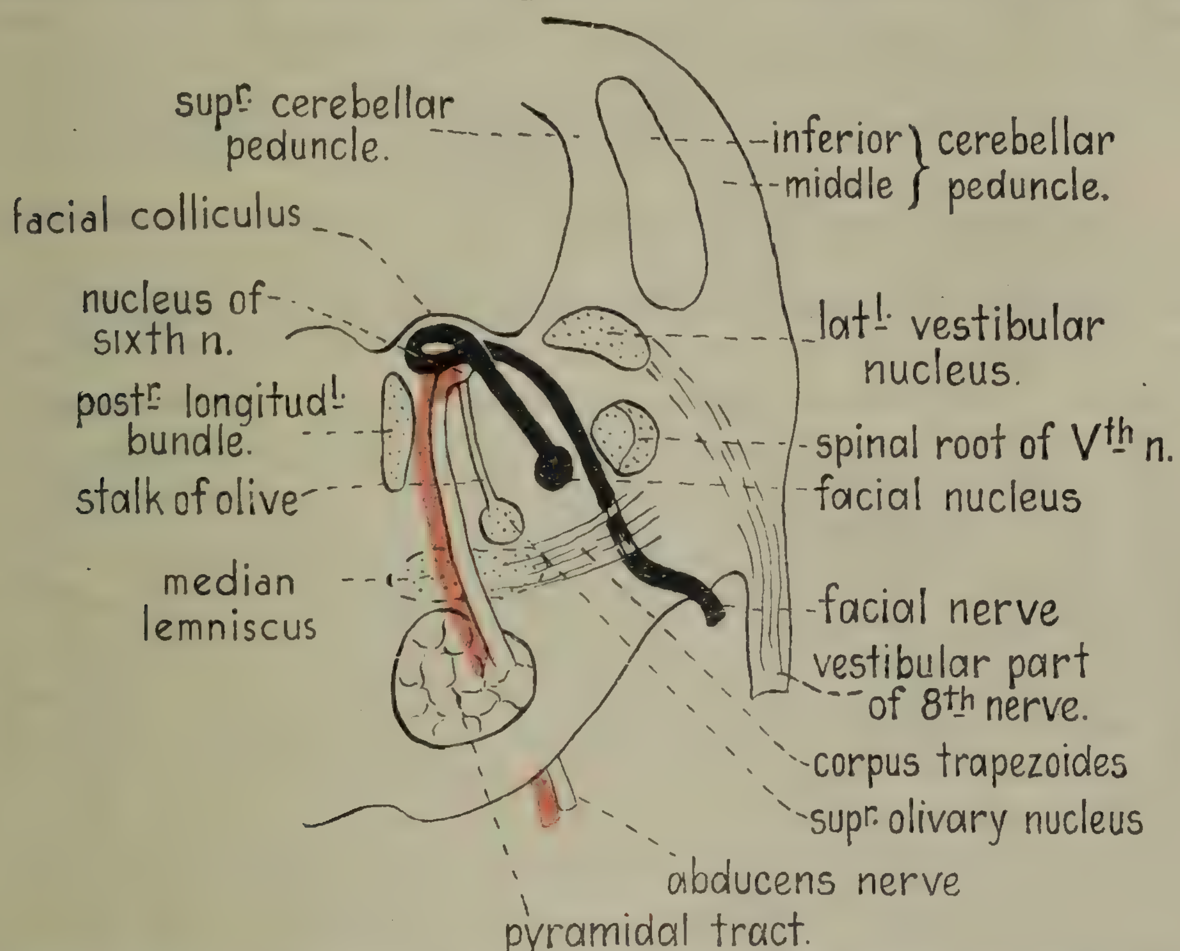


FIG. 896.—DIAGRAMMATIC SECTION THROUGH THE PONS, TO SHOW DEEP ORIGINS OF SIXTH (RED) AND SEVENTH (BLACK) CRANIAL NERVES.

of the facial colliculus which lies on the pontine part of the floor of the fourth ventricle directly above the auditory striæ.

The **medial** or **posterior longitudinal bundle** lies close to the median raphé, and on the medial side of the nucleus of the sixth nerve. Like that nucleus, it lies immediately beneath the grey matter of the pontine part of the floor of the fourth ventricle.

The **lemniscus** (medial, medial fillet) lies, as it does in the bulb, ventral to the dorsal longitudinal bundle, but in the dorsal part of the pons the two strands are separated by a distinct interval occupied

by the rubro- and tecto-spinal tracts. It will have been noticed that in the spinal cord the tecto-spinal tract lies ventral to the rubro-spinal, but later on it will be seen that the tectum or quadrigeminal region is dorsal to the red nucleus. It is therefore clear that somewhere in their course they must reverse their relative positions, and the rubro-spinal become ventral to the tecto-spinal. Where this happens is not at present clear; indeed, the exact relations of these and many other tracts, such as the vestibulo-spinal, spino-thalamic, and spino-tectal in the upper part of their course, are still under investigation. The lemniscus occupies a broad area in that portion of the lower region of the dorsal part of the pons which is contiguous to the ventral part. The area extends outwards from the median raphé.

Upper Region of the Dorsal Part of the Pons.—This region lies *above* the level of the trapezium in the ventral part of the pons. The tracts and nuclei of this region, which will be described in this place, are as follows:

1. Superior peduncle of the cerebellum.
2. Nuclei of the fifth cranial nerve.
3. Medial or posterior longitudinal bundle.
4. Medial fillet or lemniscus.
5. Lateral fillet or lemniscus.

The **superior peduncle of the cerebellum,** after emerging from the corresponding cerebellar hemisphere, lies on the lateral aspect of this region, where it forms the lateral boundary of the upper or pontine part of the floor of the fourth ventricle. Its dorsal aspect is connected with that of its fellow of the opposite side by the *superior medullary velum*, and ventrally it sinks into the upper region of the dorsal part of the pons.

The **pontine nuclei of the fifth cranial nerve** are motor and sensory. The motor and main sensory roots are pontine, and the sensory root is prolonged down as the *spinal tract*, and up as the *mesencephalic root*.

The **motor nucleus** is situated close to the superior peduncle of the cerebellum at the lower part of the lateral margin of the upper or pontine part of the fourth ventricle. It lies near the surface, and the axons of its cells form many of the fibres of the motor root of the nerve.

The **main sensory nucleus** is situated deeply on the outer side of the motor nucleus, and on the ventral aspect of the superior peduncle of the cerebellum. Some of the fibres of the sensory root ascend and terminate in arborizations around the cells of this nucleus.

The **lower** or **spinal sensory nucleus** succeeds to the main sensory nucleus, and is a continuation upwards of the substantia gelatinosa. It is elongated, and extends into the upper part of the spinal cord to about the level of the second cervical nerve. It lies on the medial side of the spinal or descending sensory root of the fifth nerve, and the fibres of that root (*spinal tract*) terminate at intervals in arborizations around its cells.

The mesencephalic root arises from groups of small cells which are placed in the grey matter of the mid-brain, beside the aqueduct,

extending up as far as the canal of the lower end of the superior colliculus. Fibres run down from this part, but their actual disposition in the fifth nerve is not yet settled.

There is some ground for supposing that this part of the nuclear arrangement of the fifth nerve is concerned with the reception of proprioceptive impulses from orbital muscles.

The **posterior** or **medial longitudinal bundle** has the same position in the upper region as it has in the lower region. It lies close to the median raphé, and immediately below the grey matter of the corresponding part of the floor of the fourth ventricle.

The **main** or **medial lemniscus,** like the main fillet in the lower region, lies in that portion of the upper region of the dorsal part of the pons which is near the ventral part, and it forms a layer of some breadth, extending outwards from the median raphé.

The **lateral lemniscus** is a strand of fibres which lies on the outer side of the medial fillet, and connects the cochlear nucleus with the opposite inferior corpus quadrigeminum. Associated with the lateral fillet, and lying between it and the medial fillet, there is a collection of nerve-cells, called the *nucleus of the lateral lemniscus.*

Development of the Pons.—The pons is developed from the ventral and lateral walls of the metencephalon, which is one of the divisions of the rhombencephalon. The nuclear matter seems to be derived from the ponto-bulbar body, spreading over the surface of the neural tube.

3. The Cerebellum.

The cerebellum, or small brain, occupies the inferior occipital or cerebellar fossæ of the occipital bone. It lies beneath the posterior parts of the hemispheres of the cerebrum, from which it is separated by a septum of the dura mater, called the tentorium cerebelli, and it is behind and above the medulla oblongata and pons. It is composed of white and grey matter, the white matter being situated in the interior, where it constitutes the medullary substance, and the grey matter being spread over the surface of the cortex. In appearance it is laminated or foliated, the laminæ being separated from each other by parallel, slightly curved sulci. It is composed of two large lateral portions, called **hemispheres,** and a connecting median portion, termed the **vermis,** these parts being much more distinct below than above. When looked at from above it presents in the median line two notches, anterior and posterior. The **anterior notch,** which is wide, is known as the *incisura semilunaris*, and it contains the inferior pair of quadrigeminal bodies and the superior cerebellar peduncles. The **posterior notch** is narrow, and is occupied by the falx cerebelli. The most conspicuous sulcus of the cerebellum is the **great horizontal fissure,** which extends round the circumference, and passes for some distance into the interior. By means of this fissure the cerebellum is divided into two parts, upper and lower.

Relatively smaller in the new-born child, the cerebellum forms in the adult about an eighth of the whole mass of the brain.

The cerebellar surface is marked, as stated above, by the presence of numerous flattened or laminar gyri or folds, each fold being separated from its neighbours by sulci of appreciable depth. Among these fissures are certain ones which are evident and deeper, and these can be taken to divide the surfaces into lobules or parts, which have some small descriptive value.

The presence of the foliated surface, and of certain striking appearances in different parts of the cerebellum, have led in the past to a wealth of terminology and description which, for the greater part, does not seem to be of much value or utility. Moreover, since these terms have in many instances come down from long past periods, they are archaic and fanciful. Thus it seems desirable to replace these with a short account of the cerebellar surface, broadly described, after which the older terms

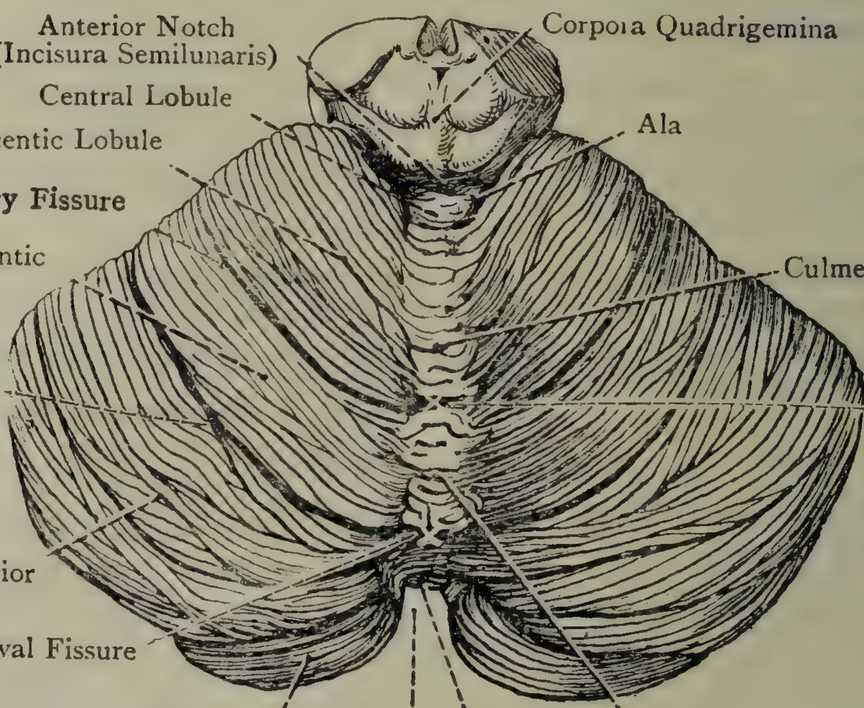


FIG. 897.—THE CEREBELLUM (SUPERIOR VIEW).

and descriptions will be given in small print, for purposes of reference if required. Subsequently a short morphological consideration of the part can be added.

Upper Surface of the Cerebellum.—This surface presents in the median line the upper part of the vermis, known as the **superior vermis** (see Fig. 897). It extends from the incisura semilunaris to the posterior notch, and it forms a laminated elevation, which is higher in front than behind, the most prominent part being known as the *monticulus cerebelli.* On either side of the superior vermis the upper surface of each hemisphere inclines downwards to the circumference, and there is no distinct demarcation between it and the superior vermis.

This **upper aspect** is divided (Fig. 898) by two main fissures, *primary* and *postclival,* which are continued across the slight elevation of the superior vermis.

The **primary fissure** (Fig. 898, PR) cuts across the vermis a little behind its highest point, the culmen. From this the fissure is continued with a slight forward curve on each side, to reach the horizontal fissure.

The fissure is termed 'primary' because it forms the posterior limit, at a fairly early stage, of the morphological entity, the anterior lobe.

The **postlunate** or **postclival fissure** (PC) is behind the primary fissure and below it; this is due to the descent of the vermis from the culmen, forming its 'declive' behind the primary fissure. The postclival fissure turns forward on each side with a bolder curve towards the horizontal fissure.

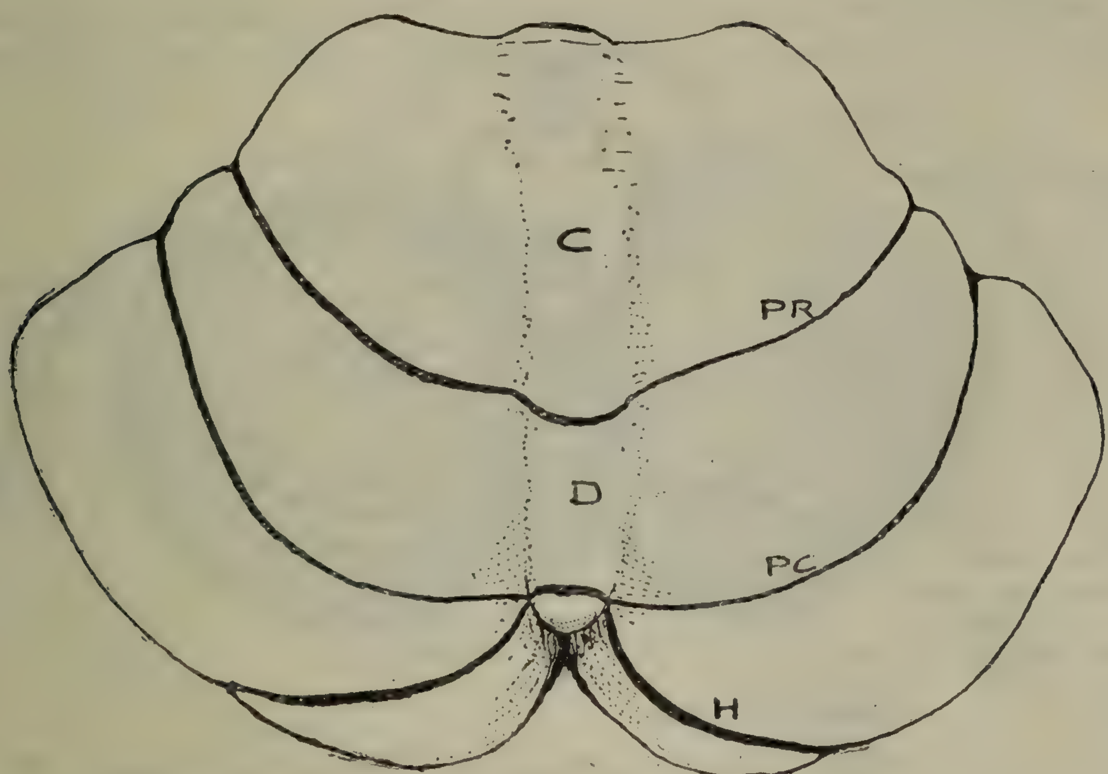


FIG. 898.—UPPER ASPECT OF CEREBELLUM, WITH MAIN SUBDIVISIONS.

C, culmen; D, declive (or clivus); PR, primary fissure; PC, postlunate (or postclival) fissure; H, posterior end of horizontal fissure.

The **anterior lobe** lies above and in front of the primary fissure, including the parts of the vermis and lateral lobes as a continuous whole.

The **posterior lunate lobe** lies between the primary and postlunate fissures, and includes also the central vermis.

The posterior end of the **horizontal** sulcus (H) appears usually on this aspect of the cerebellum. It fails to reach the vermis, usually running into the postlunate sulcus.

The lobule which is seen on each side below the postlunate and above the horizontal fissure is frequently referred to as the **superior crescentic** lobule; it is also termed the **superior** (division of the) **ansiform lobe.**

The **superior vermis** is composed of five lobules, named, in order from before backwards, the lingula, central lobule, culmen monticuli, clivus monticuli, and folium cacuminis. The **lingula** is deeply placed, and consists of about four laminæ or folia, which lie over the superior medullary

velum as it extends between the superior cerebellar peduncles. Its laminæ may be continued on either side over the superior cerebellar peduncle, and, when this is so, the prolongation is known as the **frenulum lingulæ.**

The **central lobule** is of small size, and lies at the bottom of the incisura semilunaris. It is separated from the lingula by the precentral fissure, and from the culmen monticuli by the postcentral fissure.

The **culmen monticuli** forms the summit of the superior vermis. It is composed of several laminæ, and posteriorly is separated from the clivus by the preclival fissure.

The **clivus monticuli** represents the sloping part of the monticulus cerebelli. It is situated behind the culmen monticuli, and is composed of several laminæ. Posteriorly it is separated from the folium cacuminis by the postclival fissure.

The **folium cacuminis** forms the posterior extremity of the superior vermis, and lies at the posterior notch, where it is placed above the great horizontal fissure.

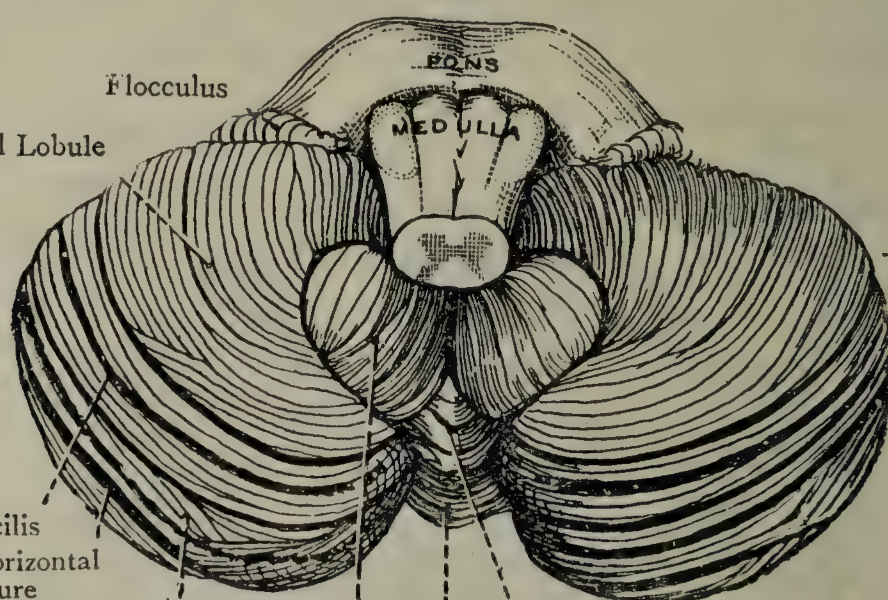


FIG. 899.—THE CEREBELLUM (INFERIOR VIEW).

The inferior semilunar lobule and the lobulus gracilis constitute the postero-inferior lobule. Old terminology used.

The **upper surface of each hemisphere** is mapped out into lobules, which are continuous with the subdivisions of the superior vermis, with the exception of the lingula. These are called, in order from before backwards, the ala, anterior crescentic lobule, posterior crescentic lobule, and postero-superior lobule.

The *ala* is continuous with the central lobule, from which it is prolonged for a limited distance round the anterior part of the hemisphere in the region of the incisura semilunaris.

The *anterior crescentic lobule* is continuous with the culmen monticuli, and represents the anterior subdivision of the upper surface of the cerebellar hemisphere. It is limited posteriorly by a curved sulcus, called the *antero-superior fissure*, which is continuous with the *preclival fissure* (fissura prima), and opens at the circumference into the great horizontal fissure. The right and left anterior crescentic lobules, together with the culmen monticuli, form the **lobus culminis** (see Fig. 897).

The *posterior crescentic lobule* is continuous with the clivus monticuli. It is limited in front by the *antero-superior fissure*, and behind by the *postero-superior fissure*, the latter being continuous with the *postclival fissure*, and opening at the circumference into the great horizontal fissure.

The right and left posterior crescentic lobules, together with the clivus monticuli, form the **lobus clivi.**

The *postero-superior lobule* (superior semilunar lobule) corresponds to, but is much more extensive than, the folium cacuminis. It is limited in front by the postero-superior fissure, and behind by the great horizontal fissure. The right and left postero-superior lobules, together with the folium cacuminis, form the **lobus cacuminis.**

Under Surface of the Cerebellum.—The under surface presents in the median line a deep groove, called the **vallecula,** which is continuous behind with the posterior notch. Anteriorly it lodges the medulla oblongata, and lying in the bottom of it there is the lower part of the vermis, which is known as the **inferior vermis.** The vallecula separates the two cerebellar hemispheres from each other, and the inferior vermis is separated on either side from the corresponding hemisphere by a furrow called the *sulcus valleculæ.* The under surfaces of the hemi-

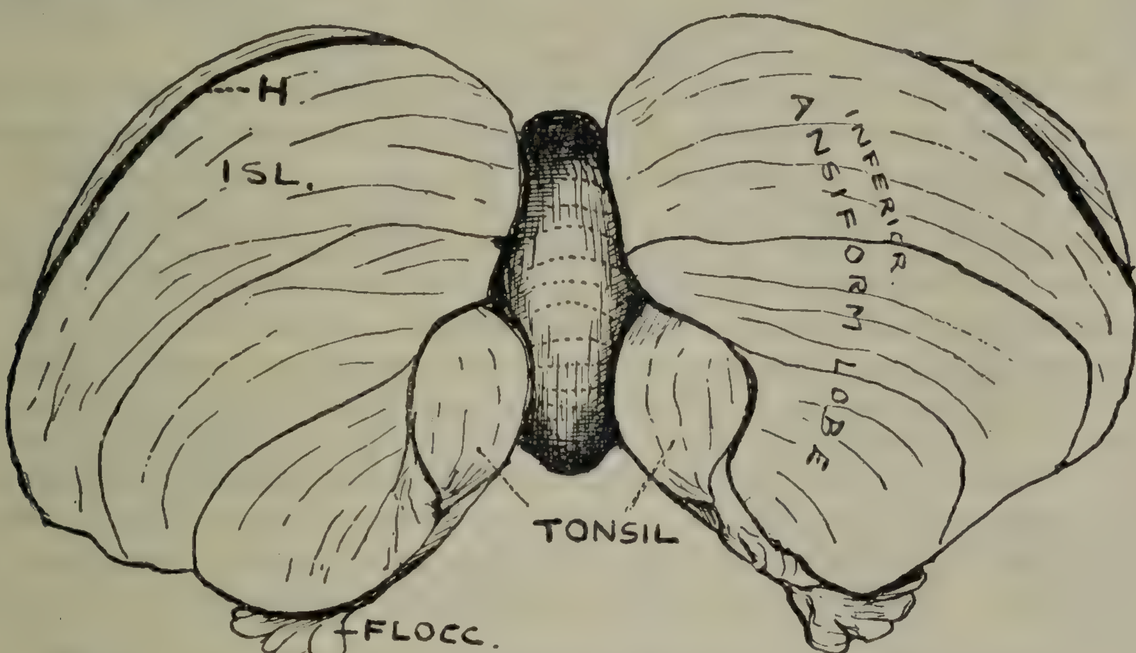


Fig. 900.—Lower Aspect of Cerebellum, showing the (Inferior) Ansiform Lobe and the Paramedian Lobule or Tonsil; also the Flocculus.

spheres are markedly convex, and are received into the inferior occipital or cerebellar fossæ of the occipital bone.

The inferior aspect of the cerebellum (Fig. 900) presents on the lateral lobes, near the margins, the greater part of the horizontal fissure (H). The two additional fissures shown in the figure are of quite secondary importance; the upper one of the two was taken formerly as the lower boundary of the 'inferior crescentic lobule' (ISL.), but it is not necessary now to subdivide the inferior surface in this way, but rather to term all this curved surface the posterior or postero-inferior lobe, or the inferior (part of the) ansiform lobe.

The paramedian lobule or tonsil, however, stands out as a striking formation on each side of the 'posterior notch,' and is not included in the name given to the rest of the inferior surface. The base of the tonsil is received in a cup-shaped concavity on the inferior and medial surface of the ansiform lobe, from which it is separated by a deep retrotonsillar fissure. The loosely foliated flocculus (FLOCC) is

visible on each side, outside and in front of the tonsil. The flocculus has a white 'stalk,' which is continuous with the inferior medullary vellum, making with this a large part of the bed of the hollow which contains the tonsil. This velum is connected centrally with the 'nodule,' the terminal piece of the inferior vermis.

The **inferior vermis** is composed of four lobules, named, in order from behind forwards, tuber valvulæ, pyramid, uvula, and nodule.

The **tuber valvulæ** (tuber posticum) forms the posterior part of the inferior vermis, and is composed of several laminæ. On either side it is prolonged into the corresponding hemisphere, and becomes continuous with the postero-inferior lobule. It is the only part of the inferior vermis which is prolonged into the cerebellar hemispheres.

The **pyramid** is situated in front of the tuber valvulæ. It presents about four laminæ, and is separated by deep sulci from the tuber valvulæ behind and the uvula in front, whilst on either side it is separated from the cerebellar hemispheres by the sulcus valleculæ. Laterally it is connected with the biventral lobule of the hemisphere by means of a faint ridge, but this lies low in the sulcus valleculæ as it crosses.

The **uvula** is situated in front of the pyramid, and between the amygdalæ or tonsils of the hemispheres. It is triangular, the base being directed backwards, and it consists of several laminæ. It is separated on either side from the hemisphere by the sulcus valleculæ. Laterally its narrow part is connected with the amygdala by a ridge of grey matter, but this lies low in the sulcus valleculæ as it crosses. This ridge is notched at intervals, and is called the **furrowed band.**

The **nodule** forms the anterior part of the inferior vermis, and is composed of several laminæ, which are largely concealed by the uvula. It is connected on either side with the flocculus by a thin semilunar band of white matter, which is the lateral portion of the **inferior medullary velum.**

The **fissures** of the inferior vermis are three: *postpyramidal*, between the pyramid and the tuber valvulæ; *prepyramidal* (fissura secunda), between the pyramid and the uvula; and *postnodular*, between the nodule and the uvula.

The **under surface of each hemisphere** is mapped out into four lobules, which are called, from behind forwards, the postero-inferior lobule, the biventral lobule, the amygdala, and the flocculus.

The **postero-inferior lobule** is situated at the back part of the under surface of the hemisphere. It is divided into four curved parts by three curved fissures. The anterior two parts are known as the *lobulus gracilis*, and the posterior two as the *inferior semilunar lobule*. The right and left postero-inferior lobules, together with the tuber valvulæ, form the **lobus tuberis.**

The **biventral lobule** is composed of curved laminæ, and is somewhat triangular. The pointed end is directed backwards and inwards, and it is connected with the pyramid by a faint ridge, which lies low in the sulcus valleculæ. The base is directed forwards towards the flocculus. The lobulus gracilis lies external to it, and the amygdala is on its inner side. The biventral lobule is divided by a sulcus into two portions, outer and inner; hence the name 'biventral.' The right and left biventral lobules, together with the pyramid, form the **lobus pyramidis.**

The **amygdala** (tonsil) forms a conspicuous prominence between the uvula and the biventral lobule. It is situated in a depression of the vallecula, which is known as the *nidus avis* (' bird's nest '), and its long axis is almost sagittal. It is connected with the narrow part of the uvula by the furrowed band in the sulcus valleculæ. The right and left amygdalæ, together with the uvula, form the **lobus uvulæ.**

The **flocculus** (subpeduncular lobule) is a small irregular lobule which

is situated between the front of the biventral lobule and the middle peduncle of the cerebellum. Internally it is connected with the nodule by the lateral portion of the inferior medullary velum. The right and left flocculi, together with the nodule, form the **lobus noduli.**

In the fœtus a structure, known as the **paraflocculus,** lies behind and to the outer side of the flocculus, and occupies a depression in the petrous bone. In the lower monkeys it persists throughout life, but in man it atrophies after birth.

The **fissures** of the under surface of each hemisphere are: (1) a continuation of the postnodular sulcus, between the biventral lobule and the flocculus; (2) a continuation of the prepyramidal sulcus, between the amygdala and the biventral lobule; (3) the pregracile, or anterior arcuate sulcus, between the biventral lobule and the lobulus gracilis; (4) the midgracile, or middle arcuate sulcus, within the lobulus gracilis; (5) the postgracile, or posterior arcuate sulcus, between the lobulus gracilis and the inferior semilunar lobule; and (6) the small horizontal sulcus within the inferior semilunar lobule.

Cerebellar Morphology.—Extensive examination of the types and varieties of the cerebellum found in different classes of animals has gradually established the fundamental parts of this organ. It has been shown to consist essentially of three lobes—anterior, middle, and posterior—of which the anterior is the most primitive, the middle and posterior appearing in higher forms; in birds both these are present, and in mammals reach a more extensive development, while in man and the higher mammals the middle lobe reaches its most expanded form, varying much in the different orders of mammals below these. It may be added that the vermis is to be looked on as a more primitive and older part of the organ than the lateral lobes, in which the paired formations exhibit much variety.

The *anterior lobe* is represented in man by that portion of the cerebellum lying above and in front of the primary fissure; this has received its name from this relationship, and various names have been given to the part thus marked off, known now as the anterior lobe. The lobe includes the vermis in this part, as far back as behind the culmen, where the fissure cuts through it.

The *middle lobe* is a simple lens-shaped formation (Fig. 901A), as seen on the surface in lower vertebrates. In the mammals, however, it is found to present a simple transverse bar immediately behind the primary fissure, but behind this it shows medial and lateral parts, of which the lateral portions exhibit (Fig. 901A) two main divisions—an upper or anterior one, curved on itself, and hence termed the *ansiform lobule*; and a lower one (continuous with the ansiform lobule) placed beside the median formations, and hence named the *paramedian lobule*.

The *posterior lobe* is also composed of a median part (posterior median lobule) and two lateral portions; these consist on each side of a flocculus and paraflocculus, as illustrated in the figure.

The **human cerebellum** possesses a relatively simple anterior lobe, as pointed out above. There is also a recognizable 'transverse bar,' marking the upper portion of the middle lobe, in the so-called 'lobulus simplex' (posterior lunate lobe or posterior crescentic), which includes

the central declive. It is behind this that the middle lobe is particularly concerned in forming the greater part of the human lateral lobe from the ansiform lobule on each side, while the posterior lobe remains centrally, but degenerates in part in its lateral portions.

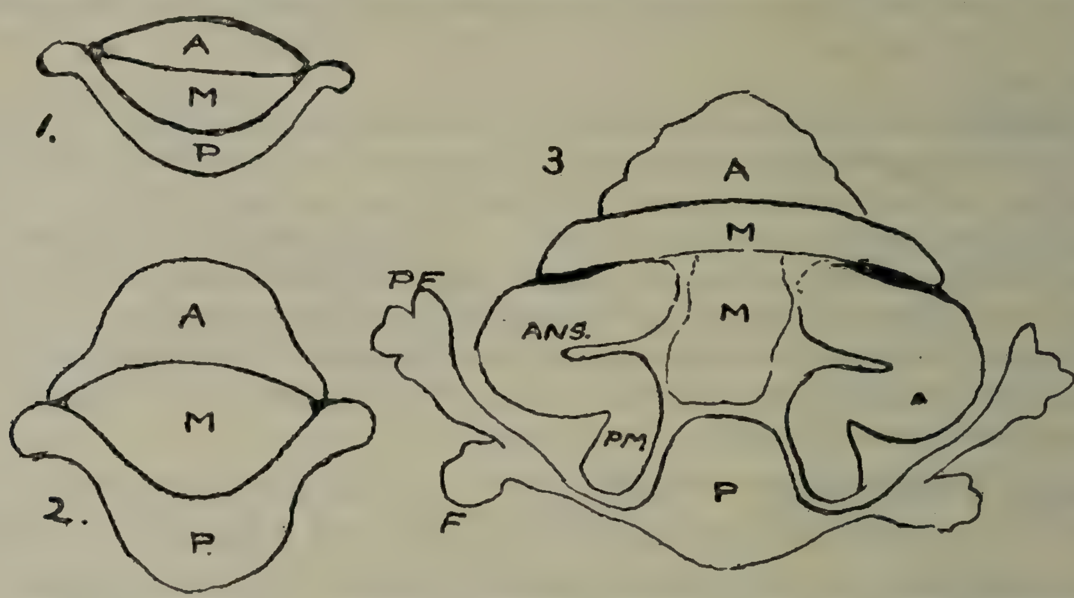


FIG. 901A.—ILLUSTRATIONS OF CEREBELLAR STRUCTURAL MORPHOLOGY, BASED ON FIGURES BY INGVAR.

1, higher reptile; 2, bird; 3, mammal; A, M, P, anterior, middle, and posterior lobes; ANS, PM, ansiform and paramedian lobules; F, PF, flocculus and paraflocculus.

The schematic drawings in Fig. 901B may make this transformation clearer. In the first scheme the recognition of the fundamental parts, as already described, is evident and straightforward; the anterior lobe (A) is separated by the primary fissure from the 'lobulus simplex,' marked by the upper M; the lower M indicates the lower portion of the

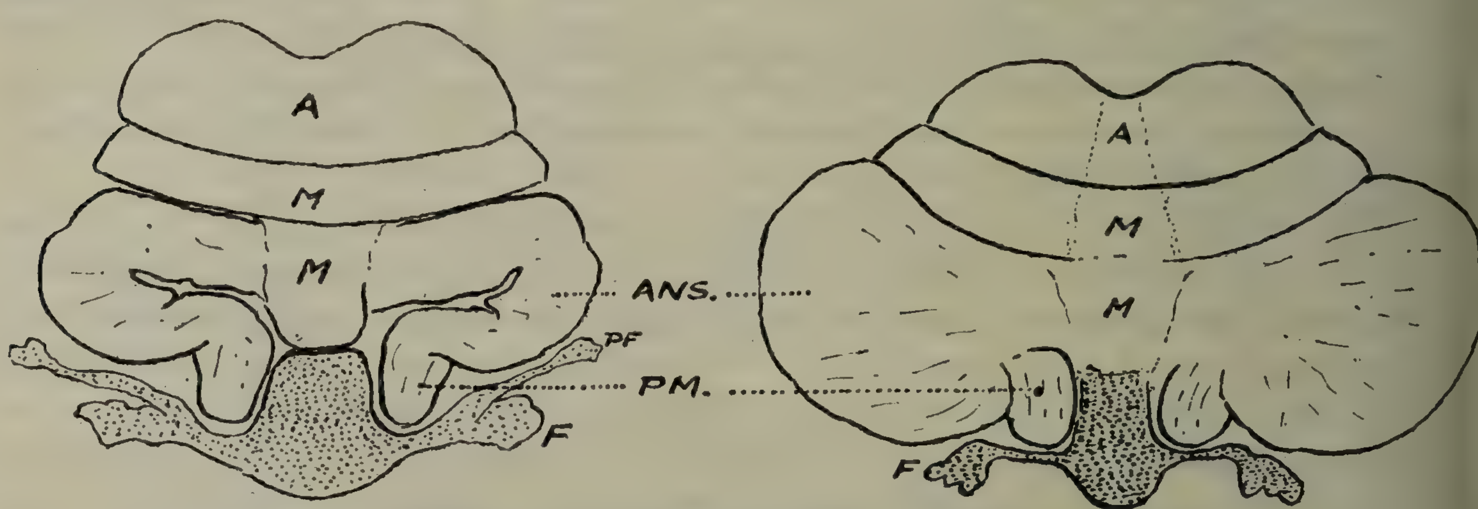


FIG. 901B.—TO ILLUSTRATE HYPOTHETICAL STAGES IN THE EVOLUTION OF FORM OF HUMAN CEREBELLUM.

(References as in previous figure.)

middle lobe, with its two lateral pieces consisting of ansiform (ANS) and paramedian (PM) lobules. The overgrowth of the ansiform lobule accounts for the greater part of the lateral lobe (behind the lobulus simplex), as shown in the second figure, while the paramedian lobule remains as the 'tonsil.' The great ansiform enlargement is naturally

in a dorsal and lateral direction mainly, so that the paramedian lobule is overlapped, and finds itself on the anterior aspect of the lower and median part of the enlargement.

The posterior lobe, stippled, is seen (as in the primitive forms, Fig. 901A) to have a central and two lateral pieces; these show floccular (F) and parafloccular (PF) enlargements. In the human fœtus these are represented, but the paraflocculus is lost, and the flocculus remains alone in the adult condition, connected still with the median part of the posterior lobe.

When estimating the comparative values of the parts of the cerebellum, as above, it must be remembered that the growing thickness of the organ affects not only the lateral, but also the median parts; thus, the vermis is very thick in the middle lobe and fades rapidly in the posterior lobe, so that this last is turned down and comes to look downwards and forwards. This is associated with the overgrowth of the ansiform lobule, whence the paramedian lobule is visible from below and in front, and not from behind, as in the scheme; it is covered behind by the increasing growth of the ansiform lobule extending medially behind it and the buried posterior derivatives.

To sum up shortly: the lateral lobes of the cerebellum are, for their posterior, lateral, and greater part, overgrowths of the *ansiform portion of the middle lobe*, the tonsil being *paramedian*. Above this is another part (lobulus simplex, upper crescentic) of the middle lobe, separated by the *primary fissure* from the simple anterior lobe, the oldest lobe of the organ. The vermis is represented in both anterior and middle lobes as the central portion, thickened very much in these parts, but getting rapidly smaller (and hence reversed, as it were) in the posterior lobe. The flocculus is the remnant of the lateral portion of the posterior lobe.

The vermis in front of the primary fissure is the central part of the anterior lobe, behind this fissure, down to and including the declive; it belongs to the upper portion (lobulus simplex) of the middle lobe, the lower part of which includes the 'tuber vermis' and ends at the 'prepyramidal fissure.' The central part of the posterior lobe includes the pyramid, uvula, and nodule, and it is of interest to note that these parts are particularly connected (Holmes and Stewart) with the medial accessory olive, the oldest part of the inferior olivary structures; the large inferior olive of higher mammals has appeared with the lateral growth of the cerebellum in them, and in less direct connection with the development of the cerebral cortex.

Peduncles of the Cerebellum.—The peduncles are three in number on either side—superior, middle, and inferior—and they are composed of fibres which enter or leave the central white medullary substance.

The **superior peduncles** (**brachia conjunctiva**) are largely composed of efferent fibres, and are at first concealed from view by the upper or anterior portions of the hemispheres. After they leave the hemi-

spheres they pass upwards on the lateral aspects of the dorsal surface of the pons in a converging manner towards the quadrigeminal bodies (or *colliculi* of mid-brain). They form the lateral boundaries of the upper part of the floor of the fourth ventricle, and by their convergence they project slightly over that part of the ventricle, so as to take part in its roof. The superior medullary velum extends between the two peduncles, and closes the interval between them. On reaching the inferior pair of quadrigeminal bodies the two peduncles pass beneath them and enter the mesencephalon, where their course will be subsequently described (see p. 1553). Most of the fibres of each superior peduncle are derived from the corresponding nucleus dentatus, but a few come from the grey matter of the cerebellar cortex. In addition to these there are the fibres of the *ventral* (or indirect) *cerebellar tract* (of Gowers).

The **middle peduncles** are of large size, and are formed by the transverse fibres of the pons, these being gathered together on either side into a large bundle, which passes backwards and laterally into the white central medullary substance of the corresponding hemisphere. The fibres of each middle peduncle are both afferent and efferent. The afferent fibres arise in the pons from the cells of the nucleus pontis of the opposite side, and terminate in arborizations around the cells of the cerebellar cortex. The efferent fibres arise from the cells of the cerebellar cortex of the same side, and terminate in arborizations around the cells of the nucleus pontis, mostly on the opposite side.

The **inferior peduncles** are principally composed of *afferent* fibres, which are derived chiefly from the dorsal (or direct) cerebellar tract and the olivo-cerebellar tract of either side. The fibres of the *dorsal cerebellar tract* terminate in the cortex of the superior vermis on both sides of the median line. The fibres of the *olivo-cerebellar tract*, which are derived from the inferior olivary nucleus of the medulla oblongata on the opposite side, terminate in the cortex of the vermis and cerebellar hemisphere. The *superficial arcuate fibres*, which form part of the inferior peduncle, are connected with the cortex of the vermis and cerebellar hemisphere. There are also fibres connecting the vermis with the vestibular nerve, thus forming the *direct sensory cerebellar tract* (see p. 1623).

It should be noted that the inferior peduncle comes up from below to a position between the other two, the middle peduncle being external and the superior internal. Having reached this position, the inferior peduncle suddenly bends backwards and passes into the cerebellum.

White and Grey Matter of the Cerebellum.—In the hemispheres and vermis the white matter is situated in the centre as the medulla, and the grey matter is disposed superficially as the cortex. The white matter in the interior of the vermis is occasionally termed the *corpus trapezoides*. When sagittal sections of a hemisphere are made, the mass of white matter in the centre is seen to send offshoots into the lobules. From the sides of these offshoots secondary processes are given off, and these in turn furnish tertiary processes, the white

ıatter in all cases being covered by grey matter. When the section ; made across the direction of the laminæ or folia the appearance ›resented is like the trunk and branches of a tree; hence the name *rbor vitæ cerebelli* is applied to it (see Fig. 902).

Nuclei.—The **corpus dentatum** (Fig. 902) is a collection of grey ıatter which is situated within the white matter of each hemisphere, ınd is very like the inferior olivary nucleus in the olivary body of the ıedulla oblongata. It is composed ıf a wavy grey lamina, disposed n the form of a capsule, which ncloses white matter. The capsule ›resents an opening or *hilum* at its ıpper and inner part, and through his a large number of the fibres ıf the superior cerebellar peduncle ›merge from the interior.

Fig. 902.—Antero-posterior Section through Lateral Lobe, showing Dentate Nucleus.

There are three other nuclei on ›ach side as follows: (1) the **nucleus ›mboliformis,** close to the inner ;ide of the hilum of the corpus lentatum; (2) the **nucleus globosus,** nternal to the preceding; and 3) the **nucleus fastigii,** or roof-ıucleus, situated in the vermis, :lose to the median line, and contiguous to its fellow of the opposite ;ide.

Commissural and Association Fibres.—The **commissural fibres** pass ŕrom the white matter of one hemisphere to that of the opposite hemisphere. They traverse the vermis in two sets, superior and inferior. Γhe **association fibres** are confined to each side, and they connect ıdjacent laminæ, passing across the bottom of the fissures which separate them.

Medullary Vela.—These are thin laminæ or curtains of white matter, and are two in number, superior and inferior.

The **superior medullary velum** (or *valve of Vieussens*) is continuous with the white matter of the vermis. It extends between the converging superior cerebellar peduncles, bridging over the interval between them, and becoming continuous with their inner margins. Superiorly it extends to the inferior pair of quadrigeminal bodies, and inferiorly it passes into the corpus trapezoides or white matter of the vermis. It forms a large portion of the roof of the upper part of the fourth ventricle, and its dorsal surface supports the lingula of the superior vermis. From the upper part of the superior medullary velum a band of white fibres, called the *frenulum veli,* passes to the lower part of the median longitudinal groove which separates the lateral pairs of quadrigeminal bodies. Immediately below the inferior pair of quadrigeminal bodies the fourth pair of cranial nerves emerge from the superior medullary velum on either side of the frenulum veli. The

tract of Gowers (**ventral spino-cerebellar tract**), after having traversed the formatio reticularis of the medulla oblongata and the dorsal part of the pons, passes into the superior medullary velum, and then descends in the superior cerebellar peduncle to the cerebellum.

The **inferior** or **posterior medullary velum** is a thin lamina of white matter which consists of three parts—median and two lateral, right and left.

The *median part* supports dorsally the nodule of the inferior vermis. It is a prolongation of the white matter of the vermis, and lies on the upper or ventral aspect of the nodule, to which it is adherent. As it leaves the white matter it is contiguous to the superior medullary velum, but the two laminæ take different directions. As they diverge they make the **cerebellar recess** or **apex** of the roof of the fourth ventricle. The superior medullary velum passes upwards between the dorsal parts of the superior peduncles of the cerebellum. The median part of the inferior medullary velum passes ventralwards and then downwards. It is succeeded in a downward direction by the ependymal epithelium and pia mater (tela chorioidea inferior), which form a large portion of the lower part of the roof of the fourth ventricle. The middle part of the inferior medullary velum forms the upper portion of the lower part of the roof of the fourth ventricle.

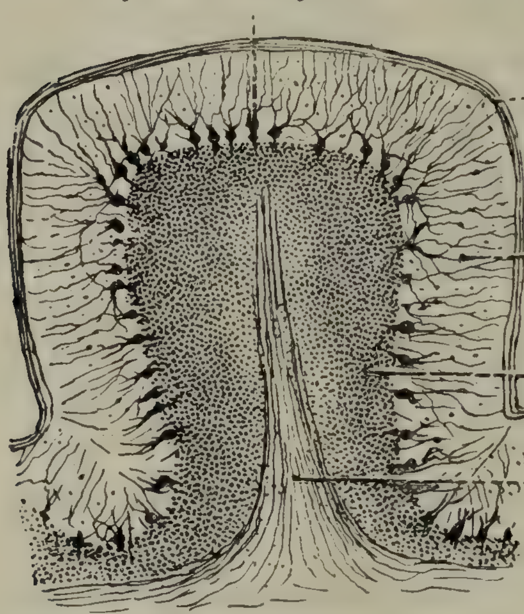


FIG. 903.—STRUCTURE OF A LAMINA OF THE CEREBELLUM (MAGNIFIED).

Each *lateral part* of the inferior medullary velum extends laterally to the corresponding flocculus in the form of a semilunar band. The ventral surface of this band is directed towards the fourth ventricle, and the dorsal surface is related to the amygdala or tonsil. One border of the band is free and concave, whilst the other is continuous with the white matter of the corresponding cerebellar hemisphere.

The inferior medullary velum forms a part of the *lobus noduli*, the other parts being the nodule and the two flocculi.

Minute Structure of the Cerebellar Laminæ.—Each lamina or folium of the cerebellum consists of (1) a central part or core of white matter, which is an offshoot from the white medullary substance; and (2) an external part or cortex of grey matter.

Grey Cortex.—The **grey cortex** is composed of two layers, an outer **molecular layer** and an inner **granular layer.** Between these two layers there is a stratum of characteristic large cells, called the cells or corpuscles of Purkinje.

The **cells of Purkinje** are pyriform or flask-shaped, and are situated, as just stated, between the molecular and granular layers. The narrow or superficial end of each cell projects into the molecular layer, and the broad or deep end rests

ı the granular layer. From the broad or deep end of each cell a single axon ısses off, which enters the granular layer, where it soon becomes medullated, ıd then forms a nerve-fibre of the white medullary substance. The axon of urkinje's cell gives off a few collateral recurrent branches, some of which end ı the granular layer, whilst others enter the molecular layer.

From the narrow or superficial end of each cell one or two dendrons are given ff. These divide and subdivide at frequent intervals in the molecular layer like the antlers of a deer.' The dendritic processes so formed are arranged ı an arborescent manner, and are distinct from those of adjacent cells. They ermeate the molecular layer as far as the surface.

The **molecular layer** consists of a few nerve-cells and many nerve-fibres.

The **nerve-cells** are situated partly in the inner or deep portion of the ıolecular layer, and partly in its outer portion.

The **inner cells** are known as the *basket-cells*, and they lie in the vicinity of he cells of Purkinje. Each basket-cell has several dendritic processes which amify in all directions. In addition to these processes there is an axon, which prings from the side of the cell and takes a transverse course. It gives off a umber of collaterals which pass towards the bodies of the cells of Purkinje. 'hese collaterals terminate by ramifying very freely around the cells of Purkinje s well as around the axons of these cells for a short distance. The minute erminal ramifications form a close basket-work, which encloses the cell of 'urkinje and its axon for a short distance.

The **outer cells** of the molecular layer are small, and each has several den- ritic processes and an axon. Each axon springs from the side of the cell, nd, taking a transverse course, it ends in numerous ramifications.

The **fibres** of the molecular layer are derived from the following sources: ı) The dendritic processes, and the recurrent collaterals of the axons of the ells of Purkinje; (2) the dendritic processes and axons of the outer cells; (3) the endritic processes of the inner or basket cells; (4) the axons of the granule-cells f the granular layer; (5) the *fibres of Bergmann*, which represent the processes f glia-cells in the granular layer; (6) the dendrons of the cells of Golgi; and 7) some fibres from the white medullary substance of the lamina.

The **granular layer** consists of (1) nerve- and glia-cells, and (2) fibres.

The **nerve-cells** are of two kinds—namely, granule-cells and cells of Golgi.

The **granule-cells** are small and very numerous. They are closely packed ogether, and impart to this layer a granular appearance. Each has several lendrons and one axon. The dendrons soon ramify, and the dendritic processes erminate in minute clusters within the granular layer, which are closely related o the granule-cells. The axon of each granule-cell passes into the molecular ayer, where it ramifies, its branches diverging and being closely related to the lendritic processes of the cells of Purkinje.

The **cells of Golgi** lie near the cells of Purkinje, and are larger than the granule- ells. They are stellate, and each has several dendrons and an axon. The lendrons enter the molecular layer, in which they ramify. The axon ramifies 'ery freely in the granular layer. The cells of Golgi may be regarded as associa- ion cells.

The **glia-cells** are situated close to the cells of Purkinje, and lie between the outer granule-cells. The superficial processes enter the molecular layer, and onstitute the fibres of Bergmann, which pass as far as the pia-matral covering f the lamina. Their deep processes pass between the granule-cells of the ranular layer, and some of them enter the white medullary substance.

The **fibres** of the granular layer are derived from the following sources: ı) The axons of the cells of Purkinje; (2) the moss-fibres of Cajal; (3) the den- lritic processes of the granule-cells; (4) the ramifications of the axons of the ells of Golgi; (5) some of the deep processes of the glia-cells; and (6) some fibres rom the white medullary substance.

White Matter.—The white matter of a cerebellar lamina is an offshoot of the principal white medullary substance, and composed

of nerve-fibres. (1) Some of these are the axons of the cells of Purkinje, and these enter the white matter. (2) Others pass through the granular layer into the molecular layer, where they divide into branches which are closely related to the more deeply placed dendritic processes of the cells of Purkinje. (3) A third set terminate in the granular layer, where they divide into branches which present moss-like swellings, furnished with short delicate filaments. These fibres are known as the *moss-fibres of Cajal.*

Development of the Cerebellum.—The cerebellum is developed from the dorsal laminæ of the metencephalon, where this forms the front limb of the pontine flexure. In its growth it extends into the roof-plate.

4. The Fourth Ventricle.

The fourth ventricle (*ventriculus quartus*) is situated behind (1) the upper or open half of the medulla oblongata or bulb, and (2) the pons. It has two walls—ventral and dorsal.

Ventral or Anterior Wall.—This wall is usually referred to as the **floor.** It is formed by (1) the dorsal surface of the upper or open half of the bulb, and (2) the dorsal surface of the pons between the converging superior peduncles of the cerebellum. In shape it is rhomboidal, the bulbar and pontine parts being triangular and having their bases applied to each other. The floor is sometimes spoken of as the *fossa rhomboidea* (see Fig. 892).

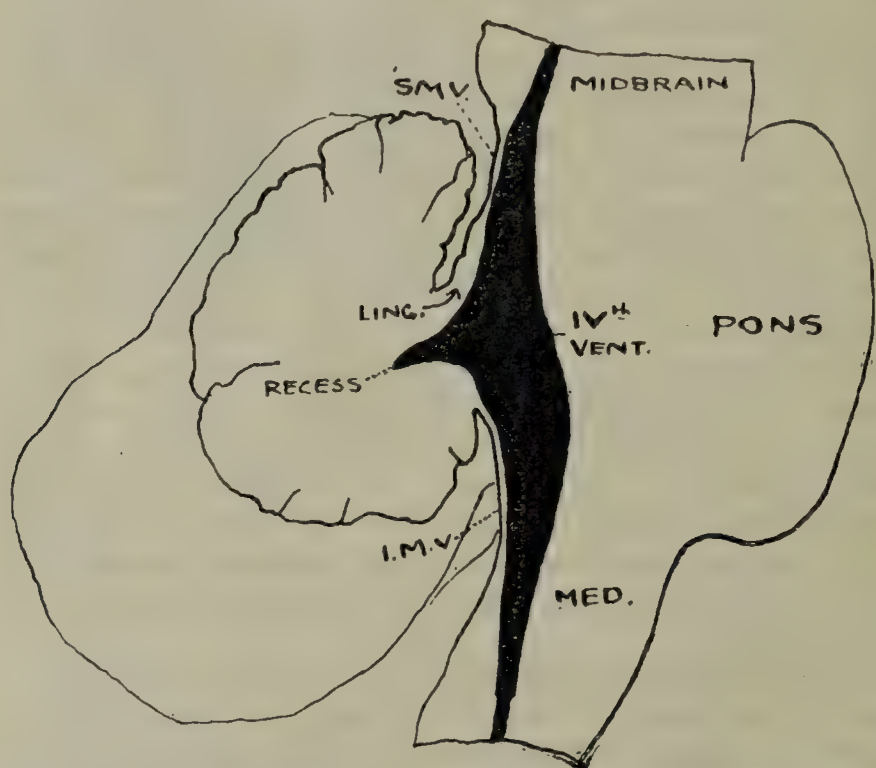


Fig. 904.—Diagram to show the Composition of Floor and Roof of Fourth Ventricle.

SMV, IMV, upper and lower medullary vela.

The *lower end* is tapering, and lies between the clavæ of the funiculi graciles. In this situation the cavity of the ventricle is continuous with the central canal of the spinal cord after that canal has traversed the lower or closed half of the bulb. The *upper end* is somewhat tapering, and lies between the converging superior peduncles of the cerebellum. In this situation the cavity of the ventricle is continued into the *aqueduct* (of Sylvius), which traverses the mesencephalon and opens superiorly into the third ventricle.

The floor is widest across its centre, which is on a level with the upper ends of the 'restiform bodies' of the bulb. The cavity of the ventricle is here prolonged on either side round the outer aspect

f the corresponding restiform body towards the olive. This prolongation is known as the *lateral recess*.

An opening in the lateral part of this recess, involving the covering pia mater and opening into the subarachnoid space, is known s the **lateral aperture of the fourth ventricle.**

The floor is covered by a thick layer of grey matter, which is ontinuous with the central grey matter of the lower or closed half f the bulb. This grey matter is covered by ependyma, the epithelial ells being continuous with those which line the central canal of the pinal cord.

The floor is traversed in the median line by a slight longitudinal roove, which divides it into two symmetrical longitudinal halves.

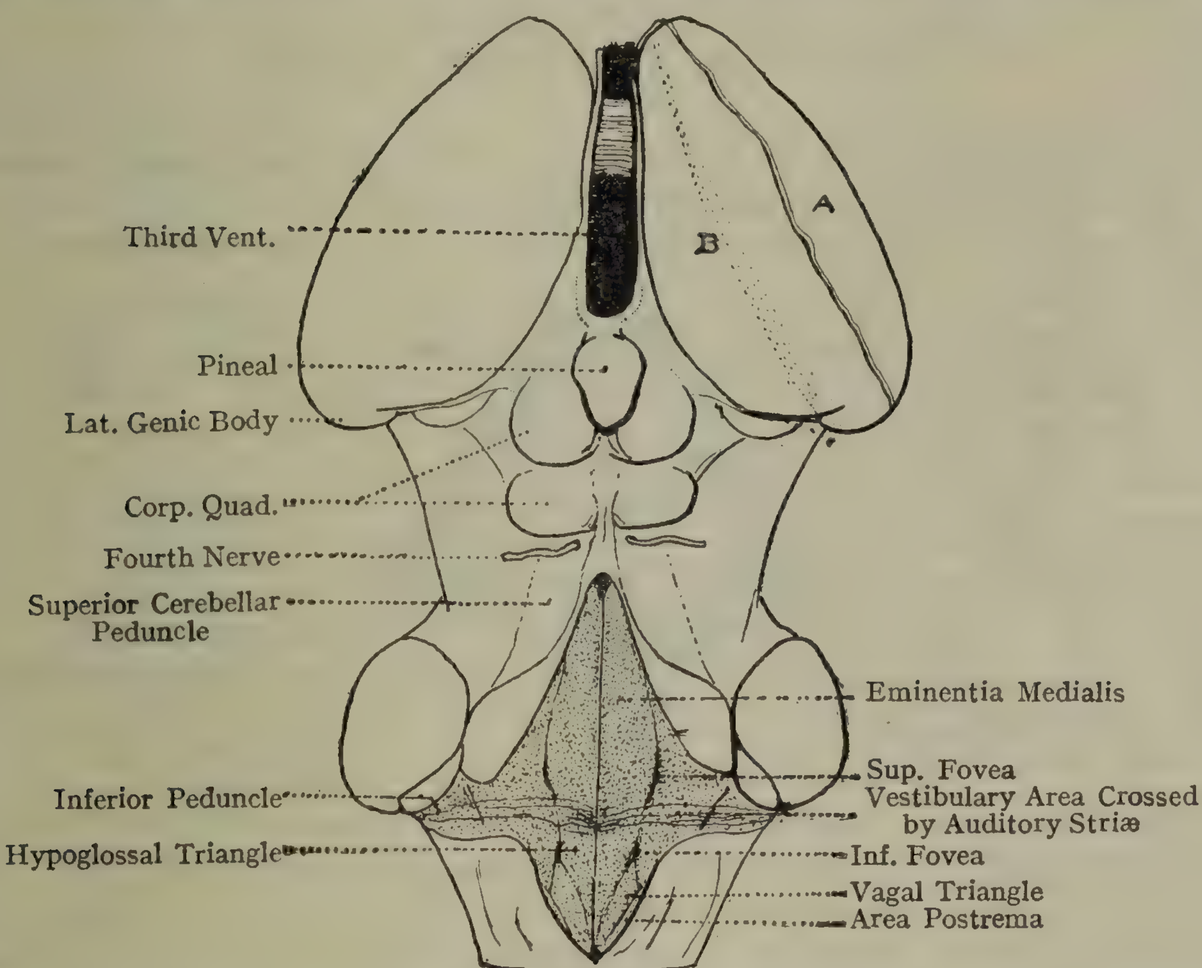


FIG. 905.—DORSAL VIEW OF MID- AND HIND-BRAINS WITH THALAMUS (CEREBELLUM REMOVED).

Each half is crossed at its widest part by bundles of white fibres, called *auditory striæ.* They wind round the upper part of the restiform body, and pass transversely across the corresponding half of the floor as far as the median longitudinal groove, into which they sink. They belong to the cochlear division of the auditory nerve, in connection with which they will be described.

The floor is divided into two parts, lower and upper, by the striæ of either side.

Lower or Bulbar Part.—The bulbar part is formed by the dorsal surface of the upper or open part of the bulb. It is bounded on either side by (1) the clava of the funiculus gracilis, (2) the cuneate tubercle of the funiculus cuneatus, and (3) the restiform body, in this order

from below upwards. The lower end constitutes, as stated, a tapering point which carries a small ridge of grey matter, the **obex,** at its extremity. The bulbar part is traversed in the median line by a longitudinal groove, already referred to, and this groove subdivides it into two symmetrical halves.

Immediately below the auditory striæ on either side, and not far from the median longitudinal groove, there is a small triangular depression, known as the **fovea inferior.** Its apex extends to the striæ and the lateral angles of its base are prolonged downwards as two grooves—inner and outer. The inner groove passes in a somewhat curved manner towards the point of the lower end, and the outer groove passes downwards and outwards towards the lateral boundary.

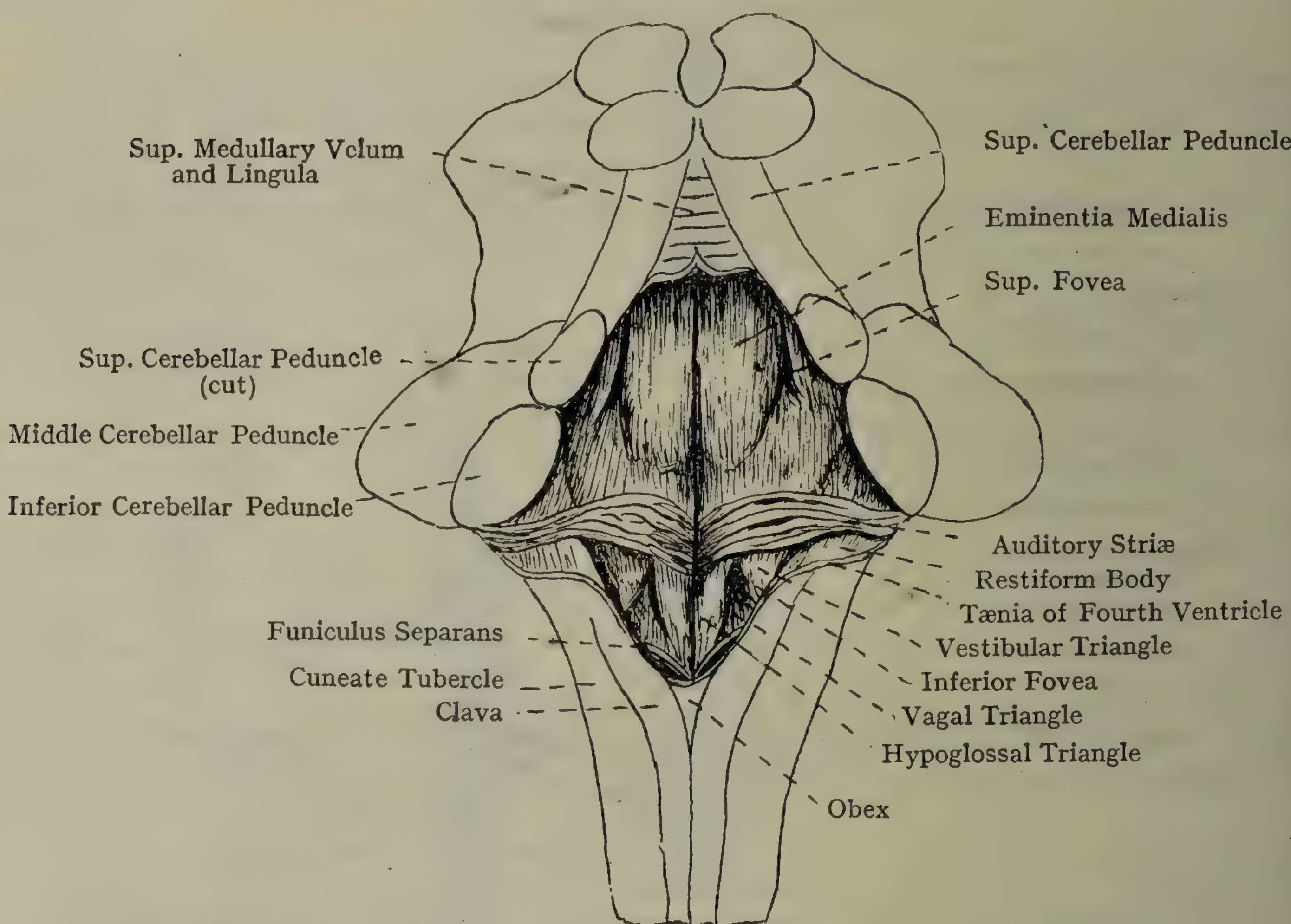


FIG. 906.—THE FLOOR OF THE FOURTH VENTRICLE.

Between these two diverging grooves there is a triangular area, called the **vagal triangle.** Its apex is at the fovea inferior, and its base is directed downwards and outwards. It has a dark colour, and from this circumstance it is known as the *ala cinerea.* Deep to it there is the dorsal nucleus of the vagus and glosso-pharyngeal nerves (Fig 905).

A second triangular area, called the **hypoglossal triangle,** is situated between the median longitudinal groove and the medial of the two grooves prolonged from the angles of the base of the fovea inferior. Its base is directed upwards towards the striæ, and its apex downwards towards the lower point. The area is slightly elevated, and is associated with the lower part of the eminentia medialis. Subjacent to this area is the upper part of the nucleus of the hypoglossal nerve.

A third triangular area, called the **vestibular area** or **triangle,** is ituated between the lateral boundary of the floor and the outer of he two grooves prolonged from the angles of the base of the fovea nferior. Its base, like that of the hypoglossal triangle, is directed pwards, and is continued into an eminence, over which the auditory triæ pass. This eminence is known as the **vestibular area** or **tubercle.** ubjacent to the vestibular area and tubercle there is the dorsal or hief terminal nucleus of the vestibular division of the eighth nerve.

Upper or Pontine Part.—The pontine part of the floor is formed y the dorsal surface of the pons between the converging superior eduncles of the cerebellum, which constitute its lateral boundaries. ts upper somewhat tapering end adjoins the lower end of the aqueduct. ike the bulbar part, it is traversed in the median line by a longi-udinal groove, already referred to, which subdivides it into two ymmetrical halves.

Above the auditory striæ, and in line with the fovea inferior, here is a slight depression, called the **fovea superior,** the two foveæ eing separated from each other by the vestibular tubercle. Between he fovea superior and the median longitudinal groove there is a vell-marked prominence, called the **eminentia medialis.** Deep to his eminence immediately above the striæ acusticæ, is the bducent nucleus, or nucleus of the sixth cranial nerve, and the minentia medialis is really formed by fibres of the seventh nerve curv-ound the dorsal surface of the sixth nucleus just deep to the floor f the ventricle. For this reason an alternative name for the eminence s the **colliculus facialis.** The eminence is continued downwards nto the trigonum hypoglossi, and superiorly it extends towards the ower end of the aqueduct of the mid-brain. Extending upwards rom the fovea superior towards the region of the lower end of the queduct there is a slight depression, known as the **locus cæruleus,** which has a dark grey or somewhat blue colour. This colour is due o a subjacent group of deeply pigmented nerve-cells, known as the *ubstantia ferruginea.* This group may belong to the chief motor ucleus of the fifth cranial nerve, or it may be a terminal nucleus for ome of the sensory fibres of that nerve.

Dorsal or Posterior Wall of Fourth Ventricle.—This wall is usually eferred to as the **roof,** and it is divisible into two parts—upper and ower.

The *upper part* is formed chiefly by the superior or anterior medul-ary velum, which extends between the inner margins of the dorsal spects of the superior peduncles of the cerebellum. It is also formed o a certain extent by these peduncles as they converge and slightly verhang the angular space between them. The *lower part* of the roof s formed, from above downwards, by (1) the inferior or posterior nedullary velum, and (2) the ependymal epithelium of the ventricle, overed by pia mater. The inferior medullary velum is separated from he superior velum by the recess (Fig. 904), within which the cerebellum ctually forms a part of the roof; the inferior velum terminates in a free

margin. Beyond this free margin there is the ependymal epitheliun of the ventricle, covered, as stated, by pia mater. This portion o pia mater is called the *tela chorioidea inferior.*

The epithelial part of the roof presents superficially thre laminæ of white nervous matter—namely, the obex and th ligulæ. The *obex* is a thin triangular lamina which is situatec at the lower point of the ventricle, being attached laterally tc the diverging clavæ. The *ligulæ* are right and left. Each is a narrow band, which is continuous inferiorly with the obex It is attached inferiorly to the clava and the cuneate tubercle It then passes transversely outwards over the dorsal aspect of th restiform body. The transverse part of the ligula forms the lowe boundary of the lateral recess of the ventricle.

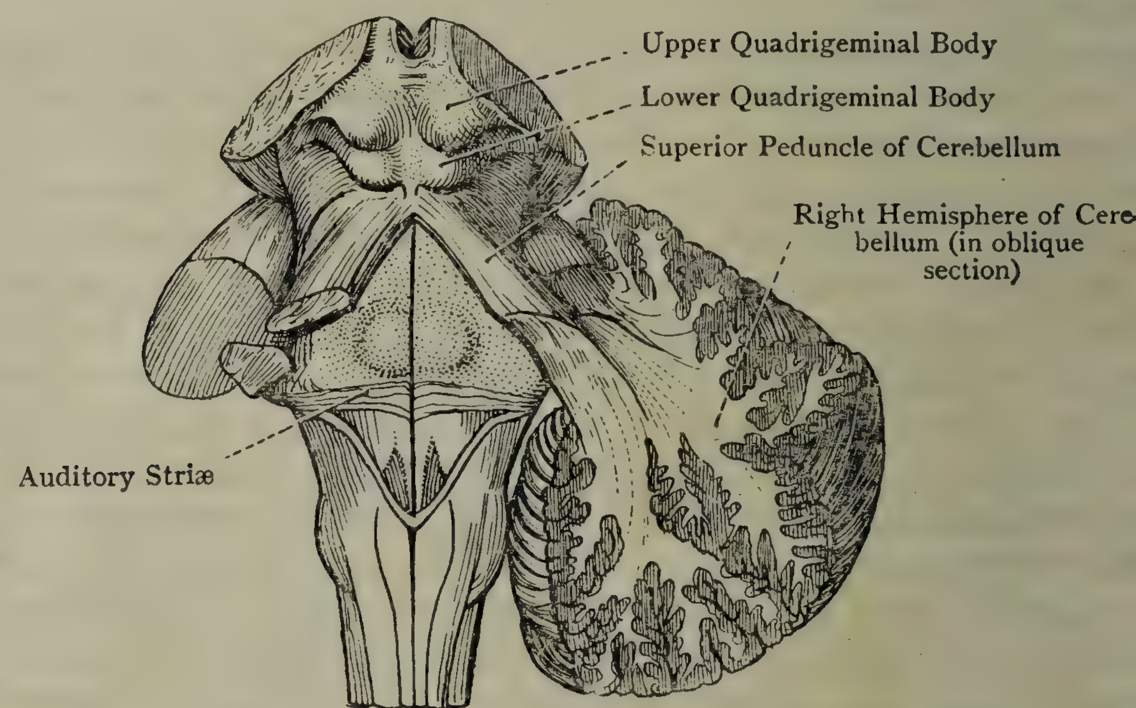


Fig. 907.—The Fourth Ventricle and Right Hemisphere of the Cerebellum (in Section) (Hirschfeld and Leveillé).

In the lower part of the roof of the fourth ventricle, below the lower limit of the inferior medullary velum, there is a perforation through the pia mater and ependyma, known as the **foramen of Magendie.** This, situated in the mid-line, forms an opening between the fourth ventricle and the subarachnoid space, and with the lateral recesses allows the cerebro-spinal fluid to pass from the interior to the surface of the brain. Its modern name is **median aperture of fourth ventricle.**

Choroid Plexuses of Fourth Ventricle.—These are two in number, right and left. Each is a longitudinal inflexion of the pia mater which forms the tela chorioidea inferior, and it invaginates the ependymal epithelium of the lower part of the roof of the ventricle, by which it is covered on its ventricular surface. Each choroid plexus consists of two parts—longitudinal and transverse—and the two plexuses are disposed thus: ⅂⌈. The longitudinal parts lie on either

ide of the median line, and extend upwards from the region of the oramen of Magendie. Each transverse part extends outwards into he corresponding lateral recess of the ventricle

Development of Fourth Ventricle.—The lower or bulbar part is developed from the myelencephalon, and the upper or pontine part is developed from the metencephalon, these being the two divisions of the rhombencephalon. The cavity is the cavity of the neural tube, dilated and made diamond-shaped as a result of the formation of the pontine flexure (p. 57).

TELENCEPHALON.

Cerebral Hemispheres.

The cerebral hemispheres are right and left. Each is semi-ovoid, ınd presents two extremities and three surfaces.

The **extremities** are anterior and posterior. The **anterior** is thick ınd round, and its most projecting part is called the **frontal pole.** The **posterior extremity** is narrow and pointed, and its most projecting part is called the **occipital pole.** The **surfaces** are lateral, medial, and inferior. The **medial surface** is convex, in adaptation to the concavity of the cranial vault. The **lateral surface** is flat and vertical, and it forms the lateral boundary of the great longitudinal fissure. For the most part it is in contact with the falx cerebri. The **inferior surface** is irregular, being adapted to the corresponding lateral divisions of the anterior and middle fossæ of the interior of the base of the skull and the upper surface of the tentorium cerebelli. It is crossed transversely by a deep cleft, representing the stem of the lateral fissure. The portion in front of this fissure is known as the *orbital area,* and is concave, in adaptation to the convexity of the orbital plate of the frontal bone, upon which it rests. The extensive portion behind the stem of the lateral fissure is known as the *tentorial area,* and is prominent and arched. Its anterior portion is received into the lateral division of the middle cranial fossa, and its posterior portion rests upon the tentorium cerebelli.

The **borders** of each hemisphere are four—supero-medial, infero-lateral, superciliary, and internal occipital. The **supero-medial border** separates the lateral from the medial surface. The **infero-lateral border** separates the lateral surface from the tentorial area of the inferior surface. The **superciliary** border separates the front part of the lateral surface from the orbital area of the inferior surface. The **internal occipital border** separates the medial surface from the tentorial area of the inferior surface, and it extends from the occipital pole to the splenium of the corpus callosum.

The exterior of each hemisphere is broken up into tortuous eminences, called **gyri** or **convolutions,** and these are separated from each other by clefts, called **sulci** or **fissures.** The exterior is composed of grey matter,

which is spoken of as the **cerebral cortex,** and the interior is occupied by white matter, which forms the **medullary centre.** The breaking up of the hemispheres into gyri, with the intervening sulci, greatly increases the amount of cerebral cortex, and to a proportionate extent of pia mater.

It is sometimes the practice to distinguish between fissures and sulci of the brain, though many regard it as a refinement. If it is necessary, the fissures may be defined as clefts which either pass from one surface of the brain to another or, if they do not do that, cause an elevation in the wall of the lateral

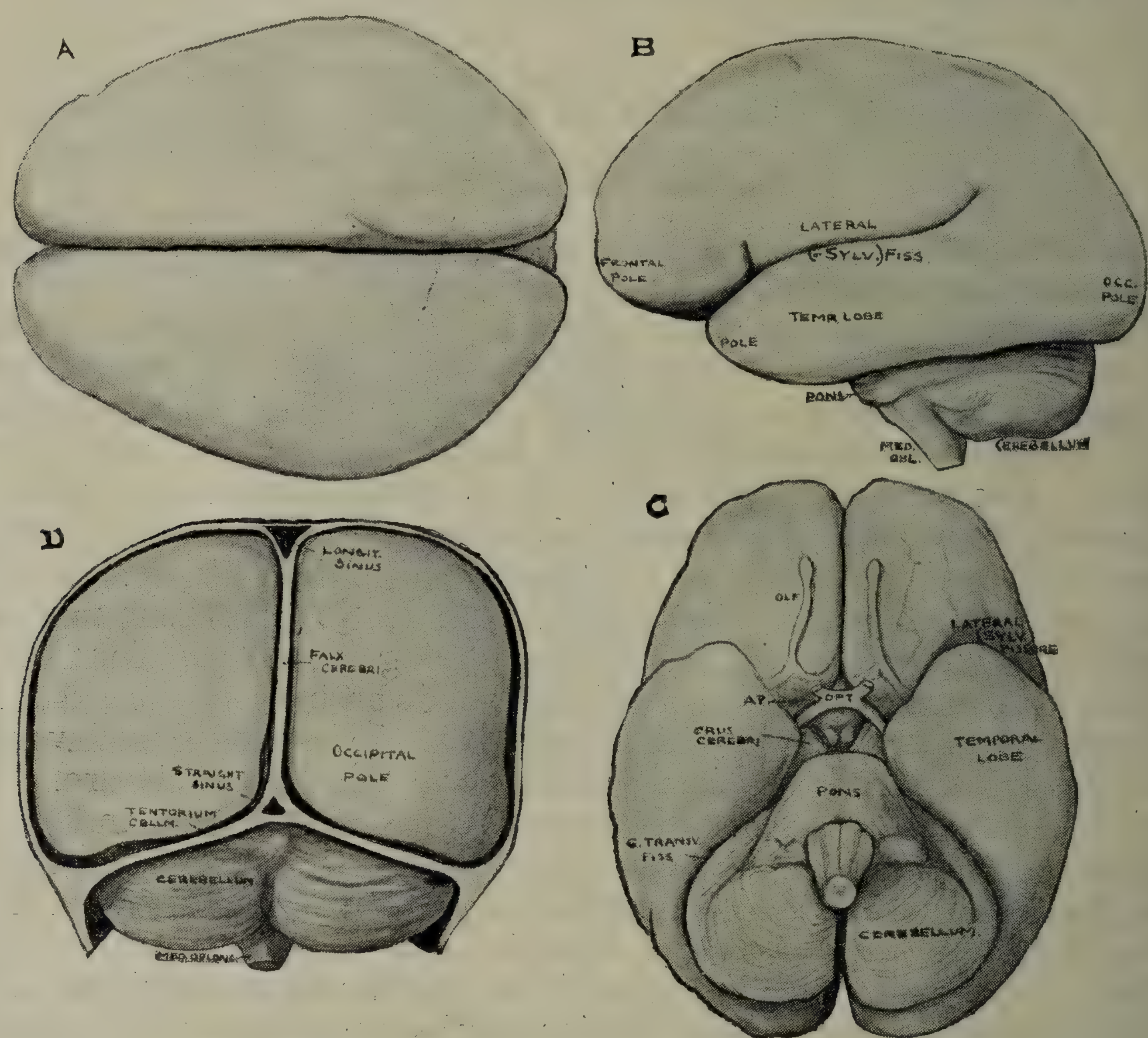


Fig. 908.—Views of Brain, not showing Convolutions.

A, from above; B, from left; C, from below; D, from behind.

ventricle. The difficulty is that, with this definition, the same depression is sometimes a fissure and sometimes a sulcus.

Subject to this explanation, the following clefts would rank as fissures, and their claims will be dealt with as they are described: (1) Lateral, (2) central, (3) choroidal, (4) hippocampal, (5) calcarine, (6) collateral, (7) parieto-occipital. Other depressions which do not fulfil these requirements merely rank as sulci. The fissures thus defined are deeper and more constant in arrangement than the sulci.

Each hemisphere presents six principal clefts, called interlobar, and by means of these it is divided into six lobes.

Interlobular Clefts.

1. Lateral fissure (*Sylvian*).
2. Central fissure (*Rolando*).
3. Parieto-occipital fissure.
4. Cingulate sulcus.
5. Collateral fissure.
6. Circular or limiting sulcus.

Interlobular Fissures.—The **lateral fissure** (O.T., fissure of Sylvius), which is the first fissure to appear in the course of development, begins on the inferior surface of the hemisphere at the anterior perforated substance in a depression, called the *vallecula cerebri* (or *Sylvii*). From this point it passes horizontally outwards to the external surface of the hemisphere, where it divides into three diverging branches. It is a deep cleft, which is overhung posteriorly by the front part of the temporal lobe, and it separates the orbital surface of the frontal from

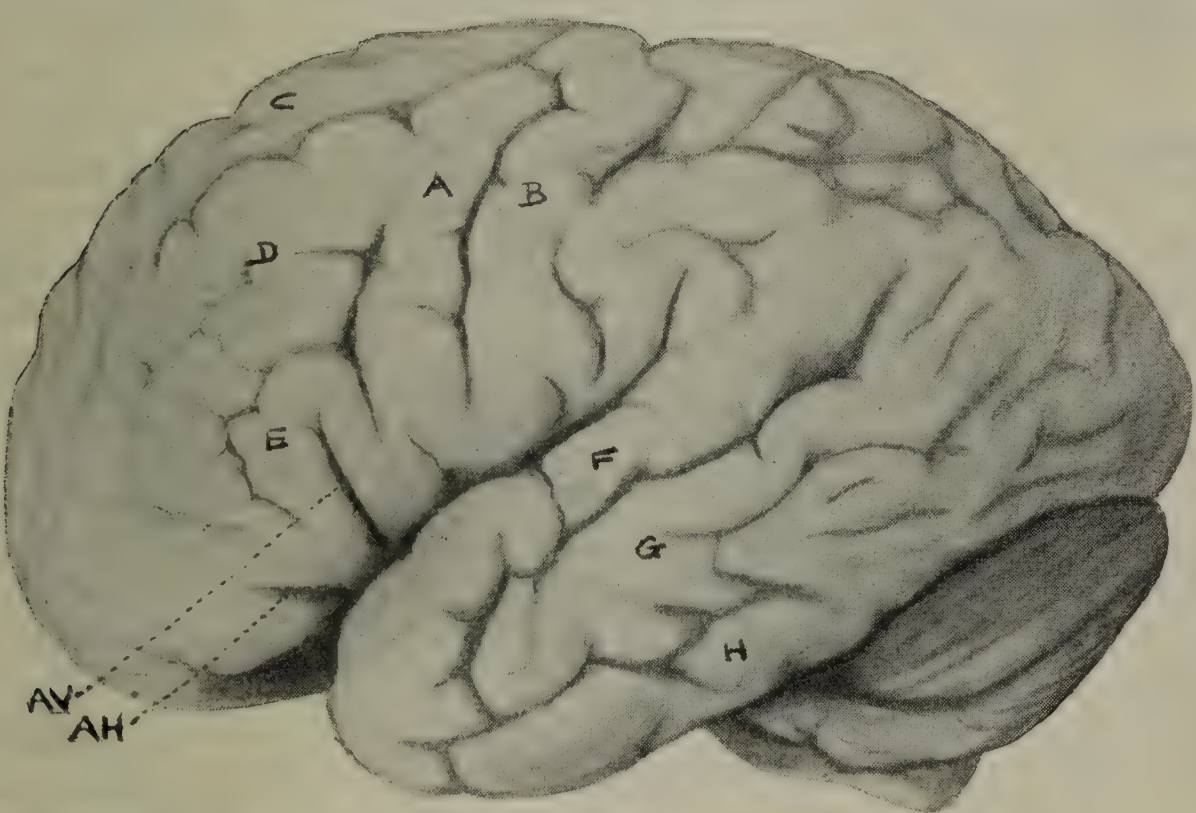


FIG. 909.—LATERAL VIEW OF LEFT HEMISPHERE.

In this specimen the horizontal (AH) and ascending (AV) anterior rami arise separately from lateral fissure. The pars triangularis lies between them.

the temporal lobe. The posterior border of the small wing of the sphenoid bone faces the fissure, which lodges the middle cerebral artery. The limbs into which the fissure divides are anterior horizontal, ascending, and posterior horizontal. The *anterior horizontal limb* passes forwards into the frontal lobe, its length being about $\frac{3}{4}$ inch. The *ascending limb* passes upwards and slightly forwards into the frontal lobe for about 1 inch, but its length is variable. The *posterior horizontal limb* is the longest and most conspicuous. It passes backwards on the external surface of the hemisphere for at least 2 inches, having portions of the frontal and parietal lobes above it, and the temporal lobe below it. Finally, it turns upwards into the parietal lobe for a very short distance.

The **central fissure** (see Fig. 909), also known as the *central sulcus* and *fissure of Rolando,* begins at the supero-medial border of the hemi-

sphere a little behind its mid-point, and ends above the centre of the posterior horizontal limb of the lateral fissure. It does not usually open into this limb, but may do so. Superiorly the fissure in most cases intersects the supero-medial border to reach the medial surface of the hemisphere, upon which it passes backwards for a very short distance. The direction of the fissure is irregularly downwards and forwards over the external surface of the hemisphere, and it *separates the frontal from the parietal lobe.* It describes two bends. The *upper genu* has its concavity directed forwards, and is situated about the junction of the upper and middle thirds of the fissure. The *lower genu* has its concavity directed backwards, and is situated on a more anterior plane than the upper genu. Below the lower genu the direction of the fissure is almost vertical, with a slight inclination backwards. The fissure is sometimes interrupted.

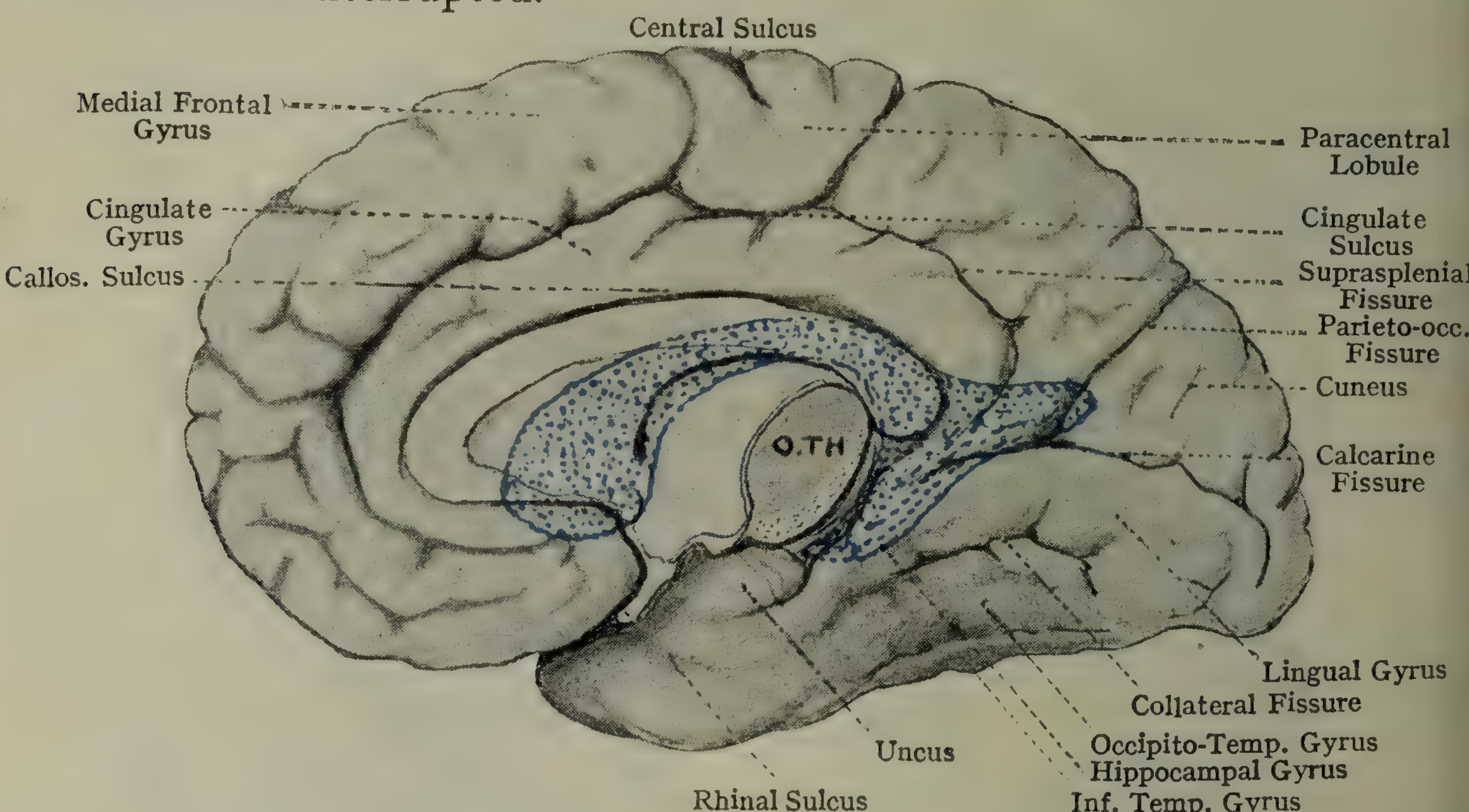


FIG. 910.—MEDIAL ASPECT OF RIGHT HEMISPHERE.
Approximate position of lateral ventricle marked in blue.

The **parieto-occipital fissure** is situated about 2 inches behind the upper end of the central fissure, and separates the parietal from the occipital lobe. It is composed of two limbs, external and internal, which are continuous with each other at the supero-medial border of the hemisphere, where they form a right angle. The **external limb** is situated on the lateral surface of the hemisphere, upon which it passes transversely outwards for about $\frac{3}{4}$ inch, when it is arrested by the convolution which connects the parietal and occipital lobes. The **internal limb** appears as a deep, almost vertical cleft on the medial surface of the hemisphere, which *opens into the calcarine fissure* a short distance behind the splenium of the corpus callosum (see Figs. 910 and 917).

The **cingulate sulcus** is situated on the medial surface of the hemisphere. It commences below the rostrum of the corpus callosum,

near the anterior perforated area, and, bending round the genu, it passes backwards above the corpus callosum, from which it is separated by the cingulate gyrus. At a point a little behind the centre of the internal surface of the hemisphere it turns upwards, and terminates at the supero-medial border a short distance behind the upper end of the central fissure. The cingulate fissure lies between the frontal and limbic lobes, the medial frontal gyrus being above it and the cingulate gyrus below it (see Fig. 910).

The **collateral fissure** is situated on the inferior or *tentorial* surface of the hemisphere. It starts near the occipital pole, and extends forwards towards the temporal pole. Posteriorly it has the calcarine fissure above, and in line with it, and anteriorly the hippocampal gyrus holds this position on its medial side. It separates the temporal lobe from the hippocampal portion of the limbic lobe. The middle portion of the collateral fissure gives rise to the eminentia collateralis in the floor of the lateral ventricle.

The **circular** or **limiting sulcus** is situated deeply in the anterior part of the posterior horizontal limb of the lateral fissure. It almost surrounds the convolutions which constitute the insula, and is composed of three parts—superior, inferior, and anterior. The *superior part* separates the insula from the frontal and parietal lobes, the *inferior part* separates it from the temporal lobe, and the *anterior part* separates it from the frontal lobe. The circular fissure is deficient in the region of the apex of the insula (see Fig. 920).

Lobes of the Cerebral Hemisphere—Frontal Lobe.—This is of large size. On the *external surface* of the hemisphere it is bounded behind by the central fissure and below by the posterior horizontal limb of the lateral fissure. On the *inferior surface* it is bounded behind by the stem of this fissure. On the internal surface it is bounded by the cingulate fissure. The frontal lobe has three surfaces—lateral, inferior, and medial.

Lateral Surface.—This surface presents three principal sulci—precentral, superior frontal, and inferior frontal.

The **precentral sulcus** is more or less parallel to the central fissure, the ascending frontal or precentral gyrus intervening between the two. It may be a single cleft, but it more frequently consists of two parts, superior and inferior. The *superior part* is usually joined above by the superior frontal sulcus. The *inferior part* passes superiorly into the middle frontal gyrus for a short distance in a forward and upward direction (see Fig. 909).

The **superior** and **inferior frontal sulci** extend forwards from the precentral sulcus.

The **gyri** of the external surface are as follows: precentral or ascending frontal, superior frontal, middle frontal, and inferior frontal (see Fig. 909).

The **ascending frontal** or **precentral gyrus** (Fig. 909, A) is bounded behind by the central sulcus, and in front by the superior and inferior parts of the precentral sulcus. It extends from the supero-medial border of the hemisphere to a little behind the 'Sylvian point,' which

corresponds to the place where the stem of the lateral fissure appears on the external surface of the hemisphere, and divides into its three branches. Below the lower end of the central fissure it is, as a rule, connected with the ascending parietal or postcentral gyrus by an annectant gyrus.

The **superior** or *first*, **middle** or *second*, and **inferior** or *third* **frontal gyri** (C, D, E) are arranged in tiers, which are disposed antero-posteriorly, but the first and second often are subdivided, so as to make five tiers in all. They are separated from the ascending frontal or precentral gyrus by the superior and inferior parts of the precentral sulcus.

FIG. 911.—THE LEFT CEREBRAL HEMISPHERE (SUPERIOR SURFACE).

Red=frontal lobe.
Orange=parietal lobe.
Blue=occipital lobe.

The **superior frontal gyrus** is narrow, and lies between the supero-medial border of the hemisphere and the superior frontal sulcus. It is continuous with the medial frontal gyrus on the medial surface of the hemisphere, and is partially broken up into two parts, upper and lower.

The **middle frontal gyrus,** which is broad, is usually connected with the ascending frontal or precentral gyrus by an annectant gyrus. It is broken up anteriorly into two parts, upper and lower, by an antero-posterior secondary sulcus; and it is cut into behind by the upper portion of the inferior part of the precentral sulcus.

The **inferior frontal gyrus** lies below the inferior frontal sulcus, and in front of the lower part of the precentral sulcus. The anterior horizontal and the ascending limbs of the lateral fissure enter it and subdivide it into three parts—namely, pars orbitalis, pars triangularis, and pars basilaris, or, better still, *orbital*, *frontal*, and *fronto-parietal opercula*. The orbital operculum lies below the anterior horizontal limb of the lateral fissure; the frontal operculum is situated between the anterior horizontal and the ascending limbs of the fissure; and the fronto-parietal operculum is placed between the ascending limb of the fissure and lower part of the precentral sulcus. The inferior frontal gyrus is connected posteriorly with the lower end of the ascending frontal or precentral gyrus by an annectant gyrus.

Inferior or Orbital Surface of the Frontal Lobe.—This surface presents two sulci, olfactory and orbital (see Fig. 914).

The **olfactory sulcus** is parallel to the medial border, from which it is separated by the gyrus rectus. It lodges the olfactory tract and olfactory bulb. The **orbital sulcus** is of very variable form, but, as a rule, bears some resemblance to the letter)–(. It has, therefore, three limbs

—medial, lateral, and transverse. The *medial limb* is separated from the olfactory sulcus by the medial orbital gyrus. The *lateral limb* is curved, and has external to it the orbital part of the inferior frontal gyrus. The *transverse limb* passes in a more or less curved manner between the other limbs.

The **gyri** of the orbital surface are: gyrus rectus, medial orbital gyrus, anterior orbital gyrus, lateral orbital gyrus, and posterior orbital gyrus.

The **gyrus rectus** lies between the olfactory sulcus and the medial border. The **medial orbital gyrus** is placed between the olfactory sulcus and the inner limb of the orbital sulcus. The **lateral orbital gyrus** is external to the other limb of the orbital sulcus. The **anterior orbital gyrus** is situated in front of the transverse limb of the orbital sulcus. The **posterior orbital gyrus** lies behind the transverse limb of the orbital sulcus.

FIG. 912.—THE RIGHT CEREBRAL AND CEREBELLAR HEMISPHERES (LATERAL SURFACE).

Red=frontal lobe. Blue=occipital lobe.
Orange=parietal lobe. Green=temporal lobe.
Purple=cerebellar hemisphere.

Medial Surface of the Frontal Lobe.—The medial surface presents only one convolution, the **medial frontal** or **marginal gyrus,** which is situated between the supero-medial border of the hemisphere and the cingulate sulcus. It is continuous with the superior frontal gyrus, and anteriorly is broken up by one or two sulci. Its posterior part is almost completely detached, and forms the **paracentral lobule,** so named because it contains the upper end of the central fissure (Fig. 910).

Parietal Lobe.—This lobe lies between the large frontal and small occipital lobes, and above the temporal lobe. It is bounded *anteriorly* by the central fissure, which separates it from the frontal lobe. *Posteriorly* it is bounded by (1) the external parieto-occipital fissure, and (2) a line drawn across the external surface of the hemisphere from the extremity of this fissure towards the *pre-occipital notch* on the infero-lateral border of the hemisphere, from 1½ to 2 inches in front of the occipital pole.

The parietal lobe has two surfaces—lateral and medial.

Lateral Surface.—This surface presents the following sulci: the intraparietal sulcus, composed of four parts; and the terminal portions of (*a*) the posterior limb of the lateral fissure, (*b*) the first temporal or parallel sulcus, and (*c*) the second temporal sulcus.

The **inferior** and **superior postcentral sulci** may be distinct, or continuous with each other. They lie behind the central fissure, with which they are parallel, and from which they are separated by the ascending parietal or *postcentral gyrus* (Fig. 909, B).

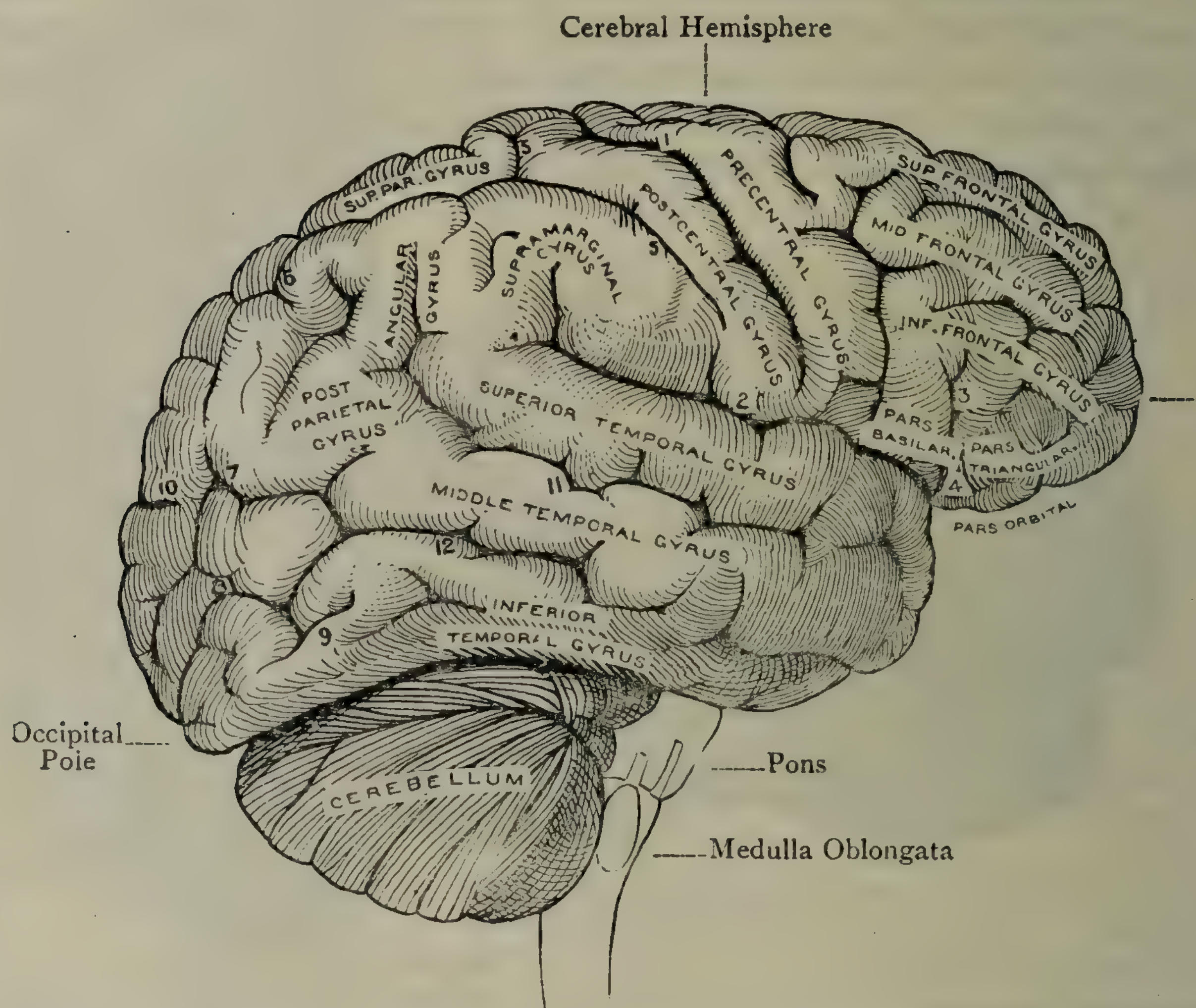


FIG. 913.—THE ENCEPHALON (RIGHT LATERAL VIEW) (HIRSCHFELD AND LEVEILLÉ).

1. Central Fissure
2. Posterior Horizontal Limb of Lateral Fissure
3. Ascending Limb of Fissure
4. Anterior Horizontal Limb of Fissure
5, 5. Intraparietal Sulcus
6. Ramus Horizontalis
7. Ramus Occipitalis
8. Transverse Occipital Sulcus
9. Lateral Occipital Sulcus
10. External Occipito-parietal Fissure
11. Superior Temporal, or Parallel, Sulcus
12. Inferior Temporal Sulcus

The **intraparietal sulcus** is often in two parts, horizontal and occipital (see Fig. 913).

The **ramus horizontalis** passes backwards and slightly upwards from the upper end of the inferior postcentral sulcus. It has the superior parietal lobule above it, and the inferior parietal lobule below it.

The **ramus occipitalis** is usually continuous with the last branch, and passes back into the occipital lobe as the lower boundary of the arcus parieto-occipitalis.

The terminal portions of (*a*) the posterior horizontal limb of the lateral fissure, (*b*) the first temporal or parallel sulcus, and (*c*) the second temporal sulcus, are confined to the lower part of the external surface of the parietal lobe, where they lie in the order named from before backwards.

The **gyri** of the lateral surface are as follows: ascending parietal; superior parietal; and inferior parietal, with its supramarginal, angular, and postparietal gyri.

The **ascending parietal** or **postcentral gyrus** is situated immediately behind the central fissure, which separates it from the ascending frontal or precentral gyrus in front of that fissure. Posteriorly it is limited by the superior and inferior postcentral sulci. It extends from the supero-medial border of the hemisphere to the posterior horizontal limb of the lateral fissure, and it lies parallel to the ascending frontal or precentral gyrus, with which it is connected below the central fissure.

These two gyri, from their relation to the central fissure, are often spoken of by neurologists as the 'central gyri,' though the name, if not clearly understood, is apt to lead to confusion with the gyri of the central lobe or insula.

The **superior parietal lobule** is situated between the ramus horizontalis and the supero-medial border of the hemisphere, where it is continuous with the quadrate lobule, or *precuneus*, of the internal surface. Anteriorly it is limited by the superior postcentral sulcus, round the upper end of which it is continuous with the postcentral gyrus. Posteriorly it is bounded by the external part of the parieto-occipital fissure, round the extremity of which it is connected with the occipital lobe by the arcus parieto-occipitalis.

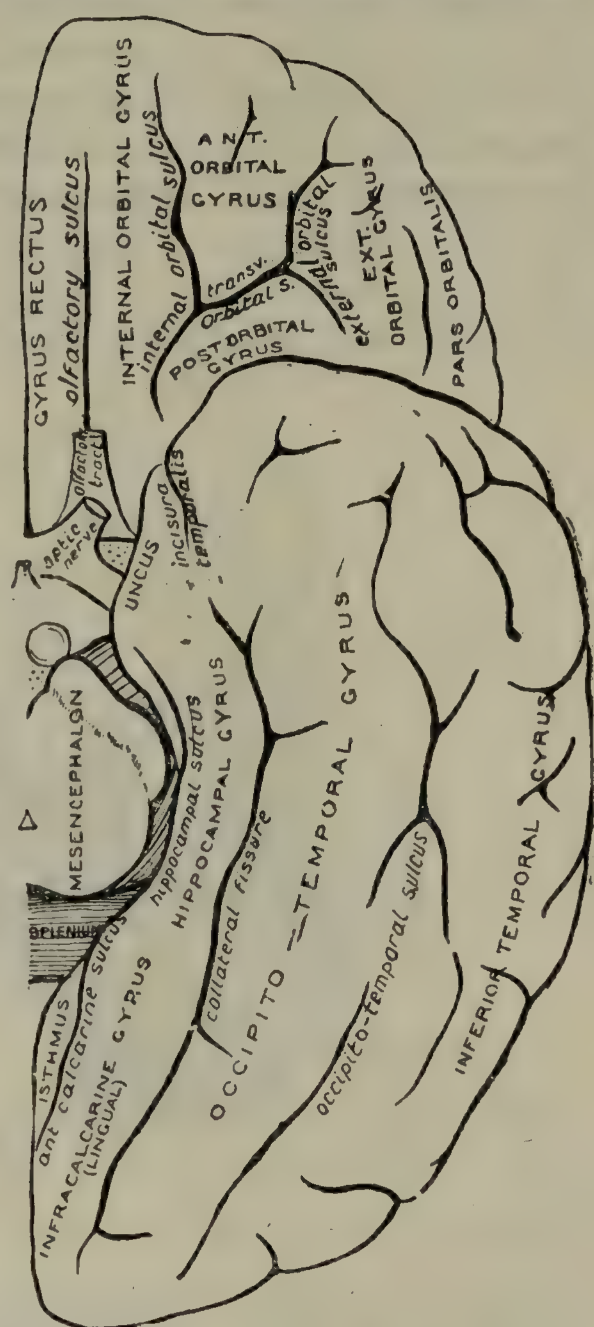


Fig. 914.—The Inferior Surface of the Left Cerebral Hemisphere, showing the Gyri and Sulci.

The **inferior parietal lobule** is situated behind the inferior postcentral sulcus, and below the ramus horizontalis and ramus occipitalis. It is broken up into several gyri, three of which—the supramarginal, angular, and postparietal—lie in this order from before backwards. The *supramarginal gyrus* arches over the ascending extremity of the posterior limb of the lateral fissure. The *angular gyrus* arches over the

ascending extremity of the first temporal or parallel sulcus, and is continuous with the second temporal gyrus. The *postparietal gyrus* arches round the ascending extremity of the second temporal sulcus, and is continuous with the third temporal gyrus. These three subdivisions of the inferior lobule are sometimes described simply as *anterior, middle,* and *posterior* parts.

Medial Surface of the Parietal Lobe.—The medial surface is of quadrilateral outline, and constitutes the **quadrate lobule** or **precuneus.** It is bounded in front by the upturned posterior extremity of the cingulate sulcus, behind by the internal parieto-occipital fissure, and below by the suprasplenial sulcus and a portion of the gyrus cinguli (Fig. 916).

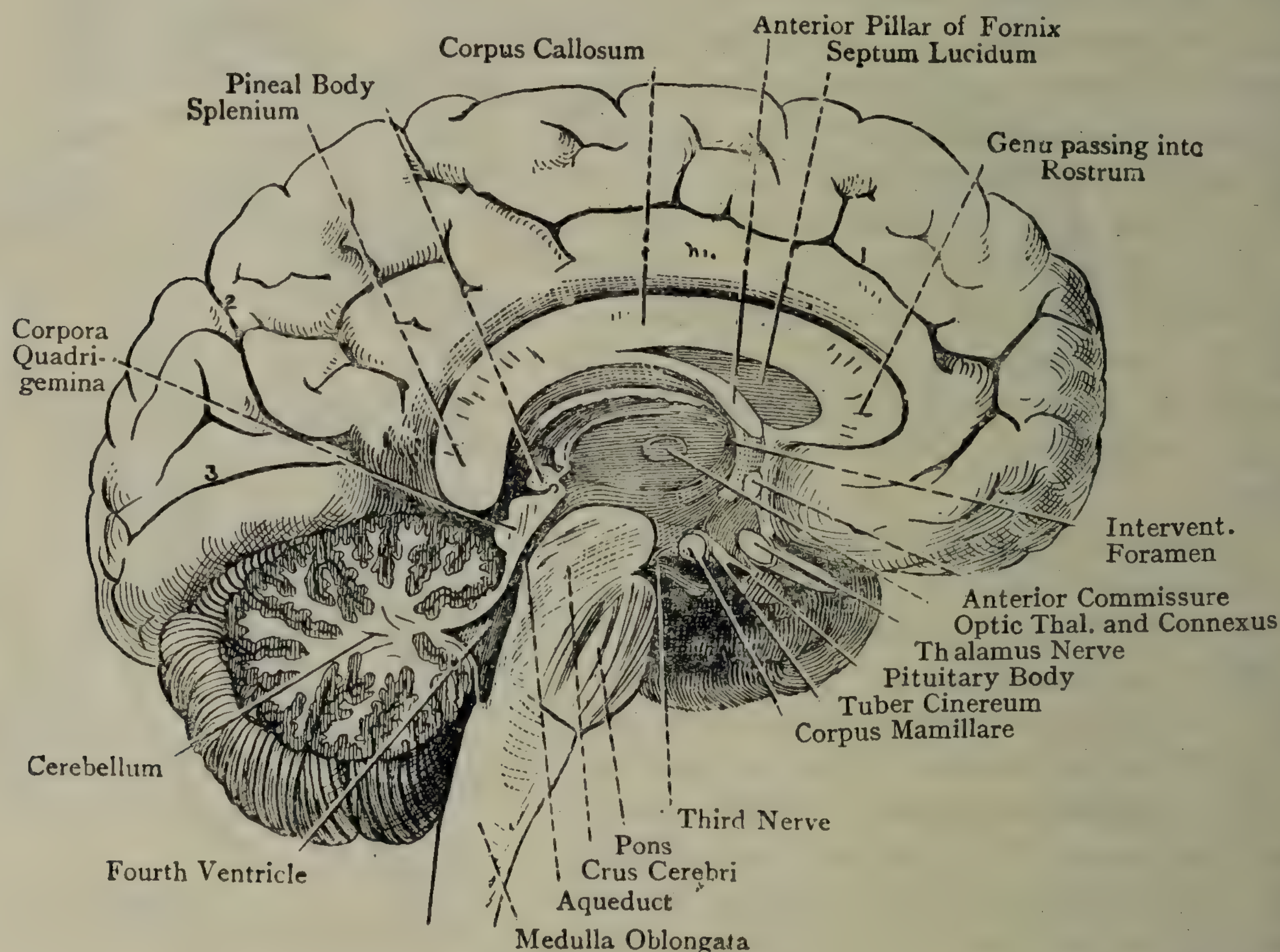


FIG. 915.—THE MEDIAL SURFACE OF THE LEFT CEREBRAL HEMISPHERE (HIRSCHFELD AND LEVEILLÉ).

Occipital Lobe.—This lobe lies behind the parietal and temporal lobes, and forms the posterior part of the cerebral hemisphere.

Laterally the lobe is bounded in front by the external parieto-occipital fissure, and a line connecting this fissure with the pre-occipital notch on the infero-lateral border of the hemisphere. *Medially* it is bounded in front by the internal parieto-occipital fissure, which separates it from the quadrate lobule, or precuneus, of the parietal lobe. *Inferiorly* it is continuous with the temporal and hippocampal regions, but the separation may be indicated by a line connecting the pre-occipital notch with the portion of the hippocampal formations which lie below the splenium of the corpus callosum, this portion being known as the 'isthmus.'

The occipital lobe is pyramidal, having an apex and three surfaces—lateral, medial, and inferior.

The **apex** forms the **occipital pole** of the cerebral hemisphere.

Lateral Surface (see Fig. 913).—This surface presents two sulci, transverse occipital and lateral occipital. The **transverse occipital sulcus** is formed by the bifurcation of the posterior end of the ramus occipitalis of the intraparietal sulcus, and it crosses the upper part of the occipital lobe obliquely. Its upper limb lies a little behind the external part of the parieto-occipital fissure, from which it is separated by a portion of the arcus parieto-occipitalis, and its lower limb is behind the postparietal gyrus. The **lateral occipital sulcus** is situated on the external surface of the occipital lobe, and extends almost horizontally from behind forwards. It divides the external surface of the lobe into two parts, upper and lower, which are connected with the

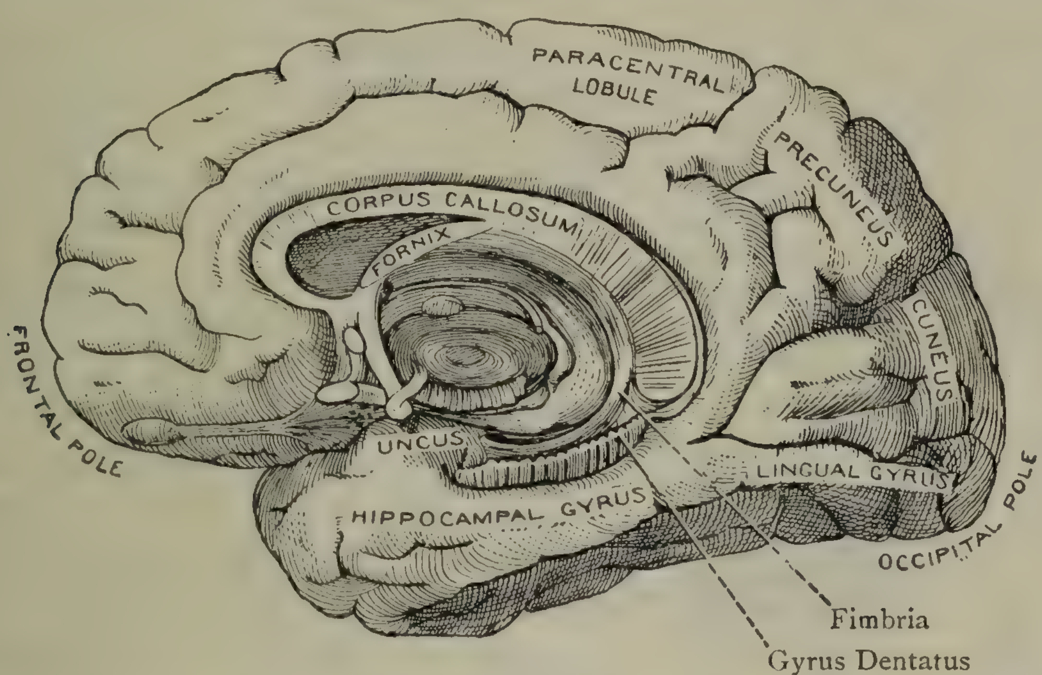


FIG. 916.—THE MEDIAL SURFACE OF THE RIGHT CEREBRAL HEMISPHERE (HIRSCHFELD AND LEVEILLÉ).

parietal and temporal lobes by annectant gyri. These sulci and gyri are very variable in appearance.

Medial Surface.—On the medial surface is the **calcarine fissure.** This is a deep cleft which starts on the internal aspect of the occipital pole in a bifurcated manner. It takes a curved course forwards, passing at first upwards and then downwards, and ends by reaching the hippocampal gyrus beneath the splenium of the corpus callosum. It is joined at a point anterior to its centre by the internal parieto-occipital fissure, and between the two fissures is the *cuneus*. The calcarine fissure is composed of two parts: precalcarine, representing the portion in front of the internal part of the parieto-occipital fissure; and postcalcarine, representing the portion behind that fissure. The *precalcarine fissure* gives rise to the calcar avis, on the inner wall of the posterior cornu of the lateral ventricle (Fig. 917).

The **gyri** of the internal surface are two in number—namely, the cuneus and the gyrus lingualis.

The **cuneus** is triangular, and is wedged in between the posterior calcarine fissure and the internal parieto-occipital fissure. The **gyrus lingualis** (infracalcarine gyrus) is situated between the calcarine fissure above and the posterior part of the collateral fissure below. Anteriorly it becomes narrow, and joins the hippocampal gyrus. The lower portion of this gyrus is visible on the inferior surface of the lobe.

Inferior Surface.—The inferior or tentorial surface presents the posterior part of the occipito-temporal gyrus, medial to which is the posterior part of the collateral fissure, and internal to this again there is the lower portion of the gyrus lingualis (see Fig. 918).

Temporal Lobe.—The temporal lobe (see Fig. 913) is prominent, and of large size. It is situated below the posterior horizontal limb of the lateral fissure, and behind the stem of that fissure. Superiorly it is bounded by the horizontal portion of the posterior limb of the

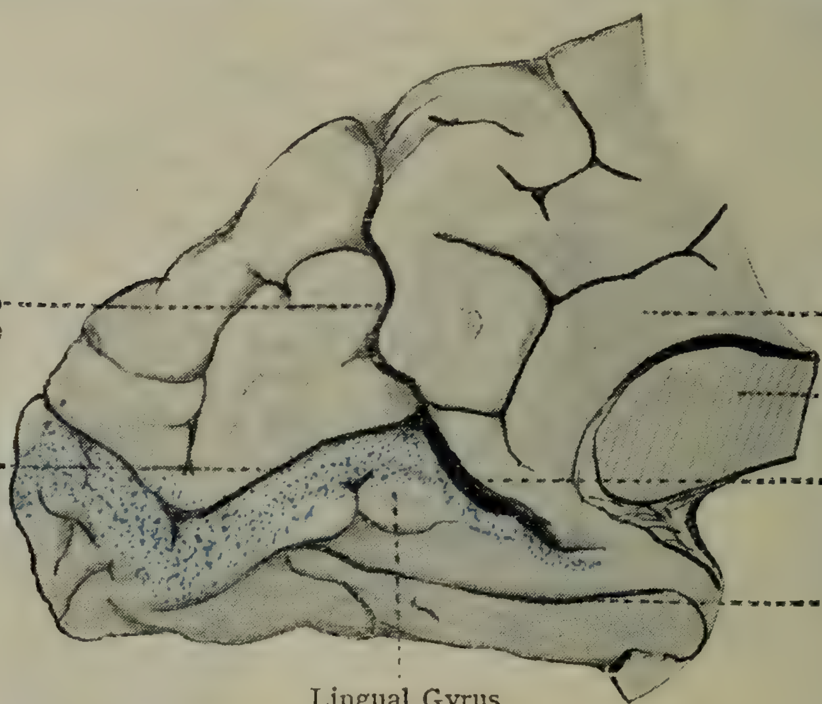


FIG. 917.—MEDIAL ASPECT OF PARIETO-OCCIPITAL REGION OF LEFT HEMISPHERE, TO SHOW INTERNAL PARIETAL OCCIPITAL FISSURE, ANTERIOR AND POSTERIOR CALCARINE.

Visual area coloured.

fissure, and a line prolonging this limb backwards to meet the anterior boundary of the occipital lobe. Anteriorly it is bounded by the stem of the fissure, which separates it from the orbital area of the frontal lobe. Posteriorly it is continuous with the occipital lobe, but the separation may be indicated by the following lines: externally by a line connecting the extremity of the external parieto-occipital fissure with the pre-occipital notch, and below and medially by a line connecting the pre-occipital notch with the splenium of the corpus callosum. Its medial surface above is separated from the hippocampal gyrus by the collateral fissure. The temporal lobe is somewhat pyramidal, the rounded apex being directed forwards. The apical part forms the **temporal pole,** and underlies the stem of the lateral fissure. The uncus of the hippocampal gyrus lies on its inner side, but on a more posterior level, and separated from it by the temporal sulcus.

The lobe presents three surfaces—superior, lateral, and inferior.

The **superior** or **opercular surface** is concealed within the lateral fissure, and is directed towards the insula.

The **lateral surface** has two horizontal sulci and three convolutions, the latter being disposed one above the other.

The **sulci** are called first and second temporal. The **first temporal sulcus** is parallel to the posterior limb of the lateral fissure, from which circumstance it is called the parallel sulcus. Starting near the temporal pole, it turns upwards posteriorly into the parietal lobe, where the angular gyrus arches over it. The **second temporal sulcus** is parallel to the first, below which it lies, and it is usually broken up into two or more parts by annectant gyri. Posteriorly it turns upwards into the parietal lobe, where the postparietal gyrus curves round it.

The **first temporal gyrus** is situated between the posterior limb of the lateral fissure and the parallel sulcus. Posteriorly it is continuous with the infraparietal lobule. The **second temporal gyrus** lies between the parallel and second temporal sulci. The **third temporal gyrus** lies below the second temporal sulcus, and posteriorly is continuous with the lower part of the external surface of the occipital lobe.

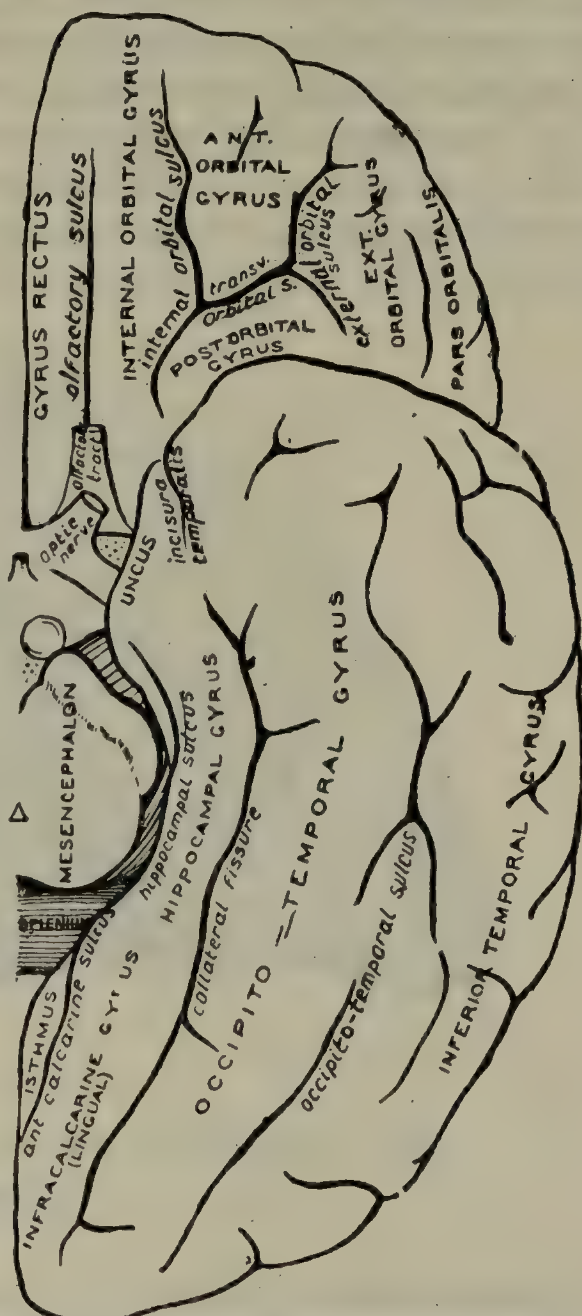


FIG. 918.—THE INFERIOR SURFACE OF THE LEFT CEREBRAL HEMISPHERE, SHOWING THE GYRI AND SULCI.

On the **inferior** or **tentorial surface** of the temporal lobe is the occipito-temporal sulcus and the occipito-temporal gyrus. The **occipito-temporal sulcus** extends from before backwards, lying near the infero-lateral margin of the hemisphere, and lateral to the collateral fissure (see Fig. 918). It is usually broken up into parts by annectant convolutions. The **occipito-temporal gyrus** is situated between the occipito-temporal sulcus and the collateral fissure, and extends from the occipital pole to the temporal pole. Lateral to the occipito-temporal sulcus there is the narrow inferior or tentorial surface of the third temporal gyrus.

Insula (Island of Reil) (see Fig. 920).—This lobe is situated deeply within the lateral fissure, and is concealed from view by the opercular gyri, to be presently described. It is triangular, the apex being directed downwards towards the vallecula cerebri and anterior per-

forated area. The circular or limiting sulcus being here absent, the grey matter of the apex is continuous with that of the perforated area, this point being called the *limen insulæ*. Elsewhere the island is surrounded by the circular or limiting sulcus, which has been already described. The insula presents several sulci, which diverge as they pass from the apical region to the base, and these map it out into gyri. One of these sulci is known as the **sulcus centralis insulæ.** It extends from the apex to the base in an upward and backward direction almost in line with the central fissure, and it divides the insula into two lobules, precentral and postcentral.

The **precentral lobule** is composed of three or four short gyri, called the *gyri breves*, which converge as they descend from the base, but they do not reach the apex or **pole** of the precentral lobule. The **post-**

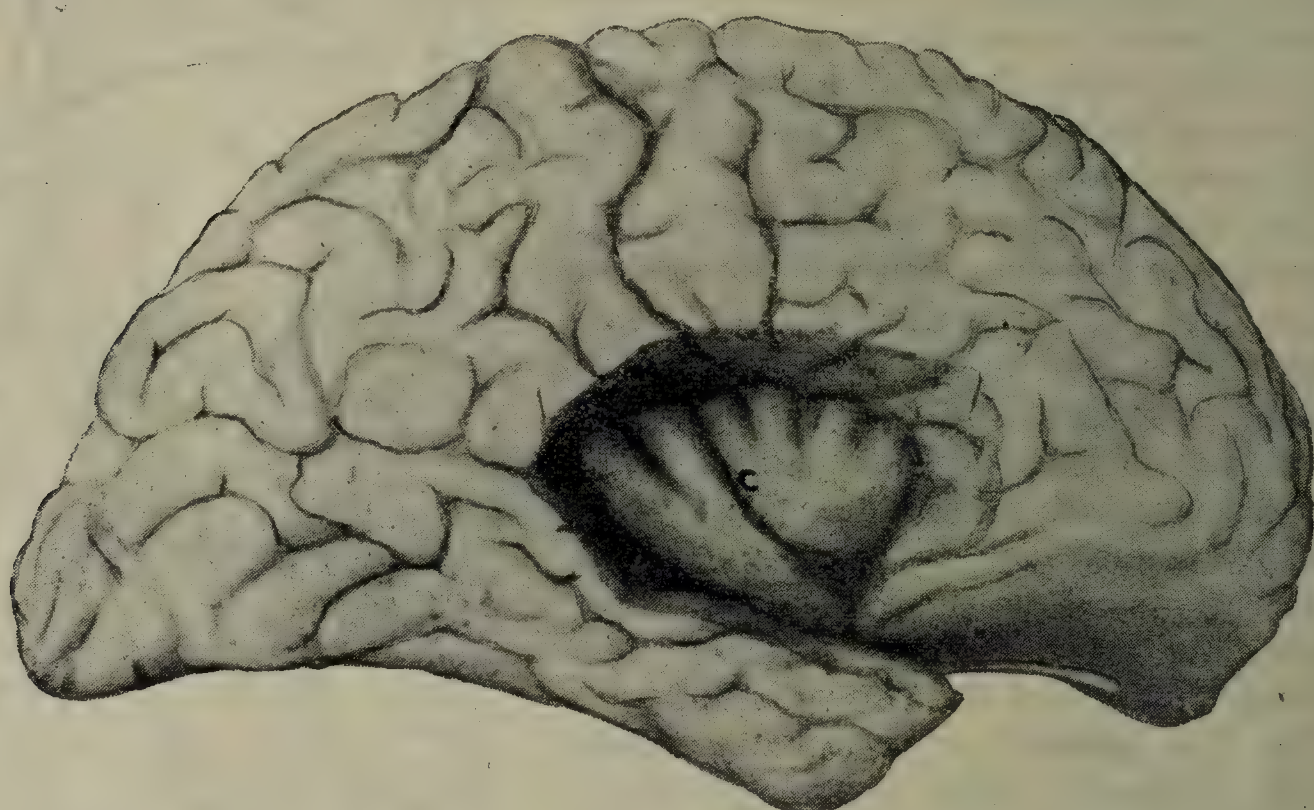


FIG. 919.—THE INSULA EXPOSED BY REMOVAL OF OPERCULA.
C, sulcus centralis insulæ.

central lobule is formed by the *gyrus longus*, which is usually broken up into two gyri towards the base of the insula.

The direct internal or medial relation of the insula is the claustrum, internal to which there are, in succession, the external capsule, the nucleus lentiformis, the internal capsule, and the nucleus caudatus.

Opercula Insulæ.—The parts of the cerebral hemisphere which bound the three limbs of the lateral fissure and overhang the insula are called the **opercula insulæ.** They are four in number—fronto-parietal, temporal, frontal, and orbital—and have been mentioned already (p. 1498).

Limbic Lobe.—This name was given in former times to a part of the brain, on its medial aspect, which included what is now known as the rhinencephalon, and also the cingulate gyrus.

The interrelations of the various parts will be considered more appropriately under the heading of rhinencephalon, but the preliminary description of these parts can be taken here, including that of the cingulate gyrus.

The **gyrus cinguli** arches round the corpus callosum. It begins at the anterior perforated substance below the rostrum of the corpus callosum, and it ends below the splenium of that body. Between these two points it pursues a semicircular course, passing forwards beneath the rostrum, upwards in front of the genu, backwards above the body of the corpus callosum, and finally, curving round the splenium, it is continued into the hippocampal gyrus through the *isthmus*. It is bounded superiorly by the cingulate sulcus, which separates it from the medial frontal gyrus (Fig. 921) and paracentral lobule, and posterior

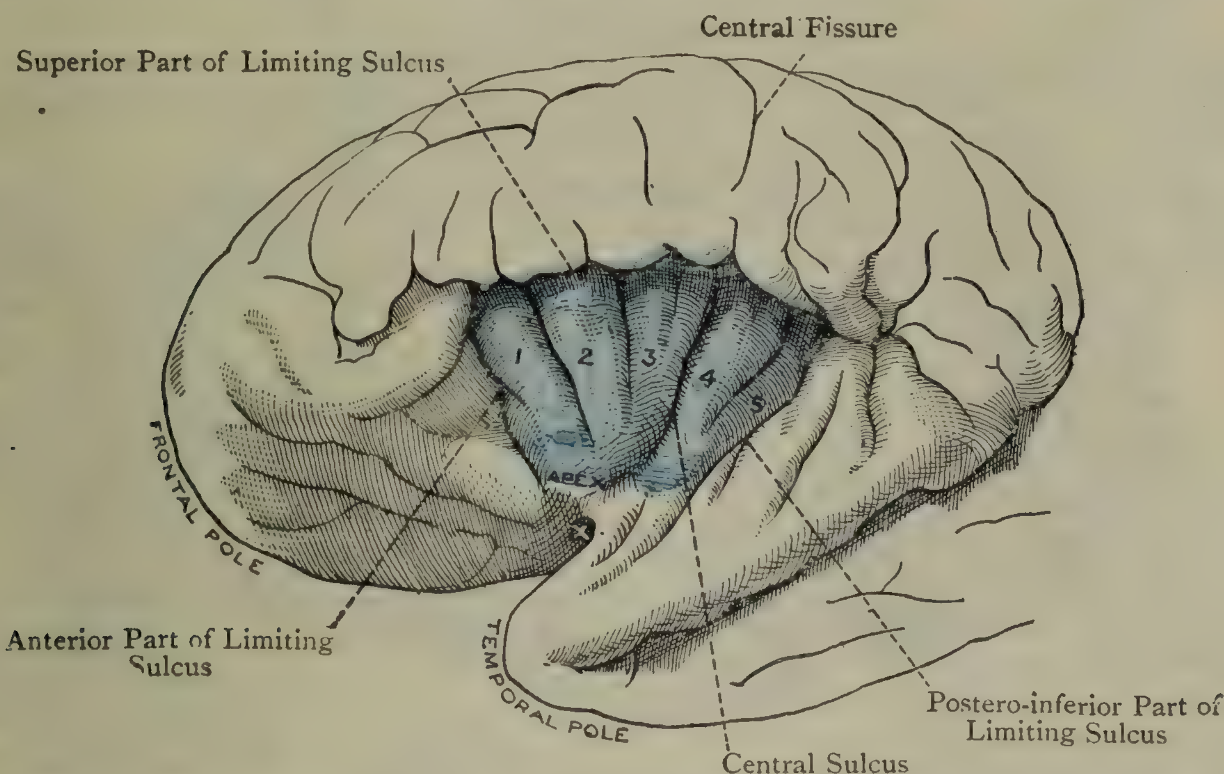


FIG. 920.—THE LEFT INSULA (POIRIER, FROM EBERSTALLER).
1, 2, 3, gyri breves; 4, 5, gyri longi; ×, limen insulæ.

to the latter it is partially separated from the precuneus by the supra-splenial sulcus. The gyrus is separated from the corpus callosum by the **callosal sulcus.**

The **hippocampal gyrus,** below the splenium of the corpus callosum, is joined above to the callosal gyrus by the *isthmus*, and *behind and below* it is continuous with the lingual gyrus (Fig. 921). As it passes forwards it has the hippocampal fissure above it, and the anterior part of the collateral fissure below it. *Anteriorly*, near the apex of the temporal pole and close behind the anterior perforated substance, it forms an enlargement, known as the **caput gyri hippocampi,** which is separated from the temporal pole by a slight fissure, called the *incisura temporalis*. From the caput a hook-like process, the **uncus,** passes backwards for a short distance above the anterior part of the hippocampal or dentate fissure. The caput represents the largely-developed

lobus pyriformis of many mammals, and it constitutes an olfactory centre of the cerebral cortex. Along with the uncus it forms part of the rhinencephalon or rhinopallium, a large part of the hippocampal gyrus belonging to the neopallium.

The incisura temporalis, which separates the caput gyri hippocampi from the temporal pole, represents the *ecto-rhinal fissure,* defining the well-developed rhinencephalon in some animals.

The **cingulum,** a narrow, tape-like band of white matter, is associated with the cingulate gyrus, and, according to Cajal, its fibres arise as the axons of cells of the gyrus, to the under surface of which the cingulum adheres. On entering the cingulum some fibres pass forwards and others backwards, whilst a few are

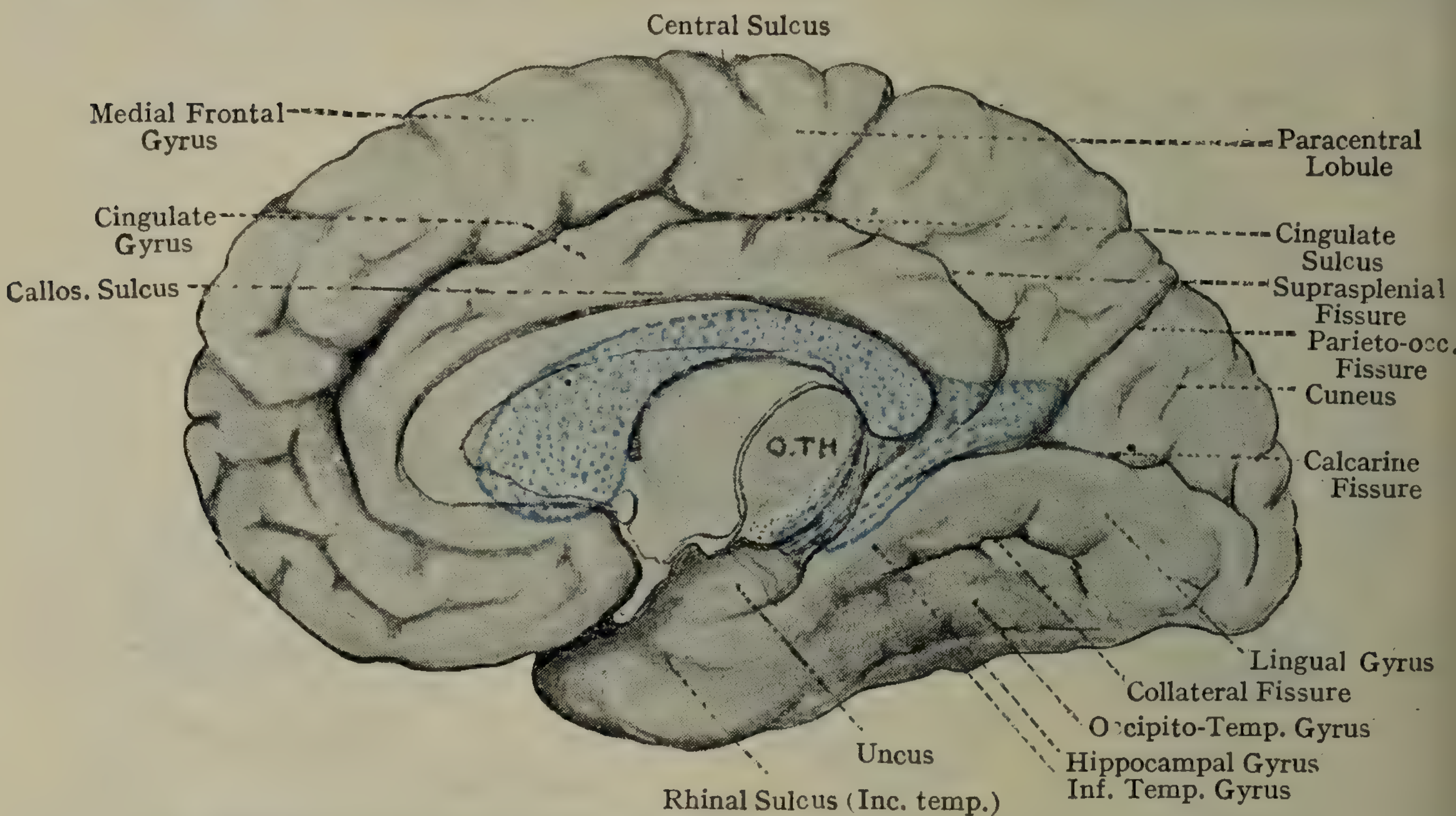


FIG. 921.—MEDIAL ASPECT OF HEMISPHERE, WITH APPROXIMATE POSITION OF LATERAL VENTRICLE REPRESENTED IN COLOUR.

described as branching into forward and backward branches. The *anterior branches* pass as far as the caput of the corpus striatum, where they are described as blending with the fibres which enter the internal capsule. Some may even pass to the cortex of the prefrontal region. The *posterior branches* turn round the splenium, and then lie upon the subiculum, or upper part of the hippocampal gyrus, as far forwards as the caput and uncus. The posterior fibres are described as ending in the cortex of (1) the subiculum hippocampi, and (2) occipital lobe. The cingulum belongs to the class of long association fibres.

Hippocampal or Dentate Fissure.—This fissure commences behind the splenium of the corpus callosum, where it is continuous with the callosal sulcus. It is directed forwards, lying between the gyrus denta-

tus above and the hippocampal gyrus below, and it terminates within the uncus of the hippocampal gyrus.

The hippocampal fissure is a *complete fissure.* It appears in the course of the fifth week, and is parallel to the temporal portion of the choroidal fissure, below which it lies. The portion of the vesicular wall between these two fissures is the **gyrus dentatus,** and the portion below the hippocampal fissure forms the **hippocampal gyrus.**

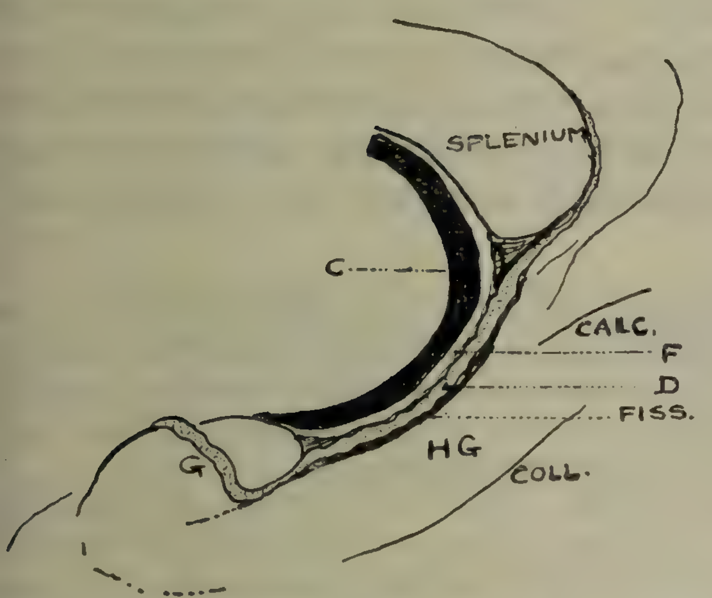


FIG. 922.—TO SHOW THE ARRANGEMENT OF STRUCTURES BELOW THE LEVEL OF THE SPLENIUM.

F, fimbria and posterior pillar of fornix; D, dentate gyrus; CALC, beginning of calcarine fissure; COLL, collateral fissure; HG, hippocampal gyrus. The 'band of Giacomini,' continuous with the dentate gyrus, is shown at G crossing the base of the uncus. C, choroidal fissure; Fiss, hippocampal fissure.

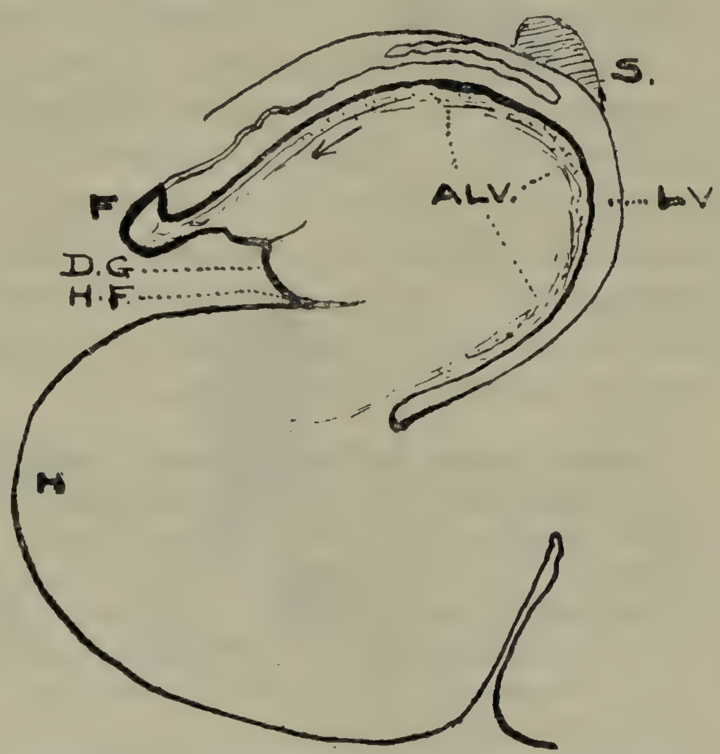


FIG. 923.—OUTLINE OF SECTION ACROSS HIPPOCAMPAL REGION.

Shows how the upper part of the region is bent on itself to make a prominence, the hippocampus, which projects in the ventricle (LV), while the thick lower part makes the hippocampal gyrus (H). The concavity of the upper bent part is provided by the hippocampal fissure (HF); the dentate gyrus (DG) is only a surface prominence on the part. The fimbria (F) is receiving fibres from the white covering of the hippocampus, known as the alveus (ALV). S, the tail of caudate nucleus.

The hippocampal fissure is associated with an internal elevation—namely, the *hippocampus*—on the wall of the descending cornu of the lateral ventricle (Fig. 923).

Gyrus Dentatus (Fascia Dentata).—The gyrus dentatus is situated above the hippocampal gyrus, and below the fimbria. It is separated from the hippocampal gyrus by the hippocampal fissure, and from the fimbria by a slight groove, called the *fimbrio-dentate sulcus.* The dentate gyrus is narrow, and its free margin is indented or notched; hence the name *dentatus.* It begins behind the splenium of the corpus callosum, and is directed forwards above the hippocampal gyrus into

the curve of the uncus. Here it describes a bend, after which it emerges from the curve of the uncus, and, crossing the recurved part, is lost on its lateral aspect. This portion, the *tail of the dentate gyrus*, is often called the band of *Giacomini*.

Posteriorly it is continuous round the splenium with the rudimentary *gyrus supracallosus*, or **indusium griseum,** which contains the *medial* and *lateral longitudinal striæ* of one-half of the upper surface of the corpus callosum.

Fimbria.—The fimbria is the prolongation of the posterior pillar of the fornix. It is situated above the gyrus dentatus, from which it is separated by the fimbrio-dentate sulcus. Posteriorly it turns upwards round the posterior extremity of the thalamus, and so becomes continuous with the posterior pillar of the fornix. Anteriorly it enters the uncus. It receives fibres along its length from the dentate gyrus and from the layer of white fibres (*alveus*) covering the ventricular surface of the hippocampus.

Development of the Cerebral Hemispheres.—Each hemisphere is developed from the wall of the **cerebral vesicle,** and is a hollow protrusion from the upper and lateral part of the telencephalon, the anterior subdivision of the prosencephalon. The anterior wall of that portion of the telencephalon which lies between the two cerebral vesicles is called the **lamina terminalis.**

The hemispheres grow out of proportion to the other parts of the encephalon in a forward, upward, and backward direction. Their backward growth is so great that they completely cover the other parts of the encephalon by the seventh month of intra-uterine life.

The sulci and gyri of the hemispheres first appear about the fifth month of intra-uterine life.

Development of the Insula and Lateral Fissure.—The insula, or island of Reil, appears as the floor of a depression, called the **lateral fossa,** on the lateral aspect of the cerebral vesicle. The wall of this fossa becomes developed into the *opercula insulæ*, and as these grow they cover the insula, and give rise to the limbs of the fissure. The insula is the superficial surface of the mass of the corpus striatum, which does not increase in surface area so quickly as the thin walls of the pallium round it, whence it is overlapped by these walls, which form the *opercula*.

Olfactory Lobe.

The olfactory formations, taken as a whole, are rudimentary in man. Although they are developments of the cerebral vesicles (with the exception of the olfactory nerves) they can be divided on each side for descriptive purposes into (*a*) external, lying apparently on the surface of the hemisphere; and (*b*) internal, forming part of the hemisphere, on its medial aspect.

(*a*) The **external** formations comprise the olfactory bulb and tract, with the dispositions of the 'roots' or 'olfactory striæ' and of the formations in their immediate neighbourhood.

The **olfactory bulb** is the enlarged anterior extremity of the olfactory tract. It is oval, and its upper surface is in contact with the orbital surface of the frontal lobe, whilst its lower surface rests upon one half of the cribriform plate of the ethmoid bone. The lower surface receives the olfactory nerves, which arise from the olfactory cells of the olfactory

mucous membrane, and pass through the foramina of the cribriform plate.

The **olfactory tract** is a white band which extends backwards from the olfactory bulb, both of them occupying the olfactory sulcus on the medial part of the orbital surface of the frontal lobe. Posteriorly it divides into two roots, medial and lateral, which diverge and enclose between them the trigonum olfactorium.

The **medial root** passes medially and upwards in a curved manner to reach the subcallosal region. Some of its fibres pass into this area, and others enter the anterior extremity of the callosal gyrus.

The **lateral root** passes backwards and laterally over the outer part of the anterior perforated area, and enters the anterior part of the hippocampal gyrus.

The **trigonum olfactorium** is the area of grey matter which lies between the diverging medial and lateral roots of the olfactory tract. It is sometimes described as the *middle* or *grey root* of the olfactory tract.

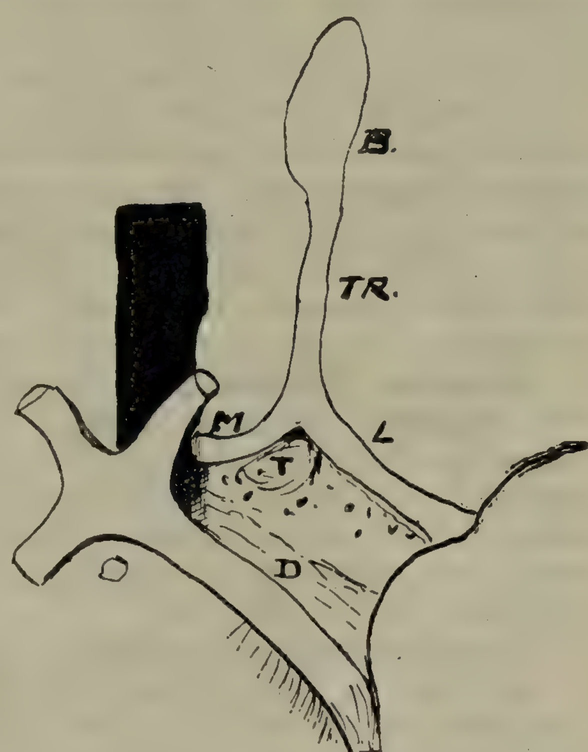


Fig. 924.—Plan of Structures Round Right Anterior Perforated Substance.

M, L, medial and lateral olfactory roots; D, diagonal band; T, olfactory tubercle. Bulb and tract are seen at B and TR.

The anterior perforated substance lies behind and between the diverging roots of the olfactory tract, and is limited behind and medially by the diagonal band, frequently not very well defined, which lies between it and the optic tract. At its anterior and medial end, where the olfactory roots are beginning to diverge, there may be a slight prominence, the olfactory tubercle. The perforations are made by central branches of the anterior and middle cerebral arteries.

The olfactory tubercle is, when present at all, a very small elevation. It represents the remnant of a large rounded mass which is found in macrosmatic brains, receiving an intermediate tract from the olfactory bulb.

The grey matter of the anterior perforated substance is continuous superiorly with the grey matter of the lentiform and caudate nuclei.

Development.—The olfactory lobe is developed from the antero-inferior part of the cerebral vesicle; an area is marked off by a groove, which deepens, and the area, growing, thus becomes a protrusion. This protrusion becomes solid, and gives rise to the olfactory tract and olfactory bulb.

Development of the Olfactory Apparatus.

This is developed in two parts—the olfactory lobe, and the olfactory epithelium. The **olfactory lobe** is *intracranial*, and is an outgrowth from the anterior part of the ventral aspect or floor of the telencephalon, which is the anterior

subdivision of the prosencephalon or fore-brain. It constitutes the olfactory lobe (rhinencephalon) of the brain, and it becomes transformed into several parts, which will presently be stated, its terminal portion being the olfactory bulb, which rests upon one-half of the cribriform plate of the ethmoid bone.

The **olfactory epithelium** is *intranasal,* and occupies the upper part of the nasal fossa of either side. It represents a *neuro-epithelium,* which is derived from an invagination of the surface ectoderm. The axons of its sensory cells constitute the *olfactory nerve-filaments,* which pass upwards through the foramina of the cribriform plate, and enter the under surface of the olfactory bulb.

Olfactory Bulb.—The olfactory bulb appears as part of a hollow protrusion, slowly lengthening, of the anterior cerebral vesicle on its ventral aspect, and near its anterior part. The cavity of this protrusion, which is continuous with the lateral ventricle, soon undergoes obliteration, and the protrusion becomes solid. Its terminal extremity undergoes enlargement, and the entire protrusion becomes differentiated into the following parts: (1) the olfactory bulb; (2) the olfactory tract; (3) the inner or medial, and outer or lateral, olfactory roots; (4) the trigonum olfactorium. Of these parts, the **olfactory bulb** is the enlarged terminal extremity of the original protrusion, and rests upon one-half of the cribriform plate of the ethmoid bone, through the foramina of which half it receives the olfactory filaments, which are the axons of the sensory cells of the olfactory epithelium of the upper part of the nasal fossa.

Olfactory Epithelium.—The first indications of the olfactory organ are the two **olfactory** or **nasal areas.** They consist of thickened ectoderm, and are placed on the ventral aspect of the anterior cerebral vesicle on either side of the medial nasal process of the fronto-nasal process, and on the cephalic side of the orifice of the stomodæum. Each olfactory area soon becomes depressed, and lies in the **olfactory** or **nasal pit.** The formation of the olfactory pits has been described on pp. 83 *et seq.*

The **olfactory epithelium** is deeply placed in the upper part of the nasal pit, in the roof of which the cribriform plate of the ethmoid bone will develop. The ectodermic cells of the upper part of the nasal pit constitute a *neuro-epithelium,* and each cell is prolonged into a slender process, which is an **axis-cylinder process,** or **axon.** These axons form the **olfactory nerve-filaments,** which are *non-medullated,* and they are connected with the olfactory area of the brain from an early stage. Within the olfactory bulb they break up into arborizations, which intermingle with the arborizations of the **mitral cells** of the bulb.

For the development of the **organ of Jacobson** and further details about nasal fossæ, see pp. 1360 *et seq.*

(*b*) **Internal Formations—Rhinencephalon.**—The rhinencephalon is that part of the cerebral hemisphere which receives and relays olfactory impulses which have been transmitted to it through the olfactory roots. It is feebly developed in man. It includes (Fig. 925) the formations which make a ring round the passage into the cerebral vesicle, a ring which is closed in front by the olfactory roots. They are the **uncus and caput hippocampi,** the **dentate gyrus, fimbria** and **fornix,** and probably a large part of the hippocampal gyrus; the **hippocampus** (in the ventricle), and the continuity (*fasciola cinerea* or splenial gyrus) between the hippocampal and dentate formations and the **indusium griseum,** is carried over the front of the corpus callosum to join the **subcallosal region.** The *medial* olfactory root reaches the subcallosal region, the *lateral* root reaches the uncus, and the **diagonal band** stretches also between these two parts. All these structures are thus included in the rhinencephalon, and to them can be added the **septum lucidum** and the **anterior commissure.**

Many of these formations have been described (p. 1507) already; others will be described in their proper place, and the developmental aspect of the part will also be considered.

Morphologically considered, the cerebral hemisphere is composed of three parts—namely, the stem, rhinopallium, and neopallium. The **stem** or **stalk** is formed by the corpus striatum; the **rhinopallium** consists of the parts which compose the rhinencephalon; and the **neopallium** represents the remainder of the hemisphere.

Corpus Callosum.—The corpus callosum is the great neopallial commissure, and connects the two cerebral hemispheres. It is situated at the bottom of the great longitudinal fissure, and extends nearer to the front than back of the hemispheres. It is arched and thicker in front and behind than at the centre, its greatest thickness being *posteriorly*, where more fibres cross in it than elsewhere, on account of there being more of the hemisphere behind it than in front of it.

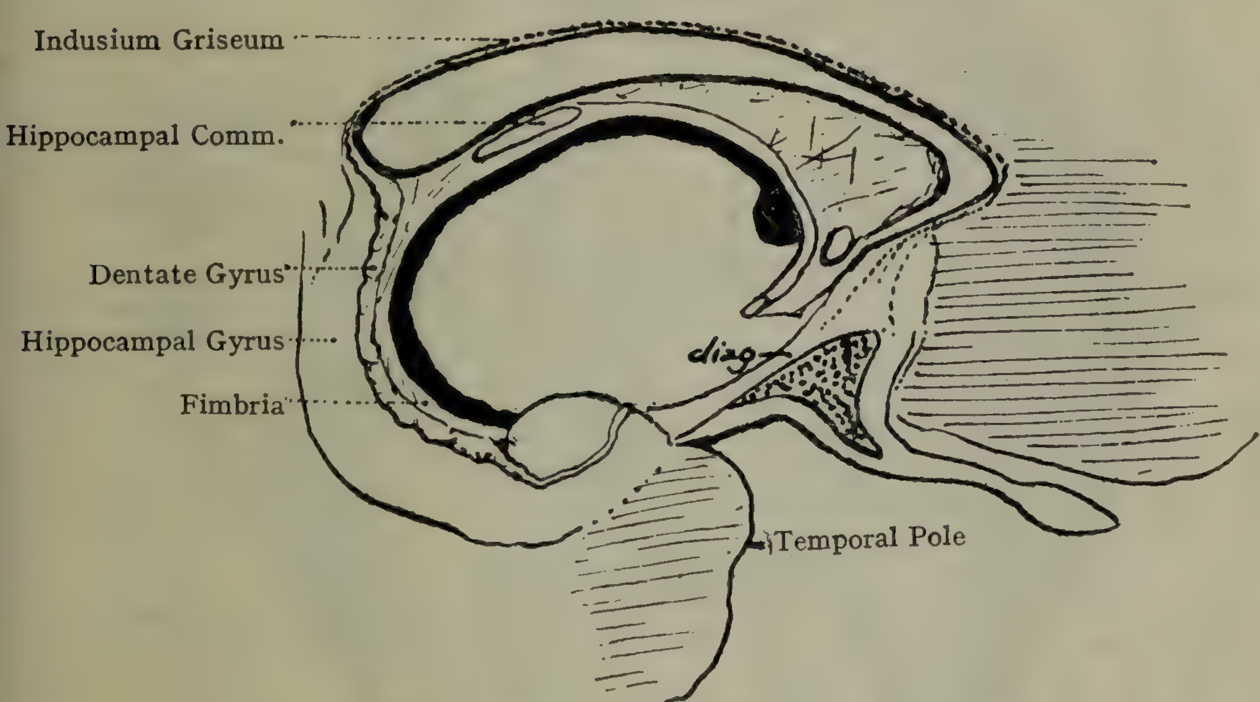


FIG. 925.—PLAN OF THE STRUCTURES CONSTITUTING THE RHINENCEPHALON.

The **superior surface** is related to the falx cerebri, but is in contact with it only posteriorly. It is covered by a thin layer of grey matter, and presents a transversely striated appearance, indicative of the direction of its fibres. In the median line there is a slight antero-posterior furrow or **raphé**, and on either side of this there is a white longitudinal band, called the **stria longitudinalis medialis.** The right and left striæ longitudinales mediales are sometimes spoken of as the *nerves of Lancisi.* Lateral to each medial stria, and situated under cover of the callosal gyrus, there is another band, composed of grey matter, called the **stria longitudinalis lateralis.**

The striæ of each side are lying in the grey layer already mentioned, and may be traced posteriorly round the splenium, where they are known as fasciola cinerea, into the corresponding gyrus dentatus. Anteriorly each medial stria, along with the grey matter in which it lies, passes round the genu and backwards on the under surface of the

rostrum under the name of the **geniculate gyrus.** This enters the subcallosal gyrus, and finally passes to the temporal pole.

The medial and lateral longitudinal striæ of each side, together with the thin layer of grey matter, represent a rudimentary convolution of the rhinencephalon called the *supracallosal gyrus.* The grey matter in the human brain is termed the **indusium griseum.**

The **posterior extremity** of the corpus callosum is called the **splenium,** and is rolled upon itself, so that its lower part is directed forwards and lies over the mesencephalon and pineal body.

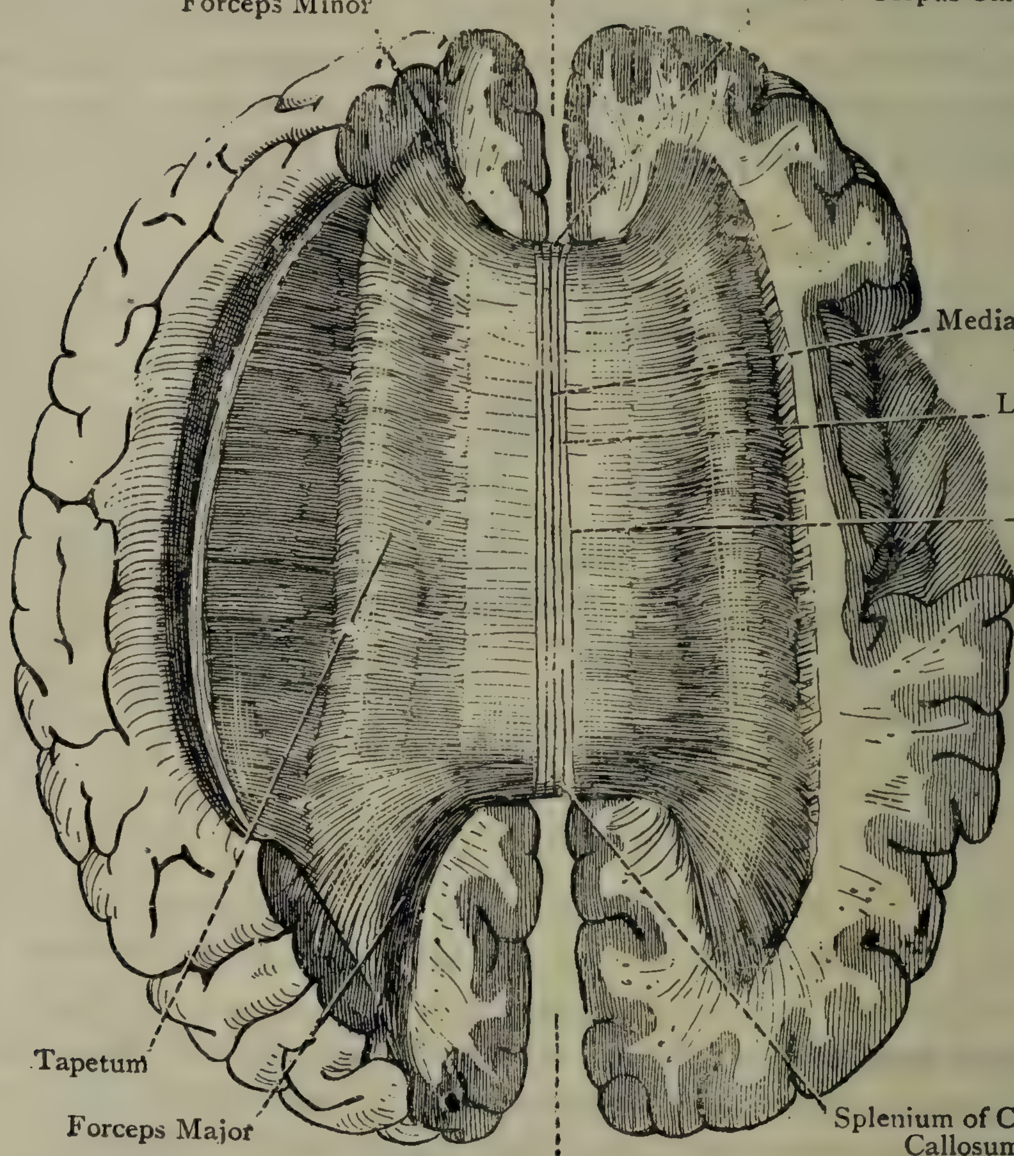


FIG. 926.—THE CORPUS CALLOSUM (SUPERIOR VIEW) (HIRSCHFELD AND LEVEILLÉ).

Anteriorly the corpus callosum is bent upon itself, and passes at first downwards and then backwards. The bent portion is called the **genu,** and the portion which passes backwards the **rostrum.** The rostrum ends by joining the lamina terminalis in the mid-line, and on either side it passes into the so-called *peduncles of the corpus callosum,* otherwise known as the **subcallosal gyri.** Each subcallosal gyrus, with the contained stria longitudinalis medialis, passes downwards on the internal surface of the cerebral hemisphere to become continuous with the anterior perforated substance, lying in front of the lateral portion of

the lamina terminalis. The gyrus then passes backwards and outwards along the posterior margin of the perforated area, forming now the **diagonal band,** and so reaches the temporal pole.

The **inferior surface** of the corpus callosum is divisible into a medial and two lateral portions. The *medial portion* is connected posteriorly with the fornix, and over the remainder of its extent with the septum lucidum. Each *lateral portion* enters into the roof of the body and anterior horn of the corresponding lateral ventricle (see Fig. 930).

Destination of the Callosal Fibres.—The transverse fibres of the corpus callosum, on entering the white medullary substance of each cerebral hemisphere, traverse it in a radiating manner as they pass

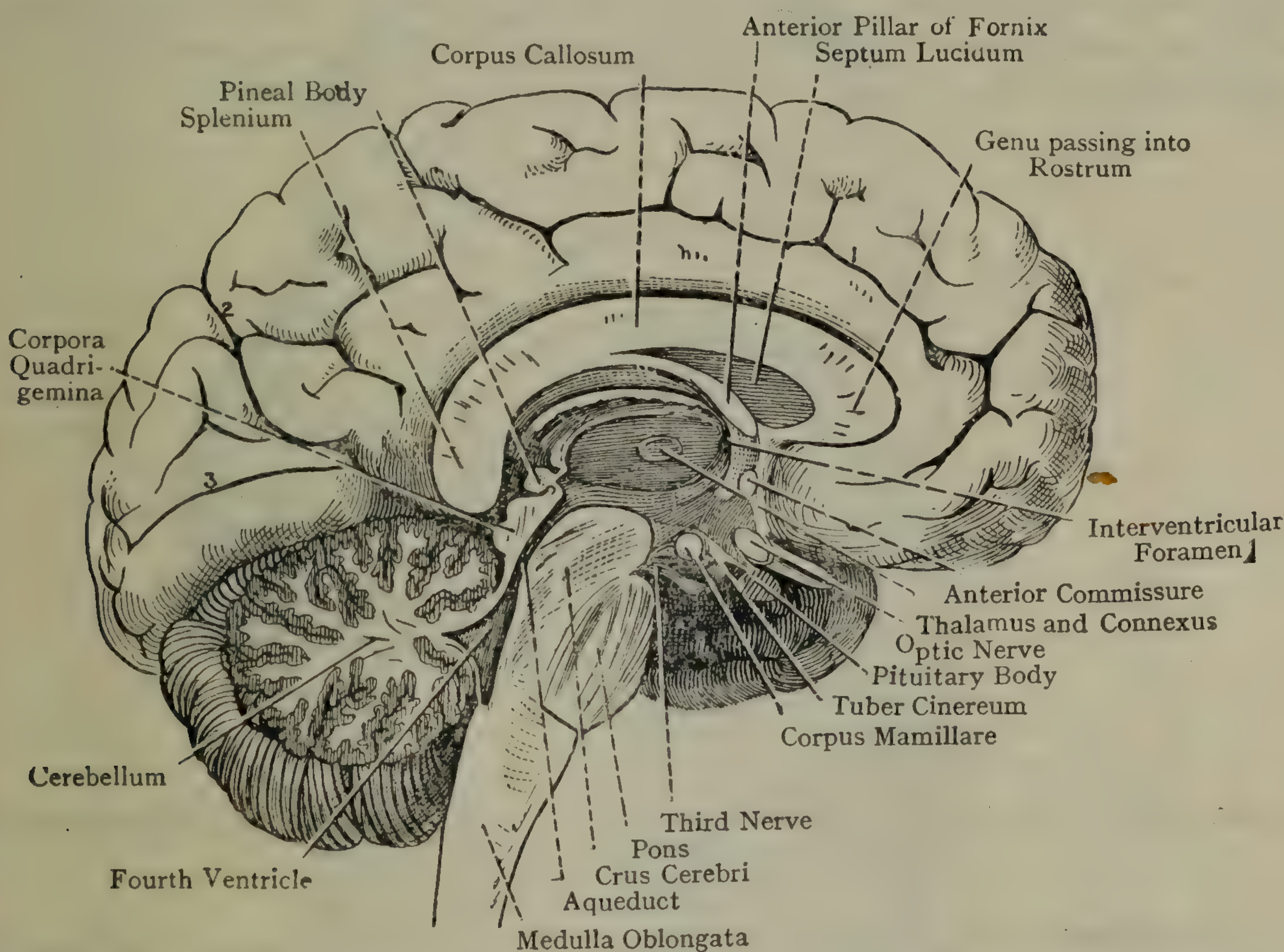


FIG. 927.—THE MEDIAL SURFACE OF THE LEFT CEREBRAL HEMISPHERE (HIRSCHFELD AND LEVEILLÉ).

to the cerebral cortex. They constitute the **radiatio corporis callosi,** and intersect in their course the fibres which pass between the internal capsule and the cerebral cortex, which form the *corona radiata.* The fibres from the central portion or body and upper part of the splenium of the corpus callosum constitute the *tapetum.* This forms the roof of the body of the lateral ventricle, the chief part of the roof, and the outer wall of the commencement of the middle or descending horn, and the roof and outer wall of the posterior horn. Most of the fibres of the tapetum ultimately pass into the temporal and occipital lobes. The fibres from the region of the genu curve forwards into the front part of the frontal lobe, and form the roof of the anterior horn of the lateral ventricle. They constitute the *forceps minor.* The fibres from the

lower part of the splenium curve backwards into the occipital lobe, and give rise to an eminence on the inner wall of the posterior horn of the lateral ventricle. They constitute the *forceps major*.

Development.—The corpus callosum is developed fro m the **lamina terminalis**, but extends beyond this. It is the commissure of the neopallium.

Fornix.—This is an arched lamina of white longitudinal fibres which lies beneath the corpus callosum, with which it is connected posteriorly, but from which it is separated anteriorly by the septum lucidum. It is composed of two lateral halves, which are united together in the median line to form the *body* of the fornix; but in front and behind they are separated from each other, and form the *anterior* and *posterior pillars*. The fornix is thus composed of a body, two anterior pillars, and two posterior pillars (Fig. 928).

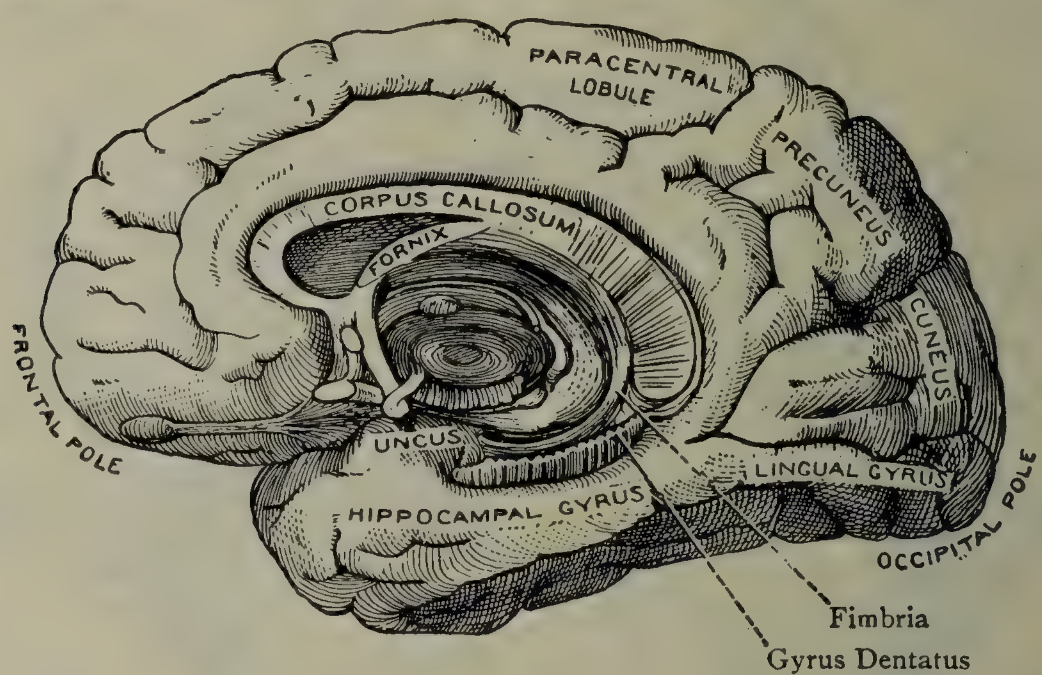


FIG. 928.—THE MEDIAL SURFACE OF THE RIGHT CEREBRAL HEMISPHERE (HIRSCHFELD AND LEVEILLÉ).

The **body** is triangular, being narrow in front, where it is continuous with the anterior pillars, and broad behind, where it is prolonged into the posterior pillars. The *superior surface* of the body is connected posteriorly with the corpus callosum, and anteriorly with septum lucidum. Each *lateral border* is well defined, and projects slightly into the lateral ventricle. The *inferior surface* rests directly upon the tela chorioidea, beneath which, in the median line, is the third ventricle, and on either side the upper surface of the thalamus.

The **anterior pillars** are two round bundles, which are continuous with the anterior part of the body, and are slightly separated from each other. They pass downwards in front of the interventricular foramina, traversing the grey matter on the sides of the third ventricle. On reaching the base of the brain each pillar becomes twisted in the form of a loop, and forms the white portion of the corresponding corpus mamillare. The fibres of the anterior pillar terminate in the grey nucleus of the corpus, and from this nucleus a bundle of fibres,

called the **mamillo-thalamic tract**, or *bundle of Vicq d'Azyr*, passes upwards and backwards into the thalamus.

The anterior pillars lie behind the anterior commissure, but give off a few precommissural fibres which, passing down in front of the

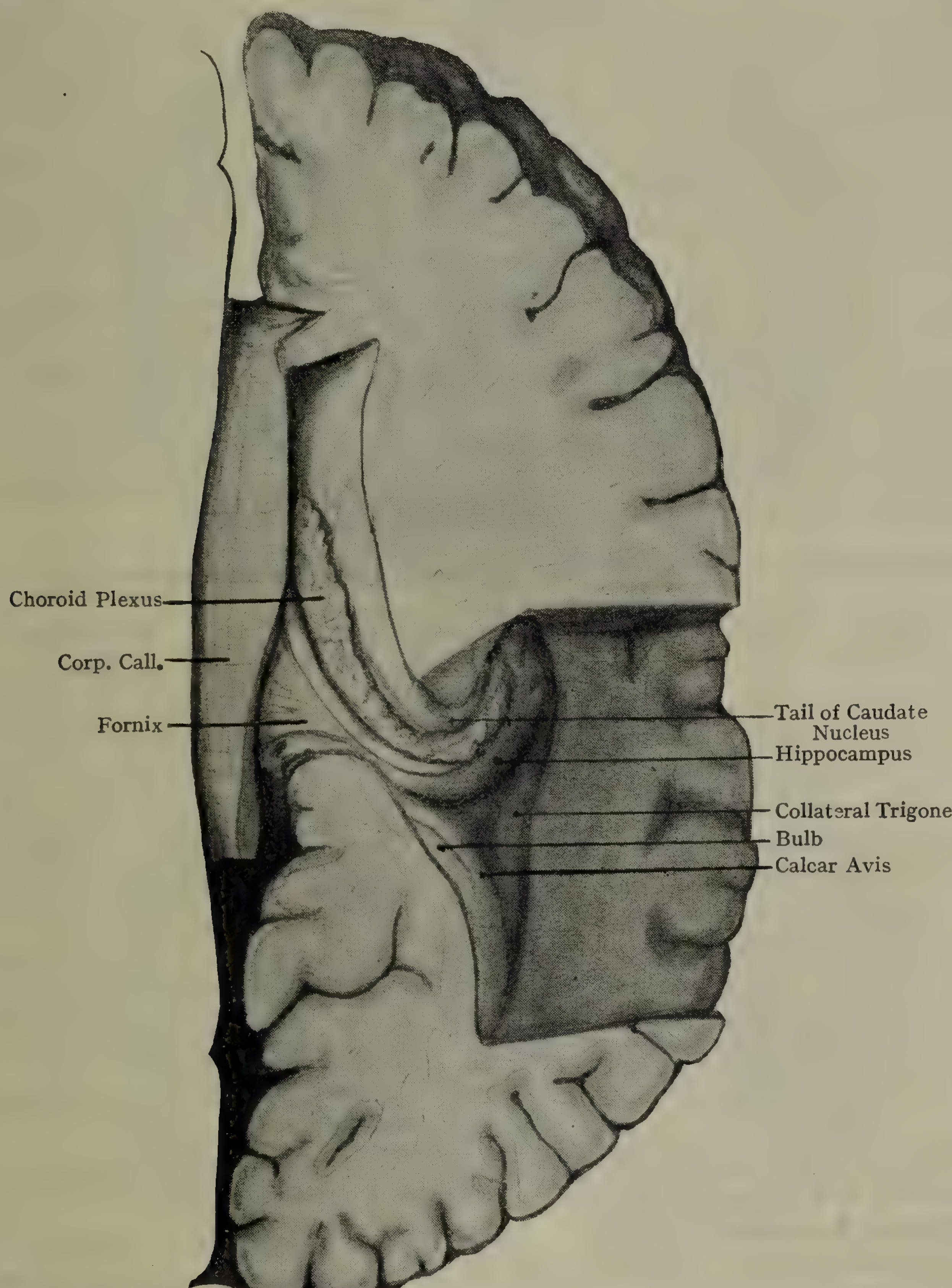


FIG. 929.—PART OF CORPUS CALLOSUM CUT AWAY TO EXPOSE FORNIX AND RIGHT VENTRICLE.

Inferior and posterior horns also opened from above.

commissure, reach the anterior perforated substance and subcallosal gyrus.

The **posterior pillars** are prolongations of the posterior part of the body on either side. They are flattened bands, which at first

adhere to the under surface of the corpus callosum. Subsequently, however, each curves laterally and downwards round the posterior extremity of the thalamus, and enters the descending horn of the lateral ventricle. Here the posterior pillar comes into contact with the hippocampus, upon the surface of which some of its fibres become spread out, forming the *alveus*. The rest of the fibres are prolonged as a narrow band of white matter, called the **fimbria,** or *tænia hippocampi*, along the concave border of the hippocampus, to which it is attached, as far as the uncus (see Fig. 929). As the two posterior pillars diverge from each other they enclose between them a small triangular space on the under surface of the corpus callosum posteriorly. This space is crossed by transverse fibres, and is known as the *lyra*, from its supposed resemblance to a lyre. The transverse fibres form a commissure between the two hippocampi, and the lyra is therefore known as the **hippocampal commissure.** Each lateral half of the fornix establishes a communication between the hippocampus, in which the majority of its fibres originate, and the thalamus of the same side by means of the anterior pillar, the corpus mamillare, and the bundle of Vicq d'Azyr (mamillo-thalamic tract).

Development.—The fornix is developed from the **lamina terminalis.**

Anterior Commissure.—This is a round bundle of white fibres which crosses the middle line immediately in front of the anterior pillars of the fornix. Anteriorly its central portion is connected with the lamina terminalis (Fig. 930), and posteriorly the central portion appears between the anterior pillars of the fornix, where it forms part of the anterior boundary of the third ventricle, and is covered by the ventricular ependyma. On either side the commissure enters the cerebral hemisphere, and divides into two parts, olfactory and temporal. The *olfactory portion* is of small size, and enters the corresponding olfactory tract. Some of its fibres serve to connect the olfactory bulb of one side with that of the other side. The other fibres connect the olfactory bulb of one side with the temporal lobe of the opposite side. The *temporal portion* is of large size, and its fibres disappear in the white matter of the temporal lobe.

The anterior commissure, therefore, serves to connect the olfactory bulbs and the temporal lobes.

Septum Lucidum.—This is a thin vertical partition which is situated between the anterior horns of the lateral ventricles, as well as between the front parts of the bodies of these ventricles. It is triangular, being broad in front and narrow behind. Posteriorly it is attached above to the under surface of the corpus callosum, and below to the upper surface of the body of the fornix. Anteriorly it occupies the concavity behind the genu of the corpus callosum, being attached above to the corpus callosum and below to the rostrum of that body. It is seen in section in the first figure in Fig. 930. The septum lucidum is composed of two delicate laminæ. The lateral

surface of each lamina looks into the corresponding lateral ventricle, and is covered by the ventricular ependyma (epithelium). The medial

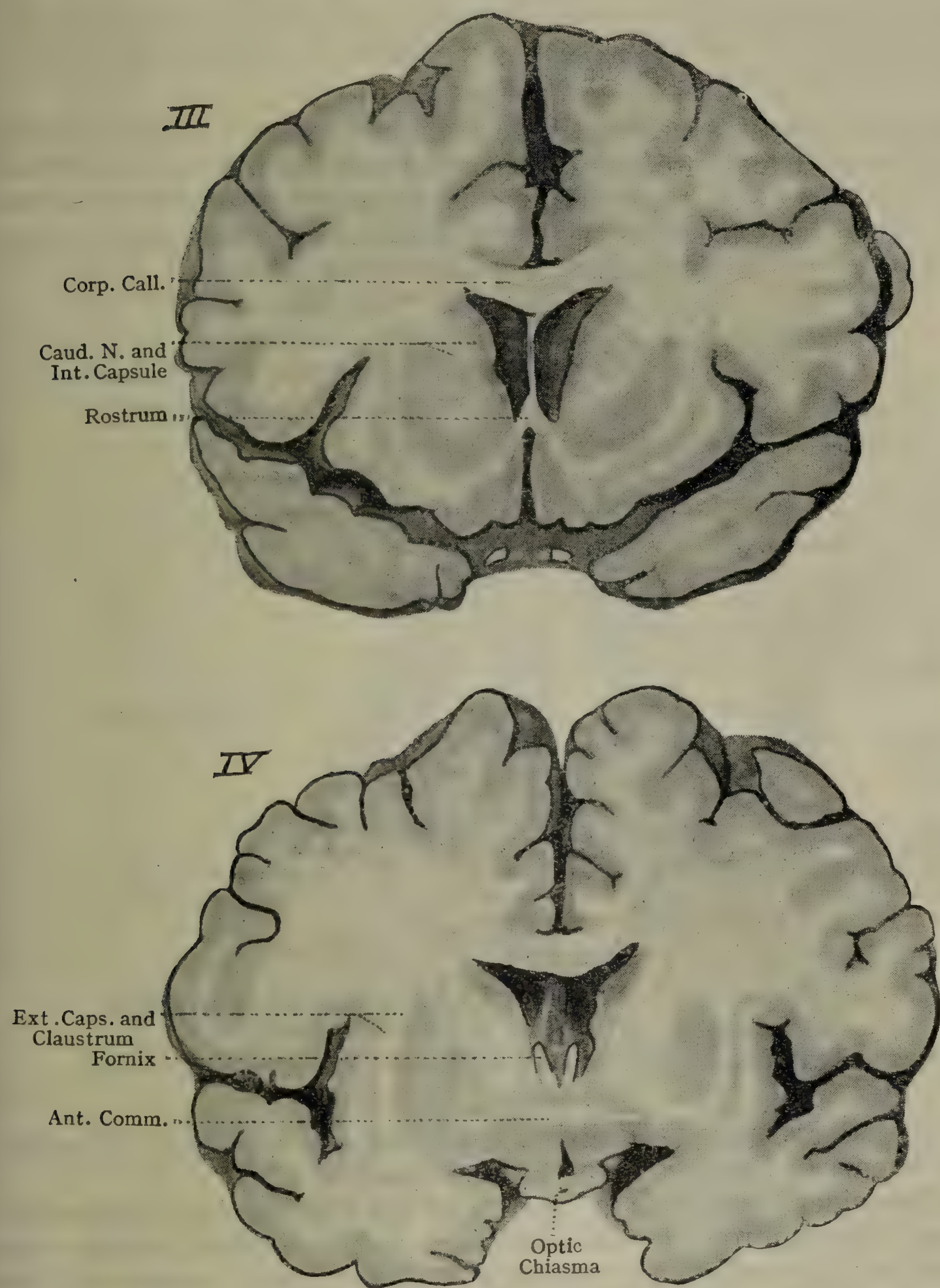


FIG. 930.

The upper section is through the anterior horn, cutting the body and rostrum of corpus callosum. The lower section is through the lamina terminalis and anterior commissure, and has cut tangential slips from the anterior pillars of fornix.

surface faces that of its fellow, a narrow lymph space, formerly called the fifth ventricle, but now the **cavity of the septum lucidum,** intervening between the two. Each lamina consists of white matter, which

is covered by grey matter on the surface looking towards the fifth ventricle.

The two laminæ are formed from portions of the medial wall of the two cerebral hemispheres, which have become detached in the course of the development of the corpus callosum and fornix.

Cavity of the septum lucidum, formerly known as the fifth ventricle, is the narrow cleft-like interval between the two laminæ of the septum lucidum. It is a closed space, and has therefore no communication with the other ventricles. It is destitute of any ependymal lining, and contains a very little fluid.

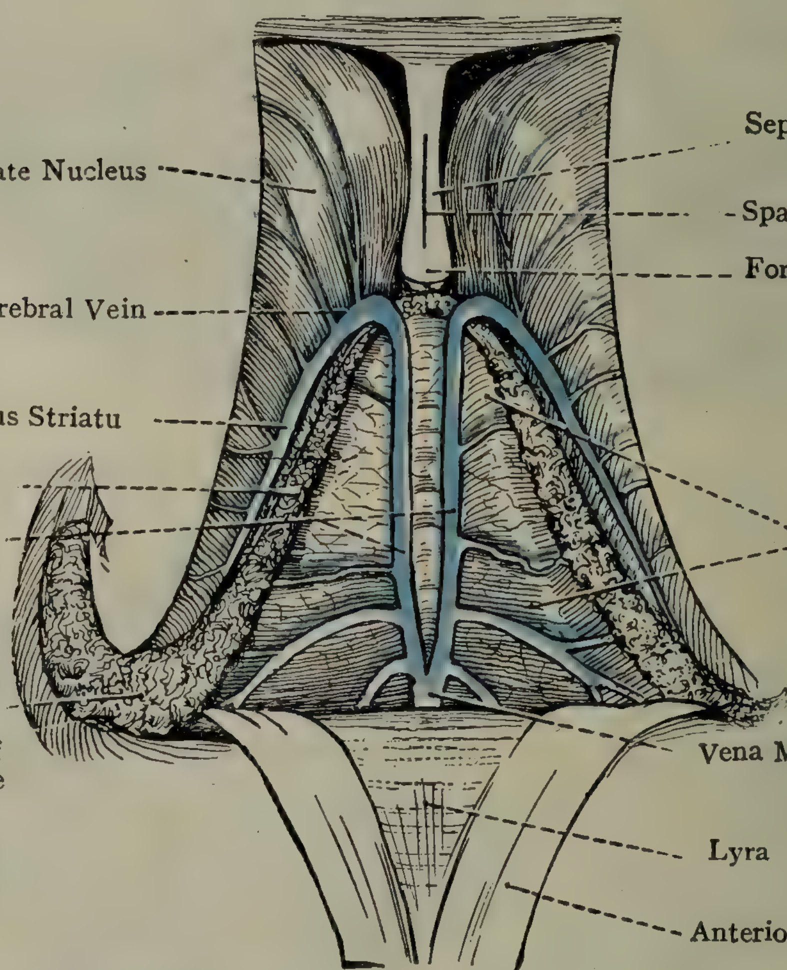


FIG. 931.—THE TELA CHORIOIDEA AND INTERNAL CEREBRAL VEINS.

As regards **development,** it differs from the true ventricles in being originally a part of the great longitudinal fissure.

Tela Chorioidea.—This is also known as the *tela chorioidea superior*, in contradistinction to the *tela chorioidea inferior*, which is the pia mater forming the roof of the lower part of the fourth ventricle. It lies immediately beneath the fornix, and rests upon the ependymal roof of the third ventricle, and also upon the adjacent portions of the thalami (Fig. 932). It consists of two layers of pia mater, and is triangular, the apex being situated behind the anterior pillars of the fornix at the interventricular foramina and the base lying beneath the splenium of the corpus callosum. In the latter situation the two layers of the tela become continuous with the pia mater, which has entered through the **transverse fissure,** situated between the splenium

of the corpus callosum and the corpora quadrigemina. On either side the tela chorioidea projects beyond the lateral border of the fornix, and appears as a vascular fringe in the lateral ventricle, where it is covered by the ventricular ependyma. This fringe is known as the **choroid plexus of the lateral ventricle.** Posteriorly it is prolonged into the descending cornu. Anteriorly it approaches its fellow of the opposite side, and the two unite in the median line behind the interventricular foramina. From this junction two other choroid plexuses extend backwards on the inferior surface of the velum interpositum, one on either side of the median line. They form the **choroid plexuses of the third ventricle,** and lie superficial to the ependymal roof of the cavity. The choroid plexuses are composed of a highly vascular villous arrangement of the pia mater, and are the structures which secrete the cerebro-spinal fluid.

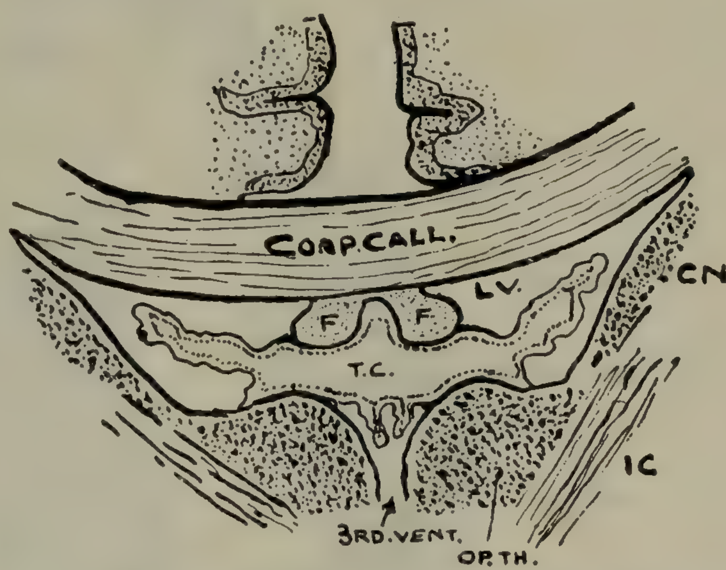


FIG. 932.—SCHEMATIC SECTION TO SHOW DISPOSITION OF TELA CHORIOIDEA, (T.C.).

LV, lateral ventricle; F, F, fornix; CN, caudate nucleus; IC, internal capsule.

The principal veins in connection with the velum interpositum are the two choroid veins and the two internal cerebral veins. The **choroid vein** of each side is situated in the choroid plexus of the lateral ventricle. It passes forwards and inwards to a point behind the corresponding foramen, where it joins the **vein of the corpus striatum,** which lies between the thalamus and the corpus striatum. In this manner the internal cerebral vein of one side is formed.

The **internal cerebral veins** (or veins of Galen) are right and left. Each is formed by the union between the choroid vein, the vein of the corpus striatum, and the vein of the septum lucidum, behind the corresponding interventricular foramen. The two veins pass backwards within the tela chorioidea, one on either side of the median line. At first they are near each other; then they diverge; but subsequently they come together again and unite to form one vessel, called the **vena magna cerebri,** which opens into the anterior extremity of the straight sinus. Each vein receives numerous tributaries from the corresponding choroid plexus of the third ventricle, the thalamus, corpus callosum, corpora quadrigemina, and pineal body. Near its termination it is joined by the large **basilar vein,** which is formed at the anterior perforated area by the union of the **anterior cerebral vein** with the **deep middle cerebral vein.** The vena magna receives tributaries from the upper surface of the cerebellum and from the occipital lobes of the cerebral hemispheres.

Lateral Ventricles.

The lateral ventricles are cavities in the right and left cerebral hemispheres. They are of irregular shape, and each is about two-thirds of the length of the corresponding hemisphere. They are lined with ependyma (epithelium), and contain cerebro-spinal fluid. Each ventricle communicates with the third ventricle by the interventricular foramen, which is situated between the anterior pillar

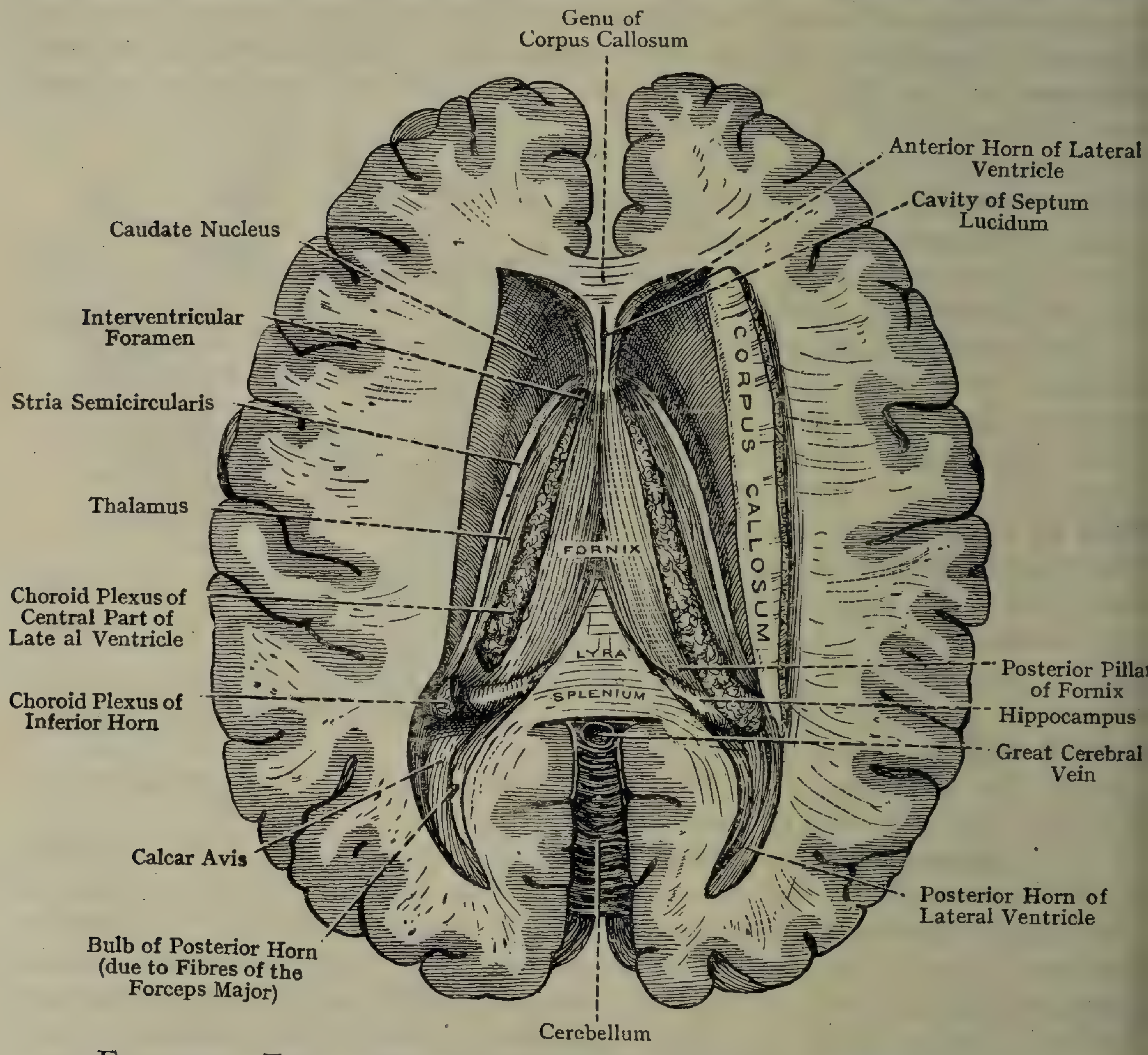


FIG. 933.—THE LATERAL VENTRICLES OF THE CEREBRUM (AFTER HIRSCHFELD AND LEVEILLÉ).

of the fornix and the front part of the thalamus. The lateral ventricle of either side consists of a body or central part and three horns—anterior, middle or descending, and posterior.

The **central part** extends from the foramen to the level of the splenium of the corpus callosum. The **anterior horn** is situated in front of the foramen, and curves forwards and laterally into the frontal lobe. The **inferior horn** enters the temporal lobe, and describes a remarkable curve as it sweeps round the posterior extremity of the thalamus. Its direction is *backwards, laterally downwards,*

rwards, and finally *medially* to a point about 1 inch from the temporal ole. The **posterior horn** curves backwards and laterally, and then ackwards and medially into the occipital lobe.

The **central part** of the lateral ventricle has a roof, a medial wall, nd a floor. The **roof** is formed by the corpus callosum (tapetum). 'he **medial wall** is formed by the posterior part of the septum lucidum, nd, behind this, by the attachment of the body of the fornix to he under surface of the corpus callosum. *Laterally* the cavity is mited by the meeting of the roof and floor. The **floor** presents he following structures, in order from within outwards: (1) the harp lateral border of the fornix; (2) the choroid plexus of the

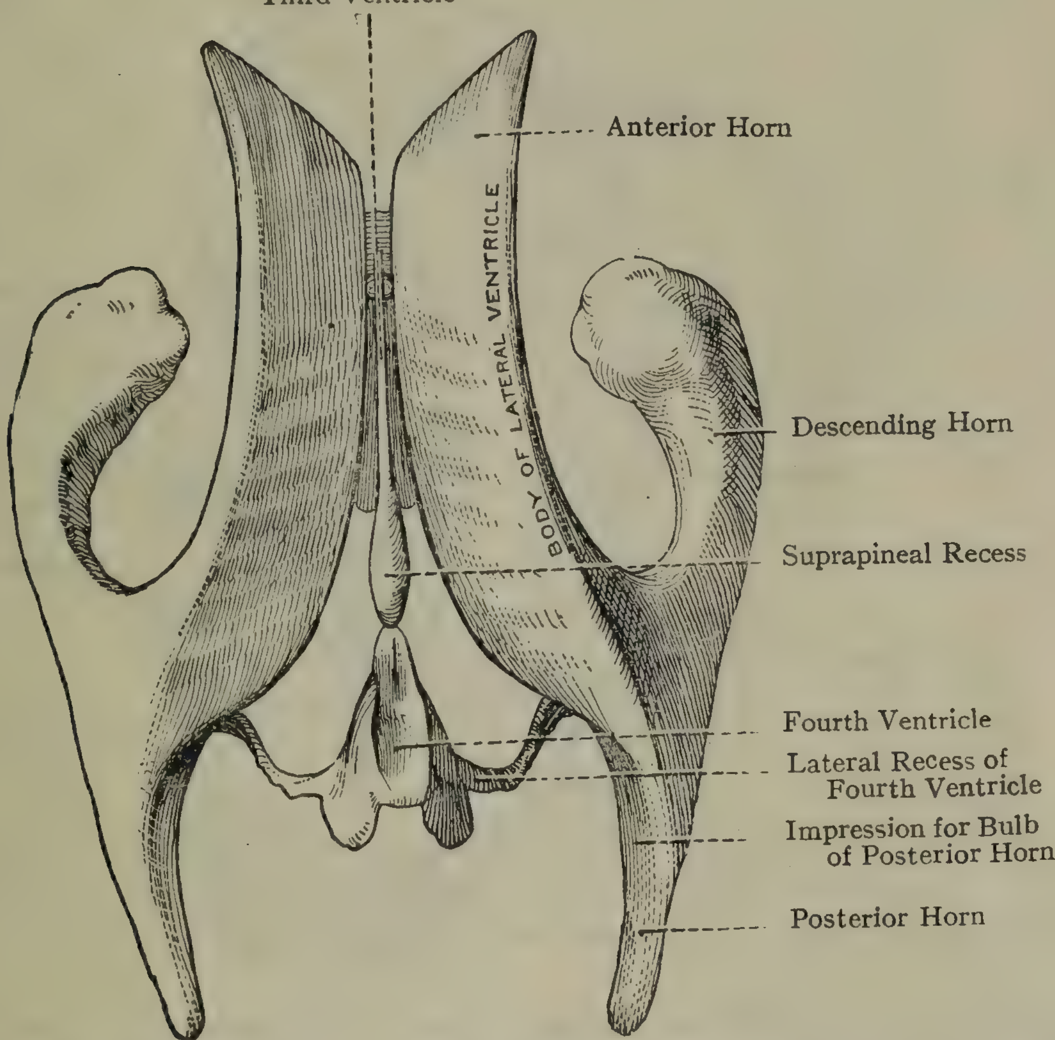


FIG. 934.—DRAWING OF A METAL CAST OF THE VENTRICLES OF THE BRAIN OF AN ADULT (SUPERIOR VIEW) (RETZIUS).

ateral ventricle; (3) a portion of the upper surface of the thalamus, covered by ependyma of ventricle; (4) an oblique groove, extending orwards and inwards between the thalamus and caudate nucleus, n which there are (*a*) a white band, called the **stria semicircularis,** und (*b*) the vein of the corpus striatum; and (5) the narrow part of he nucleus caudatus of the corpus striatum.

The **anterior horn** is compressed from side to side; its roof is formed oy the forceps minor of the corpus callosum; its lateral wall by the ıead of the caudate nucleus, round which the cavity is moulding tself; its inner wall by the septum lucidum; and its floor by the neeting of the outer and inner walls.

The **posterior horn** has its **roof** and **lateral wall** formed by th tapetum of the corpus callosum. The **medial wall** presents tw elongated curved eminences, upper and lower. The *upper* eminenc is made by the fibres of the forceps major as they sweep backward from the lower part of the splenium of the corpus callosum to th occipital lobe. It is called the **bulb of the posterior horn.** The *lowe* eminence is called the **calcar avis,** and is invaginated by the precalcarin fissure on the medial surface of the cerebral hemisphere.

The **inferior** or **descending horn** is situated in the temporal lobe The **roof** is formed chiefly by the tapetum of the corpus callosum

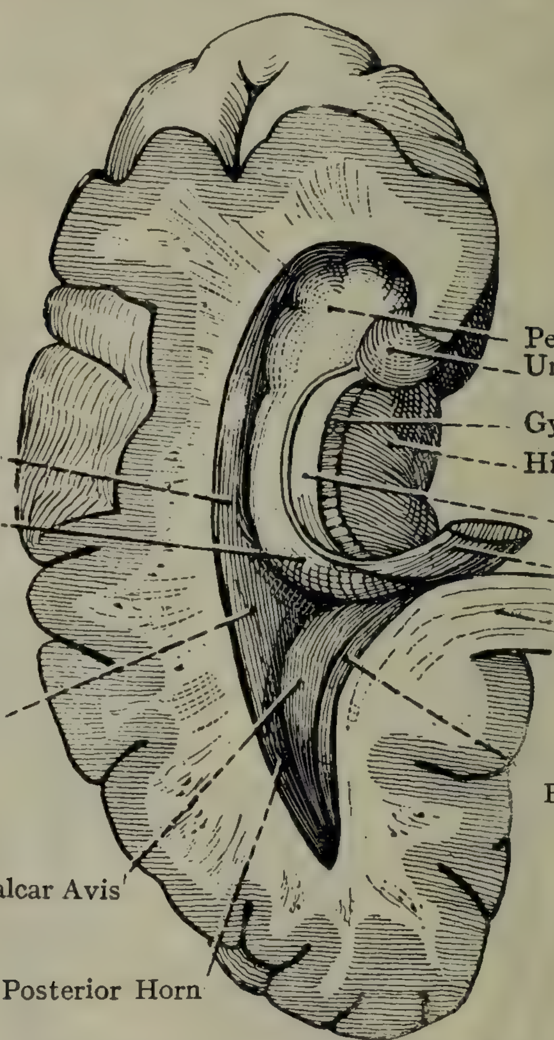


FIG. 935.—THE INFERIOR AND POSTERIOR HORNS OF THE LEFT LATERAL VENTRICLE (AFTER HIRSCHFELD AND LEVEILLÉ).

The inferior cornu has been laid open throughout its entire extent.

and at its anterior end presents the **amygdaloid tubercle,** which is produced by a collection of grey matter, called the **amygdaloid nucleus.** The narrow part or **tail** of the nucleus caudatus and the tænia semicircularis are prolonged into the roof, and extend in it as far as the amygdaloid nucleus. The **floor** of the descending horn presents the following structures: (1) the hippocampus; (2) the fimbria; (3) the trigonum collateralis; and (4) the choroid plexus of the descending horn. The **hippocampus** is a prominent curved elevation which traverses the entire length of the descending cornu, accurately adapting itself to its curves. It enlarges as it descends, and beneath the amygdaloid

ubercle it terminates in a swelling, which is notched on the surface. 'his swelling is called the **pes hippocampi.**

The hippocampus is invaginated by the dentate or hippocampal ssure on the medial surface of the cerebral hemisphere (see Fig. 923).

The **fimbria** is the continuation of the posterior pillar of the fornix. t lies along the inner concave border of the hippocampus, to which t is attached, and it is composed of white fibres, some of which form he layer on the surface of the hippocampus, called the *alveus*.

The **trigonum collateralis** is an elevation which is situated in the ngle between the descending and posterior horns, where there is a mall triangular space, called the *trigonum ventriculi*. It extends backvards into the posterior horn, and for a variable distance into the lescending cornu.

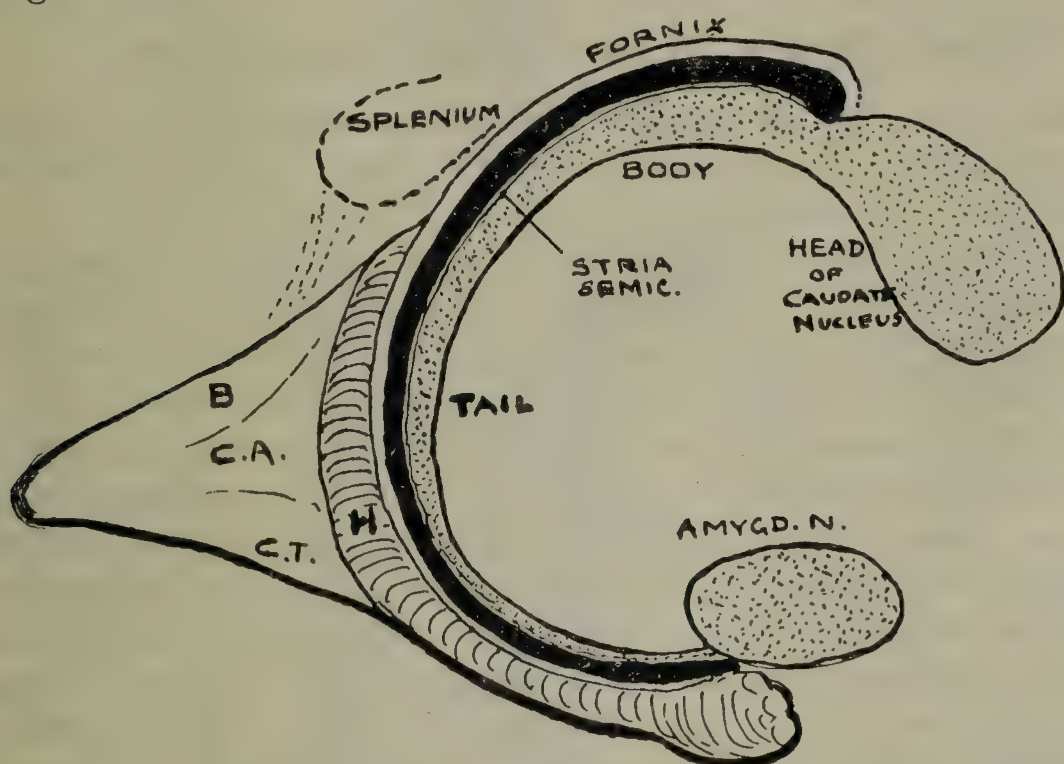


FIG. 936.—PLAN OF RELATIONS TO CHOROIDAL FISSURE AND TO EACH OTHER OF STRUCTURES FOUND IN LATERAL VENTRICLE.

H, hippocampus; B, bulb of posterior horn; C.A., calcar avis; C.T., collateral trigone.

The trigonum collateralis is produced by the central portion of the collateral fissure on the tentorial surface of the cerebral hemisphere.

The **choroid plexus of the descending horn** rests upon the surface of the hippocampus, and is continuous with that of the body of the lateral ventricle. It is covered by the ependyma of the medial wall of the descending cornu, which it invaginates. When the choroid plexus is removed its ependymal covering comes away along with it, and the choroidal fissure then becomes apparent.

The **choroidal fissure** is situated between the fimbria and the roof of the descending cornu, and, curving round the back part of the thalamus, it is traceable as far forwards as the interventricular foramen of the same side. In the other direction it extends to the lower extremity of the inferior cornu.

It is produced by an infolding or invagination of the epithelial medial wall of the cerebral vesicle of one side over the choroid plexus of the descending horn of the lateral ventricle. On either side it is continuous with the lateral and lower part of the *transverse fissure.*

When the choroid plexus is withdrawn from the descending horn of the lateral ventricle the epithelial or ependymal covering of the plexus comes away with it, or is broken down. Under these circumstances the descending horn *opens freely* upon the exterior.

Development.—The **lateral ventricles** represent the cavities of the primitive cerebral vesicles. The **choroidal fissure** is developed as an invagination of the medial wall of the cerebral vesicle; and the choroid plexus is developed from a growth of mesoblast into the choroidal fissure.

Basal Ganglia of the Cerebral Hemispheres.

The basal ganglia of each cerebral hemisphere are the nucleus caudatus and nucleus lentiformis of the corpus striatum, the claustrum, and the amygdaloid nucleus.

The **corpus striatum** is a large ovoid mass, which is situated in front, and on the outer side of the thalamus. It is composed of two collections of grey matter, one of which is intraventricular and the other extraventricular. The *intraventricular portion* is called the **nucleus caudatus.** The *extraventricular portion* is embedded in the white matter of the cerebral hemisphere, and is termed the **nucleus lentiformis.** Between these two nuclei there is a part of the thick tract of white fibres which constitutes the **internal capsule ;** and on the outer side of the nucleus lentiformis there is the thin lamina of white matter, called the **external capsule.** When a coronal section is made through the corpus striatum on a level with the anterior part of the nucleus lentiformis (see Fig. 939), the white matter of the front part of the internal capsule is seen to be intersected by striæ of grey matter which pass between the nucleus caudatus and nucleus lentiformis. From the striped appearance thus produced the body has received the name of *corpus striatum.*

The **nucleus caudatus** is pyriform. The large round end is directed forwards, and projects into the anterior horn of the lateral ventricle. The narrow portion is directed laterally and backwards in the floor of the central part of the lateral ventricle, where it lies lateral to the thalamus, from which it is separated by the stria semicircularis. Its tapering tail is continued into the roof of the descending horn of the lateral ventricle, and is prolonged in the roof as far as the amygdaloid nucleus, in which it terminates. The nucleus caudatus is composed of grey matter, and its cells are of the multipolar variety.

The **nucleus lentiformis** is embedded in the white matter of the cerebral hemisphere, and lies on the outer side of the nucleus caudatus and thalamus, from both of which it is separated by the internal capsule. It is of more limited extent than the nucleus caudatus, and receives its name from the fact that in certain sections it has the

appearance of a biconvex lens, the broadest part being on a level with the front of the thalamus. Anteriorly it is closely related to the front part of the nucleus caudatus, being continuous with it inferiorly, and connected with it superiorly by striæ of grey matter which intersect the white matter of the front part of the internal capsule.

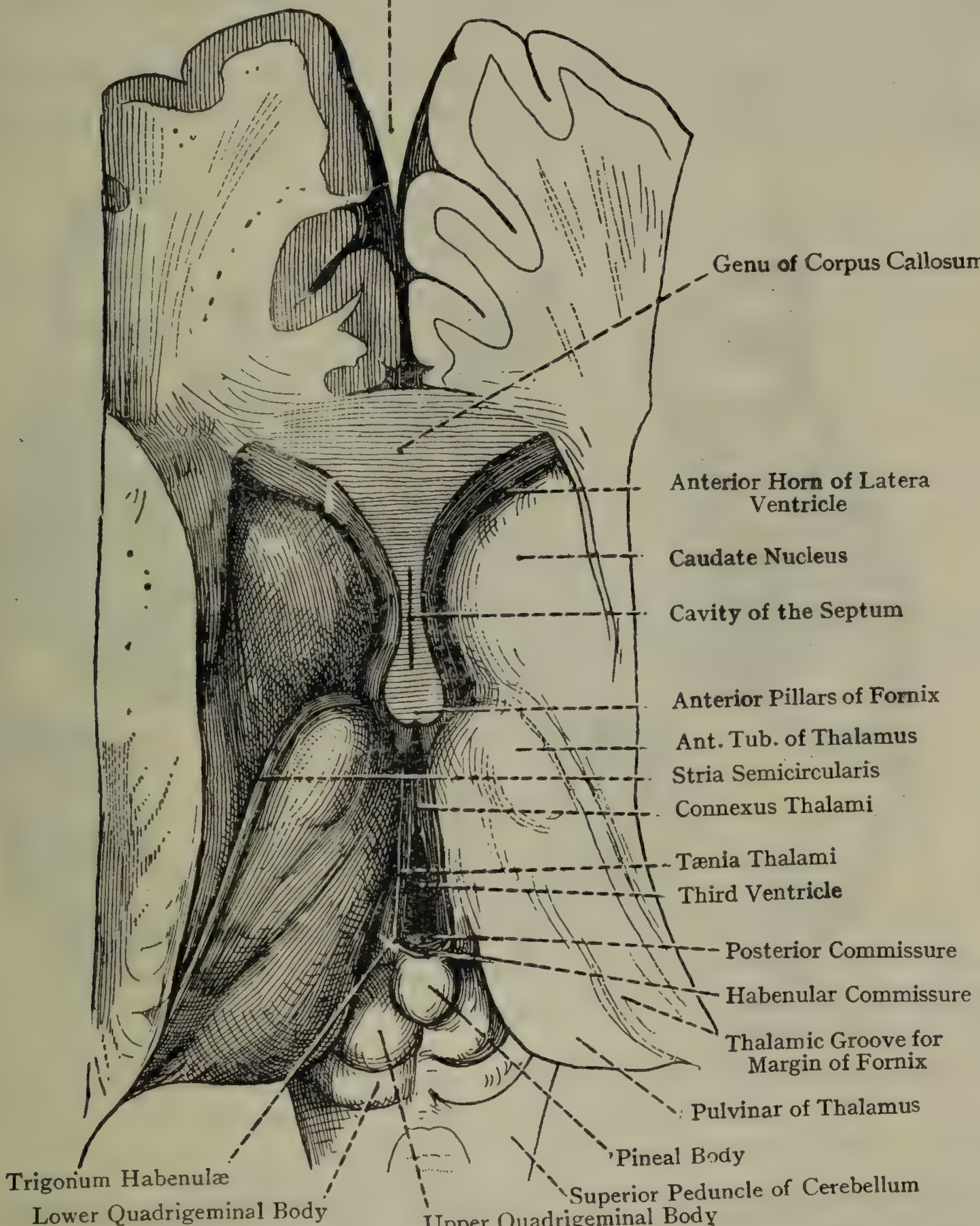


FIG. 937.—THE THIRD VENTRICLE, PORTIONS OF THE LATERAL VENTRICLES, PINEAL BODY, AND CORPORA QUADRIGEMINA (SUPERIOR VIEW) (HENLE).

The corpus callosum, fornix, and tela chorioidea have been removed.

When either a horizontal or a coronal section is made through the centre the nucleus has a triangular outline, the base being directed towards the insular surface; it is, therefore, clear that the nucleus is really a pyramid, lying on its side with the base outwards, in contact with the external capsule, while above, behind, and in front the walls are surrounded

by the internal capsule. Below lies the anterior commissure and the temporal lobe. In such a section the nucleus is seen to be traversed vertically by two white bands, called the *medullary laminæ,* which divide it into three zones. The outer zone, which has a dark reddish colour, is the largest, and is called the *putamen.* The inner two zones, which are somewhat yellowish, are together known as the *globus pallidus.* The putamen and globus pallidus, which consist of grey matter, are traversed by white fibres.

The grey matter of the nucleus caudatus and nucleus lentiformis comes to the surface at the base of the brain in the region of the anterior

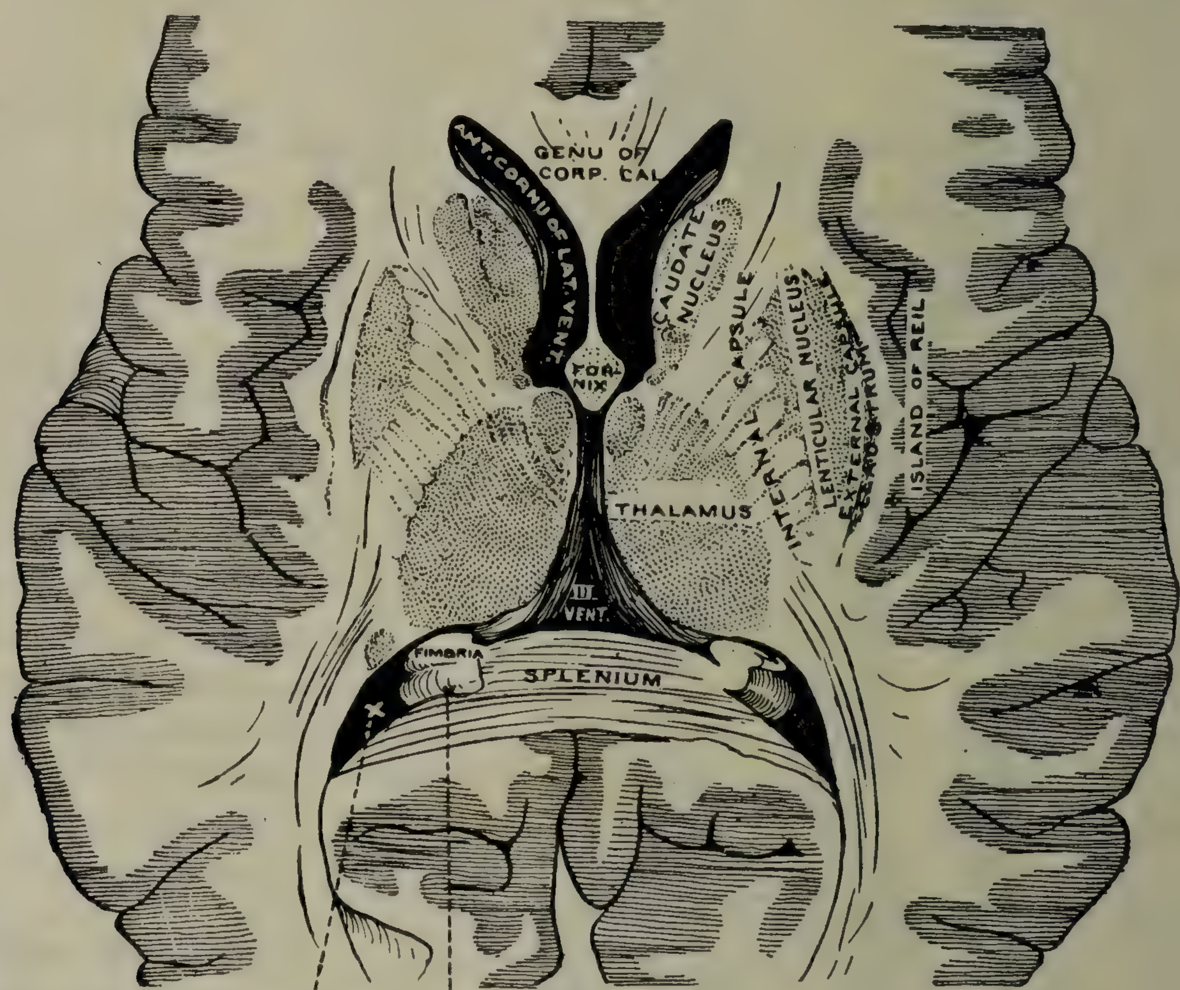


FIG. 938.—HORIZONTAL SECTION OF THE BRAIN THROUGH THE GENU AND SPLENIUM OF THE CORPUS CALLOSUM (DALTON).

perforated substance, where it is continuous with the grey matter of the cerebral cortex.

The **internal capsule** is the thick tract of white matter which lies between the nucleus lentiformis externally, and the nucleus caudatus, stria semicircularis, and thalamus internally. As seen in horizontal section it describes the bend opposite the front part of the thalamus (see Fig. 938). This bend is called the **genu,** and its convexity is directed inwards. The part of the internal capsule in front of the genu is called the **anterior limb.** It forms about one-third of the entire capsule, and its direction is forwards and outwards. The part behind the genu is called the **posterior limb.** It forms about

two-thirds of the entire capsule, and its direction is backwards and outwards.

The **anterior limb** of the internal capsule is situated between the front part of the nucleus lentiformis and the nucleus caudatus. Anteriorly it is intersected by the striæ of grey matter which pass between the two nuclei.

The fibres which compose the anterior limb are partly corticipetal and partly corticifugal. The *corticipetal fibres* are as follows: (1) **thalamo-frontal fibres,** which pass from the thalamus to the cortex of the frontal lobe; (2) **thalamo-striate fibres,** which pass from the thalamus to the corpus striatum (thalamo-caudate and thalamo-

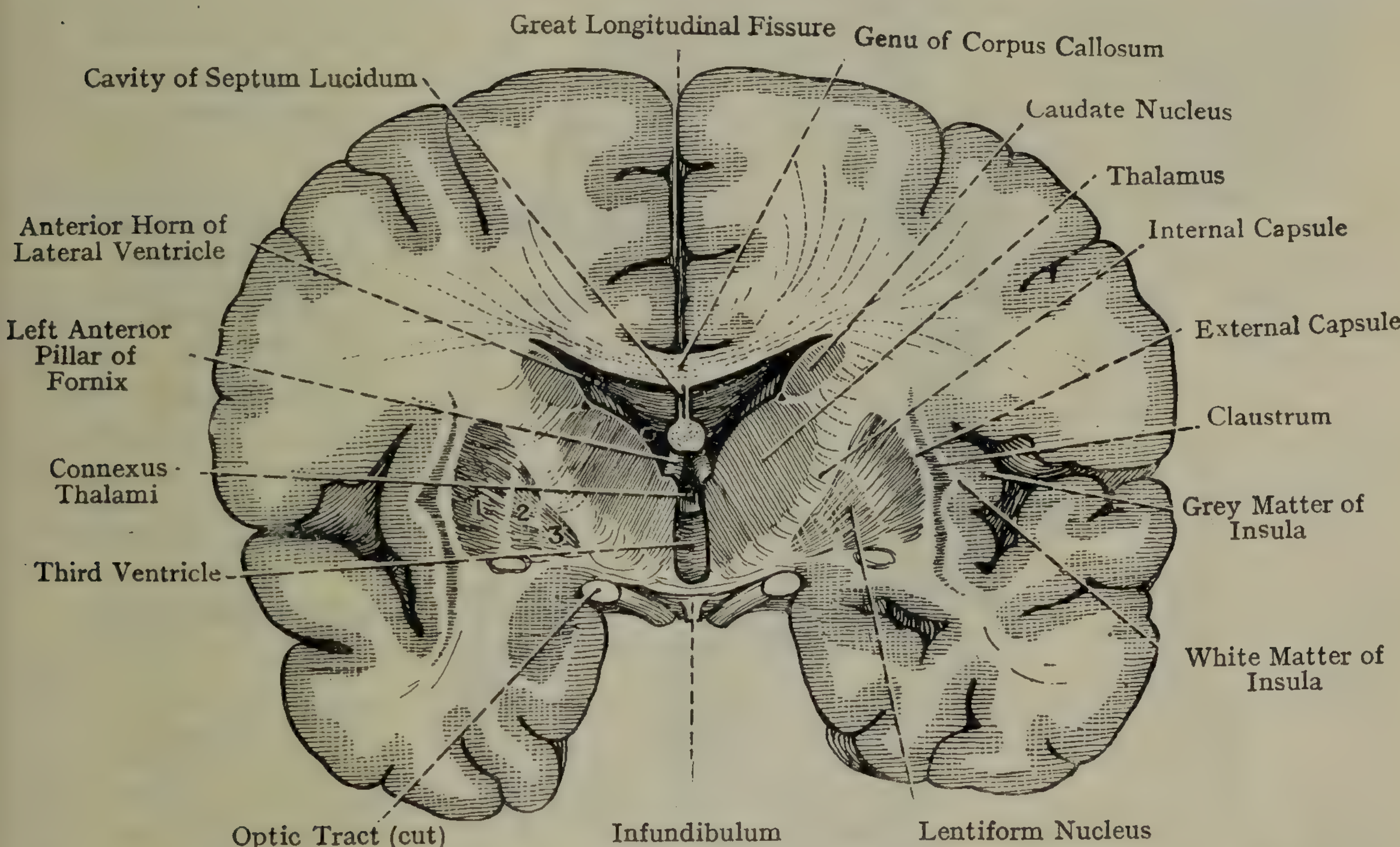


FIG. 939.—CORONAL SECTION OF THE FRONTAL PORTIONS OF THE CEREBRAL HEMISPHERES PASSING THROUGH THE ANTERIOR HORNS OF THE LATERAL VENTRICLES (POSTERIOR VIEW).

1, putamen of lentiform nucleus; 2, 3, globus pallidus of lentiform nucleus.

lenticular fibres); and (3) **strio-frontal fibres,** which pass from the corpus striatum to the cortex of the frontal lobe.

The chief *corticifugal fibres* constitute the **fronto-pontine** tract. The fibres of this tract arise in the cortex of the prefrontal region. They traverse the anterior limb of the internal capsule, and then descend in the *inner part* of the basis pedunculi of the crus cerebri to the pons, within which they terminate in connection with the cells of the nucleus pontis.

Other corticifugal fibres constitute *fronto-thalamic, fronto-striate,* and *strio-thalamic tracts.*

The **posterior limb** of the internal capsule is situated between the back part of the nucleus lentiformis and the thalamus, and is pro-

longed backwards for a little beyond the posterior limit of the nucleus lentiformis. It is therefore conveniently divided into two parts—lenticular, representing the anterior two-thirds; and post-lenticular, representing the posterior third.

The *lenticular part* of the posterior limb, like the anterior limb, is composed of centripetal and centrifugal fibres. The **corticipetal fibres** arise in the thalamus, and their destination is the cerebral cortex. The **corticifugal fibres** represent the *pyramidal* or *motor fibres*, and they

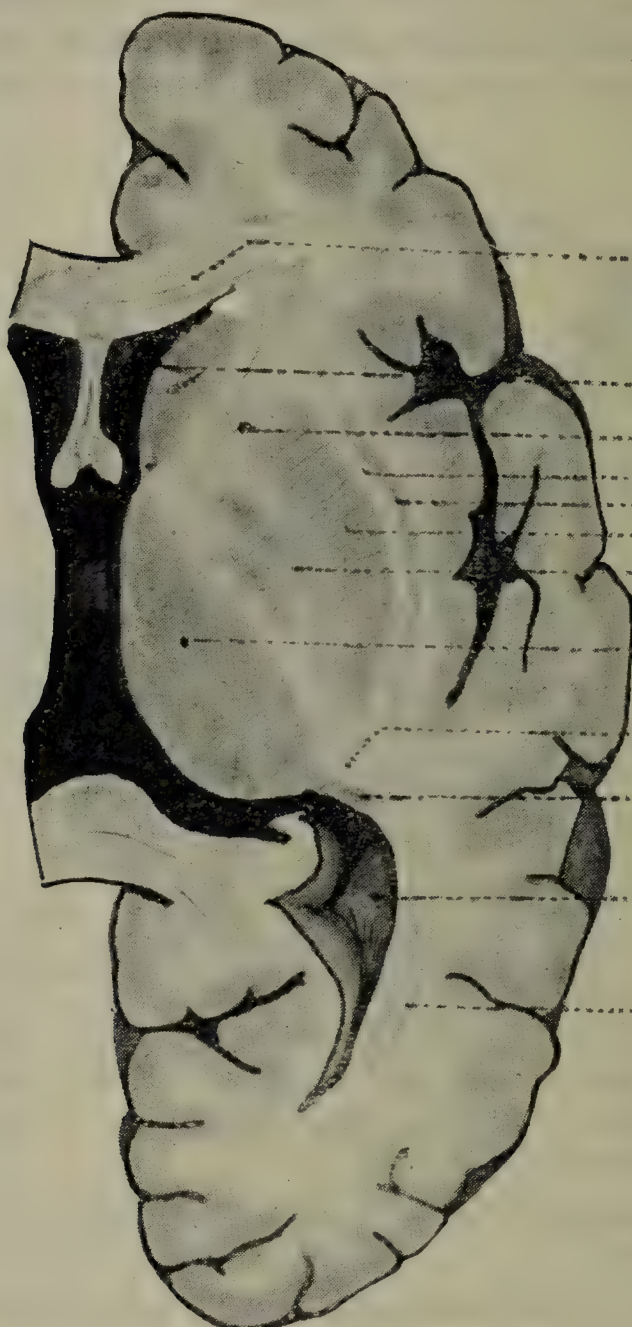


FIG. 940.—HORIZONTAL SECTION THROUGH RIGHT HEMISPHERE, SHOWING DISPOSITION OF CORPUS STRIATUM, ETC.

occupy the anterior portion of the lenticular part of the posterior limb of the internal capsule. These fibres descend from the central region of the cerebral cortex. Some of them pass to the nucleus of the facial nerve; others pass to the nucleus of the hypoglossal nerve; but the majority of them are destined for the motor cells in the anterior grey column of the spinal cord. The fibres which pass to the facial nucleus lie close to the genu, and those which pass to the hypoglossal nucleus lie close behind the facial fibres. The fibres of the pyramidal tract

occupy the central portion of the crusta of the crus cerebri in their downward course.

The *postlenticular part* of the posterior limb contains the following sets of fibres: (1) the fibres of the optic radiation on their way from and to the thalamus, lateral geniculate body, and superior quadrigeminal body; (2) the fibres of the auditory radiation, passing between the auditory region of the temporal lobe and the medial geniculate body; and (3) the fibres of the temporo-pontine tract (cortico-protuberantial fibres), which pass from the cortex of the temporal lobe through the outer part of the basis pedunculi to the pons, where they terminate in the nucleus pontis. The internal capsule is continuous inferiorly with the crusta or basis of the crus cerebri. Superiorly its fibres diverge in a radiating manner on their way to the cerebral cortex, forming the **corona radiata,** the fibres of which are intersected by those of the radiatio corporis callosi.

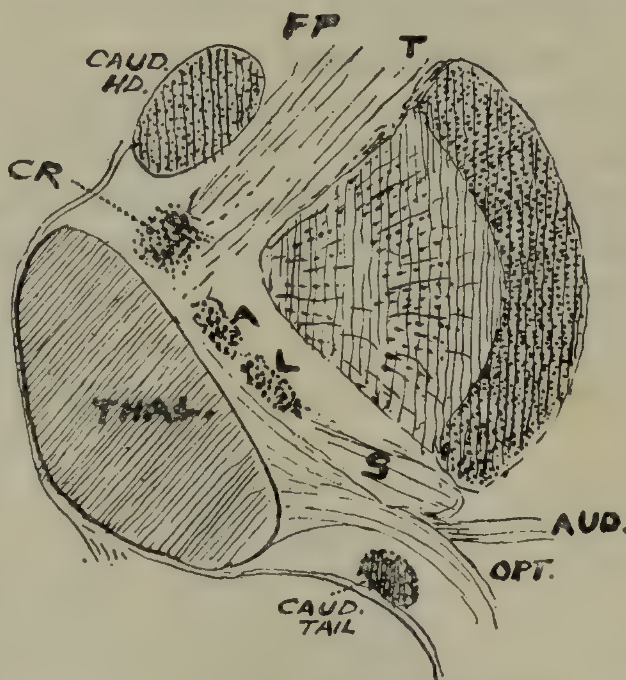


Fig. 941.—Plan of Internal Capsule in Horizontal Section, to show Positions of Main Fibre-tracts.

FP, fronto-pontine; T, thalamo-cortical; CR, motor for head and neck; A, for arm; L, for leg; S, sensory from thalamus; OPT, AUD, optic and auditory fibres.

The **external capsule** is a thin lamina of white matter which is situated on the outer side of the nucleus lentiformis, where it lies between that nucleus and the claustrum. In front of and behind the nucleus lentiformis it is continuous with the internal capsule. The external capsule is, as stated, only loosely connected with the putamen of the nucleus lentiformis. The fibres of which it is composed are probably derived from the anterior white commissure and the thalamus.

Connections of the Corpus Striatum.—(1) The nucleus caudatus and nucleus lentiformis are partly continuous with each other, and partly connected by stria of grey matter. (2) The corpus striatum is connected with the thalamus by strio-thalamic and thalamo-striate fibres. (3) The nucleus caudatus is said to be connected with the substantia nigra by a tract of fibres known as the *stratum intermedium.* (4) The nucleus lentiformis is connected with the thalamus by the ansa lenticularis. (5) The corpus striatum is connected with the cerebral cortex by cortico-striate fibres.

Development.—The corpus striatum is developed as a thickening of the floor and outer wall of the cerebral vesicle.

The **claustrum** is a thin lamina of grey matter which is situated on the outer surface of the external capsule. It lies embedded in the white matter which occupies the region between the lentiform nucleus

and the insula. Superiorly it is narrow and tapering, but inferiorly it expands and reaches the surface at the base of the brain in the region of the anterior perforated substance. Its outer surface presents elevations and intervening depressions, which correspond to the sulci and gyri of the insula.

The claustrum is regarded as an isolated portion of the grey matter of the insula.

The **amygdaloid nucleus** is an oval collection of grey matter which is situated in the anterior part of the temporal lobe, where it lies in the roof of the extremity of the inferior horn of the lateral ventricle. The putamen of the nucleus lentiformis lies above it; anteriorly it is continuous with the cerebral cortex; posteriorly it receives the narrow

FIG. 942.—TRANSVERSE SECTION ACROSS CEREBRUM.

part or tail of the nucleus caudatus; and the stria semicircularis arises from it.

The **stria semicircularis** is a narrow white band of fibres arising from the amygdaloid nucleus. It passes backwards in the roof of the descending horn of the lateral ventricle, and then sweeps upwards and forwards into the central part of the lateral ventricle, lying between the nucleus caudatus and the thalamus. Anteriorly in the region of the interventricular foramen it dips downwards towards the anterior pillar of the fornix and the anterior white commissure. In this situation its fibres are variously disposed. Some pass into the anterior pillar of the fornix; others pass in front of the anterior commissure, and enter the grey matter between the head of the nucleus caudatus and the septum lucidum; whilst a few are regarded as entering the nucleus caudatus.

Relation of Structures in the Region of the Corpus Striatum.—When a coronal section has been made the relation of structures, *from within outwards*, is as follows (see Fig. 942):

1. Nucleus caudatus.
2. Internal capsule.
3. Nucleus lentiformis.
4. External capsule.
5. Claustrum.
6. Insular cortex.

THIRD VENTRICLE.

The third ventricle is the cleft-like interval which is situated in the median line between the two thalami. It extends from the pineal body posteriorly to the anterior pillars of the fornix in front, is very narrow from side to side, and is deeper in front than behind. The cavity presents a roof, a floor, two lateral walls, an anterior boundary, and a posterior boundary.

The **roof** is formed by a delicate layer of epithelium which extends across between the upper margins of the lateral walls, and is continuous with the ependymal lining of the ventricle. Lying on this epithelial roof, and intimately connected with it, is the tela chorioidea, from the under surface of which the two choroid plexuses of the ventricle project downwards, one on either side of the middle line, each invaginating the epithelium of the roof. The epithelium of the roof is so intimately connected with the tela that, when the latter is removed, the epithelium comes away with it, and the cavity of the ventricle is exposed. Above the tela chorioidea is the ' body ' of the fornix, and above this again is the ' body ' of the corpus callosum.

Summary of the Roof.—To expose the ventricle from above, the following structures must be removed, in the order named: (1) the body of the corpus callosum; (2) the body of the fornix; and (3) the tela chorioidea, along with the epithelium of the roof.

The **floor,** which is sloped downwards and forwards (see Fig. 944), is formed by the structures which lie within the interpeduncular space at the base of the brain, from behind forwards: the locus perforatus posterior, the corpora mamillaria, and the tuber cinereum, with the upper end of the infundibulum. The tegmenta of the crura cerebri enter to a certain extent into the floor posteriorly, and the optic commissure lies across it anteriorly. Above the optic commissure the floor presents a depression, called the *optic recess*, and behind this there is another depression or diverticulum, called the *infundibular recess*. The latter forms the upper part of the infundibulum, which leads to the posterior lobe of the hypophysis.

The **lateral wall** is slightly convex, and is formed for the most part by the inner surface of the thalamus, which has a thick covering of grey matter. Towards its centre it presents a furrow, which leads from the interventricular foramen in a backward direction towards the upper opening of the aqueduct. This groove is called the *hypothalamic sulcus*. At the upper part of the lateral wall there is

a delicate band of white fibres, called the *stria thalami*, which runs back toward the root of the pineal body, and passes to the anterior pillar of the fornix. Connecting the two lateral walls (the thalami), in front of the centre of the ventricle, there is a fragile band of grey matter, formerly called the **middle** or **soft commissure**, but now usually known as the massa intermedia or *connexus thalami*, since it is not really a commissure. At the anterior part of the lateral wall the corresponding anterior pillar of the fornix passes downwards and backwards.

The **anterior boundary** is formed inferiorly by the lamina terminalis, which extends upwards from the optic commissure to the rostrum of the corpus callosum, and superiorly by the anterior pillars of the fornix and the central portion of the anterior commissure.

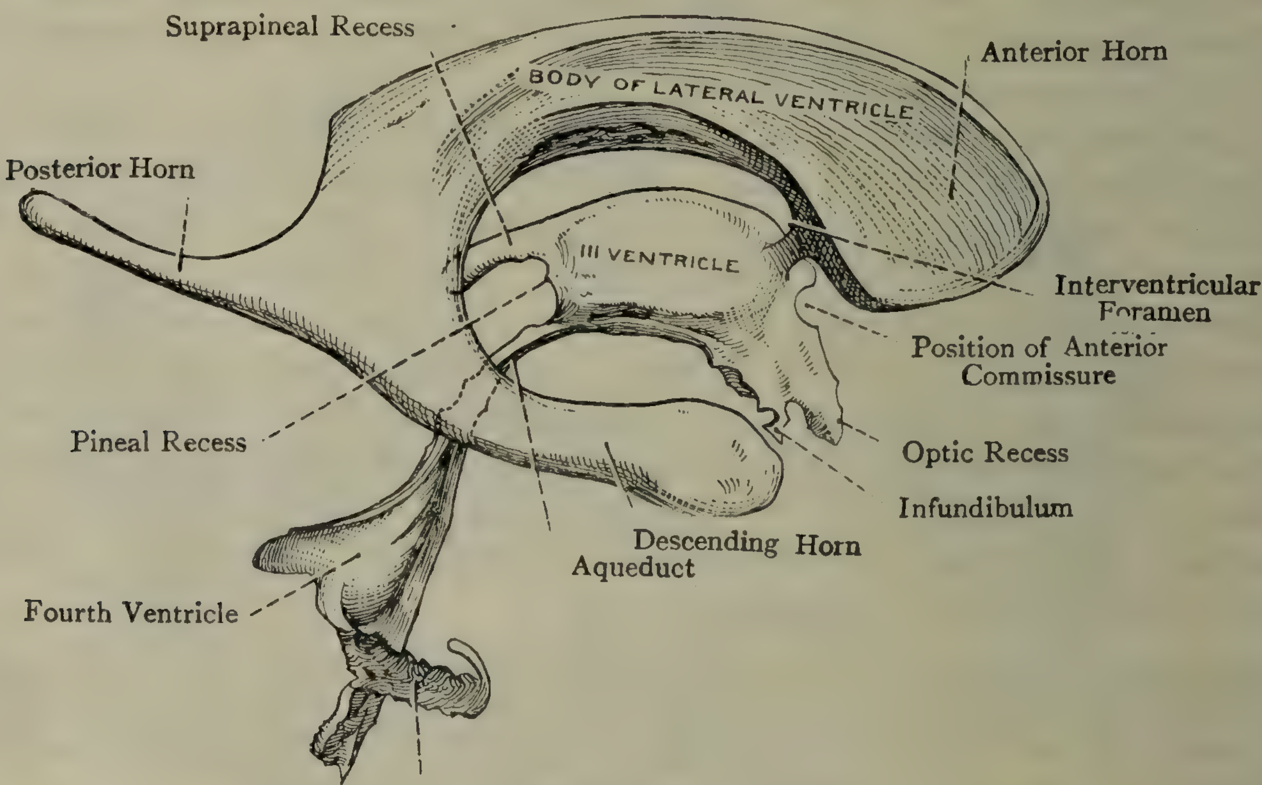


FIG. 943.—DRAWING OF A METAL CAST OF THE VENTRICLES OF THE BRAIN OF AN ADULT (RIGHT LATERAL VIEW) (RETZIUS).

The **posterior boundary** is formed by the pineal body and the posterior commissure, and under cover of the latter is the upper opening of the aqueduct. The posterior boundary presents two recesses, pineal and suprapineal. The *pineal recess* passes backwards for a very short distance above the posterior commissure into the stalk of the pineal body, separating the stalk into two portions, dorsal and ventral. The *suprapineal recess* is connected with the back part of the epithelial roof of the ventricle, and passes backwards over the pineal body. The third ventricle has thus four diverticula—namely, the optic recess, the infundibular recess (both of which recesses are associated with the floor), the pineal recess, and the suprapineal recess. The cavity communicates with the fourth ventricle by means of the aqueduct of the mid-brain, and with the two lateral ventricles by means of the interventricular foramina.

Interventricular Foramina (Foramina of Monro).—These two openings lead one on each side from the third ventricle into the lateral ventricles. Each foramen is situated between the anterior pillar of the fornix in front and the anterior tubercle of the thalamus behind. From this point the foramen of each side leads medially and slightly downwards, and opens into the third ventricle at the anterior and upper part of the corresponding lateral wall. By means of the foramina the lateral ventricles communicate with the third ventricle, and through that ventricle with each other. The choroid plexuses of the lateral ventricles also become continuous with each other and with those of the third ventricle just above the roofs of these foramina.

Development.—The posterior and greater part of the third ventricle is the cavity of the thalamencephalon or diencephalon; and the anterior part in the region of the foramina represents the cavity of the telencephalon.

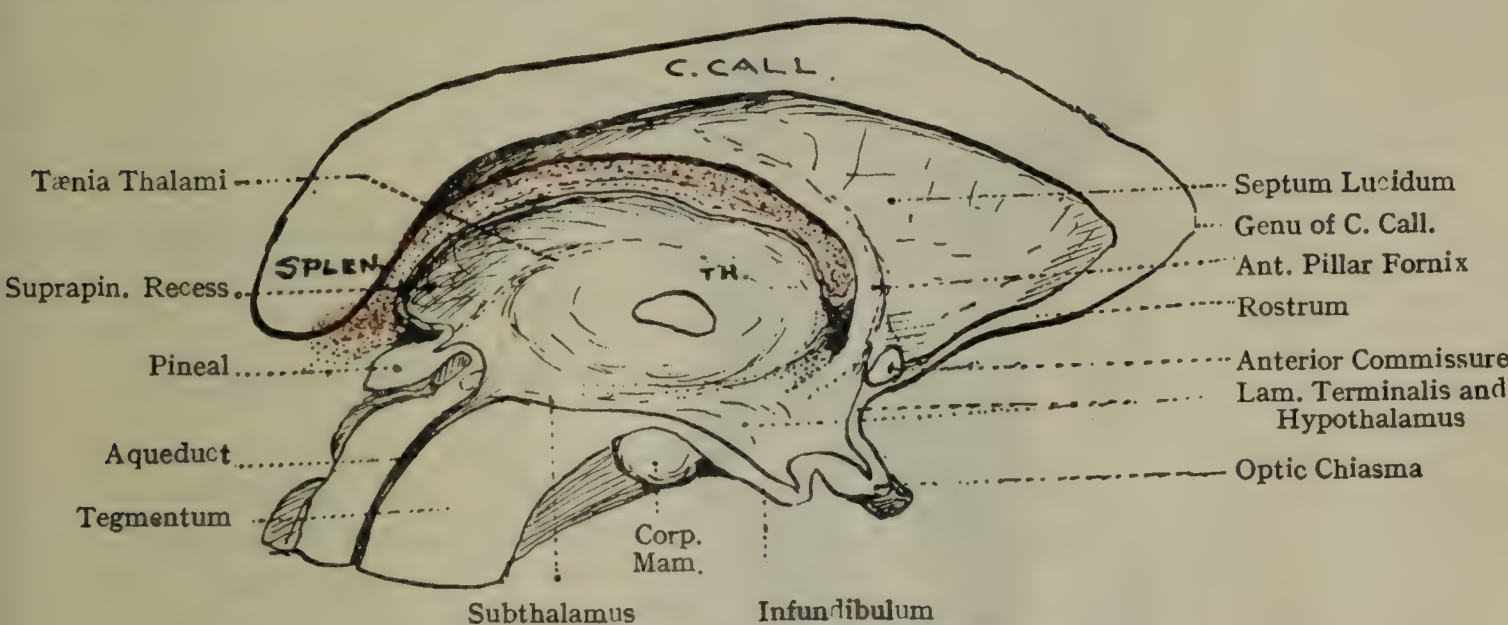


FIG. 944.—LEFT WALL OF THIRD VENTRICLE.

The foramen of each side represents the original wide communication between the cavity of the cerebral vesicle and the cavity of the telencephalon.

Thalami.—The thalami (*O.T. optic thalami*) are two large ovoid masses of grey matter which lie obliquely, with their long axes directed backwards and outwards, for the most part on the sides of the third ventricle. Their anterior extremities are near each other, but their posterior extremities stand apart, the superior corpora quadrigemina being situated between them. Over their anterior two-thirds they are separated from each other by the third ventricle.

Each thalamus presents four surfaces—superior, inferior, lateral, and medial; and two extremities—anterior and posterior.

The **superior surface** is limited laterally by an oblique groove, which separates it from the nucleus caudatus, and contains the stria semicircularis, and anteriorly the vein of the corpus striatum. Medially it is bounded, from before backwards, by (1) the stria thalami, (2) the trigonum habenulæ, and (3) the corpora quadrigemina. It is divided into two areas, lateral and medial, by a groove which is

directed backwards and laterally from near the anterior extremity to the lateral end of the posterior extremity. This groove corresponds to the lateral margin of the body of the fornix. The *lateral area* enters descriptively into the body of the lateral ventricle, but is covered by the ependyma of that ventricle. The *medial area* is excluded from

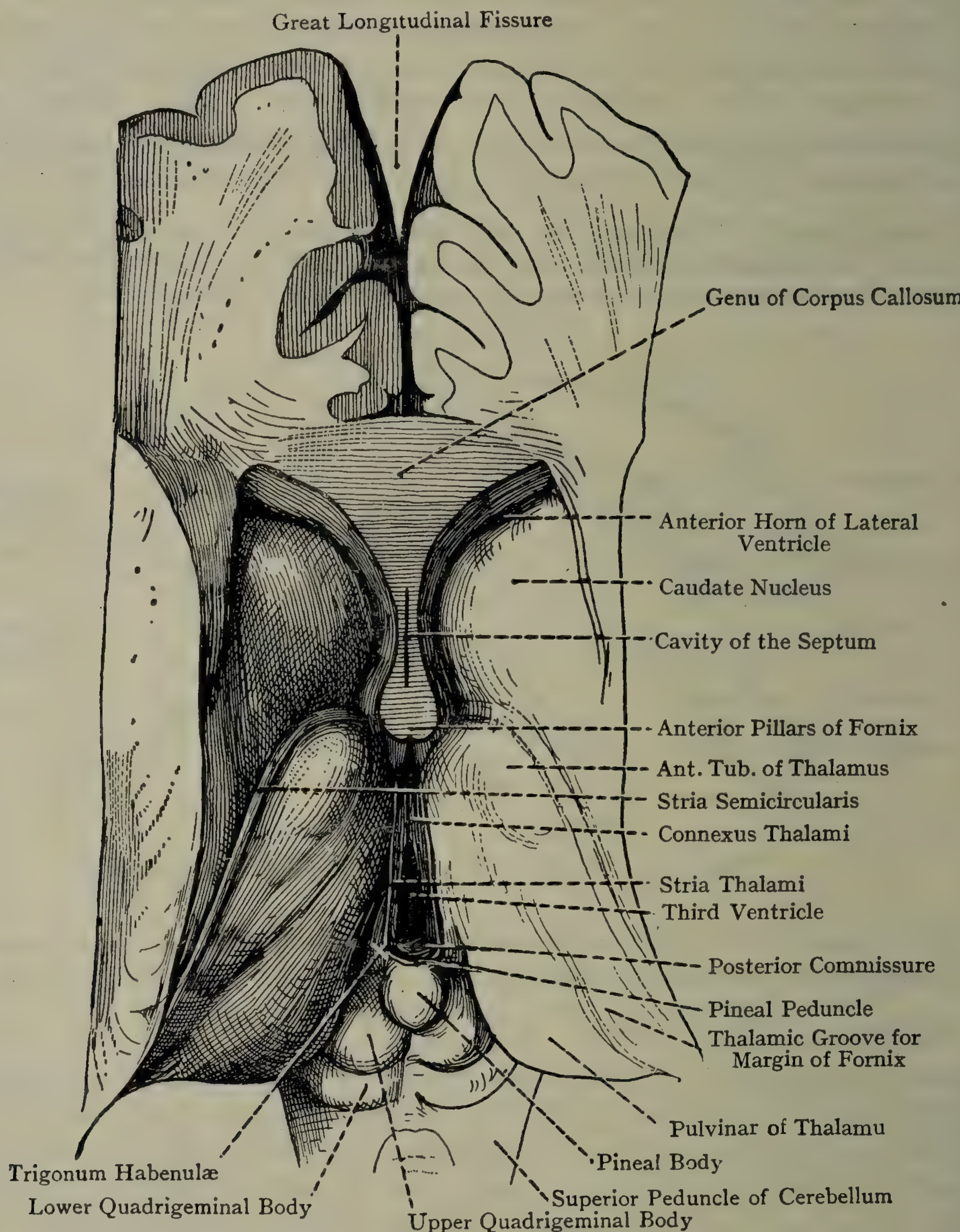


Fig. 945.—The Third Ventricle, Portions of the Lateral Ventricles, Pineal Body, and Corpora Quadrigemina (Superior View) (Henle).

The corpus callosum, fornix, and tela chorioidea have been removed.

the lateral ventricle, and is covered by portions of the tela chorioidea and body of the fornix (see Fig. 933). The superior surface is covered by a thin layer of white fibres called the *stratum zonale*, these fibres being derived from the optic tract and optic radiation.

The **inferior surface** lies posteriorly upon the upward prolongation

of the tegmental fibres of the crus cerebri, which constitutes the subthalamic tegmental region, but anteriorly it rests upon the corpus mamillare and a portion of the tuber cinereum.

The **lateral surface** is directly related to the posterior limb of the internal capsule, which separates it from the nucleus lentiformis (see Fig. 940). Many fibres emerge from this surface, and enter the internal capsule on their way to the cerebral cortex, whilst others from the cerebral cortex enter the thalamus through this surface. These fibres constitute the thalamic radiation. On its surface the fibres form a well-marked reticular layer of white matter, which is called the *external medullary lamina.*

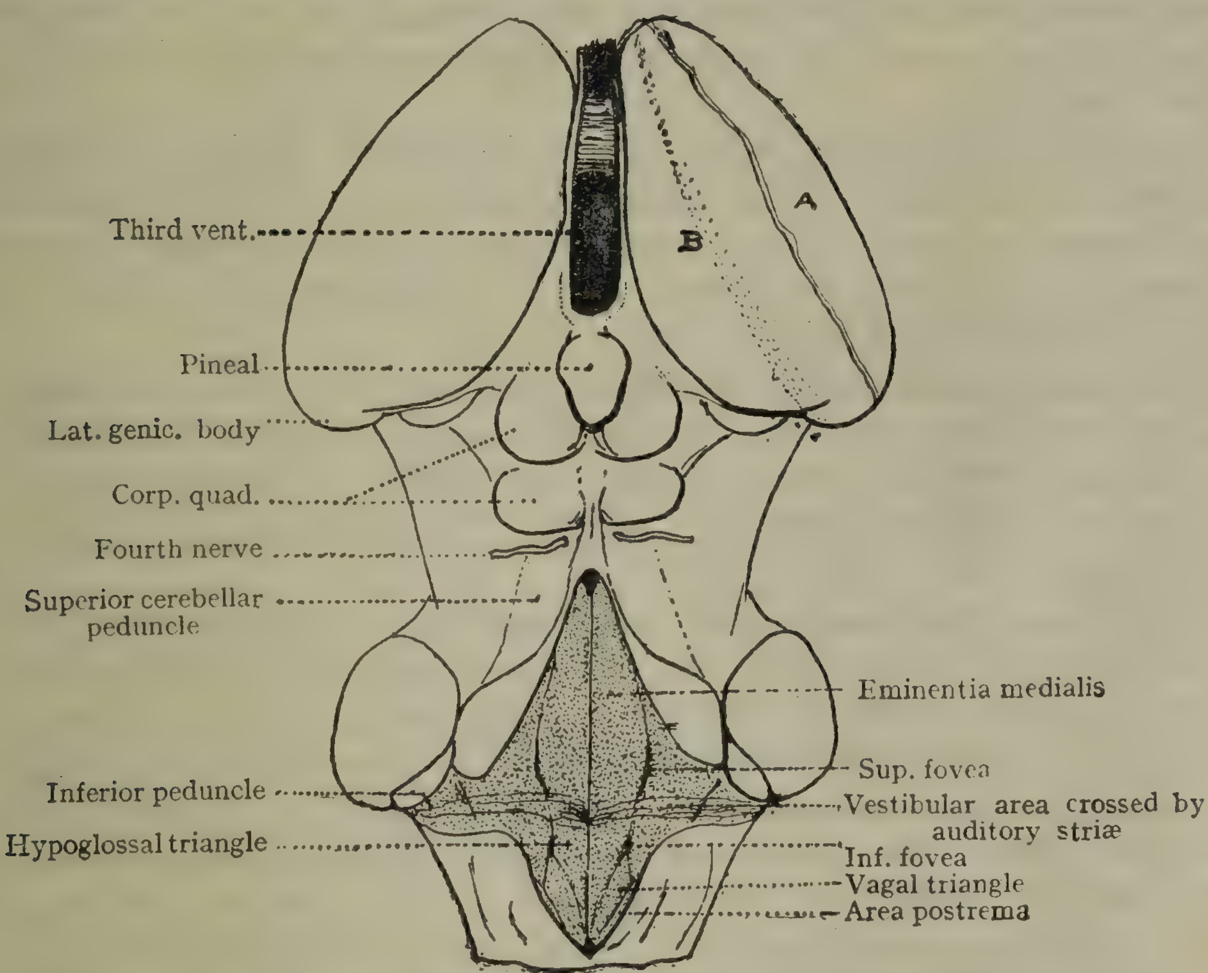


FIG. 946.—SHOWING THE RELATIONS OF THE THALAMUS TO MID-BRAIN, ETC.

A, surface covered by ependyma of lateral ventricle; B, groove caused by fornix.

The **medial surface** faces its fellow of the opposite side, with which it is connected by means of the connexus thalami. It forms the lateral wall of the third ventricle, and superiorly is limited by the stria thalami. It is covered by a thick layer of grey matter, which is continuous with that around the aqueduct of the mid-brain.

The **anterior extremity** is marked by a prominence, called the *anterior tubercle*, which enters into the body of the lateral ventricle, and forms the posterior boundary of the corresponding interventricular foramen.

The **posterior extremity** presents at its inner end a well-marked prominence, called the *posterior tubercle* or *pulvinar*. It lies over the

brachia of the corpora quadrigemina, which it almost conceals. Below and external to the pulvinar there is an oval swelling, called the *corpus geniculatum externum.* Medial to this body is the brachium of the upper corpus quadrigeminum, and inferior to this is the *corpus geniculatum internum* (see Fig. 946).

Metathalamus or Corpora Geniculata.—The corpora geniculata are external or *lateral* and internal or *medial.* They are associated with the posterior extremity of the thalamus, and the medial also with that portion of the mesencephalon which constitutes the corpora quadrigemina (see Fig. 946).

The **corpus geniculatum laterale** is an oval eminence situated on the posterior extremity of the thalamus below and lateral to the pulvinar. Internally it is connected with the *upper* quadrigeminal body by the superior brachium.

It consists of grey and white curved lamellæ, which alternate with each other. The fibres of the white lamellæ belong to the outer or visual root of the optic tract. The axons of the cells of the grey matter enter the optic radiation as corticipetal fibres. The lateral or outer geniculate body is associated with sight.

The **corpus geniculatum mediale** is a small oval eminence which is situated below the pulvinar, and on the lateral aspect of that portion of the mesencephalon which constitutes the corpora quadrigemina. The inferior brachium, which is beneath it, connects it with the *lower* quadrigeminal body.

The medial geniculate body contains many nerve-cells, the axons of which become corticipetal fibres, their destination being the cortex of the temporal region of the brain. By means of the lower quadrigeminal body and the inferior brachium this geniculate body receives fibres from the *lateral* or *acoustic fillet,* which terminate in arborizations around its cells. The axons of these cells become corticipetal fibres, the destination of which is the cortex of the temporal region of the brain. The medial geniculate body is associated with hearing.

Development.—The corpora geniculata appear as elevations on the lateral wall of the thalamencephalon or diencephalon.

Structure of the Thalamus.—The thalamus is composed chiefly of grey matter. Its superior surface is covered with a layer of white matter, known as the *stratum zonale,* and its lateral surface is covered with a reticular layer of white matter, called the *external medullary lamina.* The medial surface has a thick coating of grey matter, which is continuous with the grey matter around the aqueduct.

The grey matter of the interior of the thalamus is traversed by a plate of white matter, called the *internal medullary lamina,* which divides it into two nuclear areas—lateral and medial. The *lateral nuclear area* lies between the internal and external medullary laminæ, and extends backwards as far as the pulvinar. The *medial nuclear area* lies between the internal medullary lamina and the thick layer of grey matter which coats the medial surface of the thalamus. It extends backwards as far only as the habenular region, and anteriorly it is separated from the anterior tubercle by a lamina of white matter. The region of the anterior tubercle therefore constitutes a third or *anterior nuclear area* of grey matter. The grey nuclear areas are consequently three in number —lateral, medial, and anterior.

Lateral Nuclear Area.—This area includes the pulvinar, the geniculate bodies, and the radiate nucleus. The pulvinar and geniculate bodies have just been described. The *radiate nucleus* is associated with the fibres of the thalamic radiation, referred to later.

Anterior Nuclear Area.—This area includes the anterior tubercle, and is the chief sensory nucleus. It receives corticifugal fibres, and its cells furnish corticipetal fibres. It also receives many of the fibres of the lateral lemniscus as well as those of the superior cerebellar peduncle, and the fibres of the *bundle of Vicq d'Azyr*, the mamillo-thalamic tract.

Medial Nuclear Area.—This area contains the ganglion habenulæ, to be presently described.

Connections of the Thalamus.—(1) Viewing the thalamus as an aggregation of 'cell-stations' in the course of the centripetal fibres of the tegmentum of the crus cerebri, the tegmental fibres probably all terminate in the thalamic cells. (2) Through the lateral geniculate the thalamus is connected with the optic tract and optic radiation. (3) The cells of the anterior nucleus receive the fibres of the mamillo-thalamic tract, which are connected through the corpus mamillare with the fibres of the anterior pillar of the fornix. (4) **Thalamic Radiation.**—This is composed of **thalamo-cortical fibres** which arise within the thalamus as the axons of the thalamic cells. They issue from its lateral and inferior surfaces, and pass to all parts of the cerebral cortex. They are conveniently arranged in four groups or **stalks**—frontal, parietal, occipital, and inferior or ventral. (*a*) The fibres of the **frontal stalk,** having emerged from the front part of the external surface, traverse the lateral part of the anterior limb of the internal capsule, and most of them pass to the cortex of the frontal lobe. Some of these fibres are thalamo-caudate and thalamo-lenticular as regards their destination. (*b*) The **parietal stalk,** having issued from the thalamus, passes for the most part through the internal capsule, but also to a certain extent through the external capsule, to the cortex of the parietal lobe, and the central region of the frontal lobe. (*c*) The **occipital stalk** issues from the pulvinar, and, having traversed the postlenticular portion of the posterior limb of the internal capsule, it passes backwards and outwards lateral to the posterior horn of the lateral ventricle, and so reaches the cortex of the occipital lobe. (*d*) The **inferior** or **ventral stalk** emerges from the front part of the inferior surface of the thalamus, and its fibres arise as the axons of the cells of the lateral and medial nuclei. The most superficial of these fibres constitute a band, called the *ansa lenticularis,* which enters the nucleus lentiformis, where it terminates. The remaining fibres pass outwards beneath the nucleus to the cortex of the temporal lobe and insula.

Besides the thalamo-cortical fibres there are **cortico-thalamic fibres,** which pass from the various parts of the cerebral cortex into the thalamus, where they terminate in arborizations around the thalamic cells.

Development.—The thalamus is developed as a thickening of the dorsal lamina of the thalamencephalon.

Subthalamic Tegmental Region.—This region represents the upward prolongation of the tegmental fibres of the crus cerebri beneath the posterior portion of the thalamus. The parts to be noted are the upward prolongations of the red nucleus and substantia nigra of the tegmentum of the crus; the medial lemniscus; the fibres of the superior peduncle of the cerebellum; and the corpus subthalamicum (or nucleus of Luys). The *red nucleus* and the *substantia nigra* gradually disappear, and are no longer visible at the level of the corpus mamillare. The medial lemniscus lies on the superficial and lateral aspects of the red nucleus. The fibres of the superior peduncle of the cerebellum partly terminate in connection with the cells of the red nucleus, but many of them surround it in the form of a capsule. Beyond the red

nucleus the medial fillet, fibres of the superior cerebellar peduncle, and fibres which issue from the red nucleus enter the inferior surface of the thalamus, and terminate in connection with the thalamic cells. Some of these fibres may pass through the thalamus into the internal capsule, and thence to the cortex of the central (Rolandic) region of the cerebral hemisphere. The *corpus* or *nucleus subthalamicum* (or *nucleus of Luys*) is a small lenticular mass of grey matter, surrounded by white fibres, which lies above the substantia nigra.

Epithalamus.—The epithalamus includes the following parts:

1. **Pineal body.**
2. **Stria thalami.**
3. **Trigonum habenulæ.**
4. **Posterior commissure.**

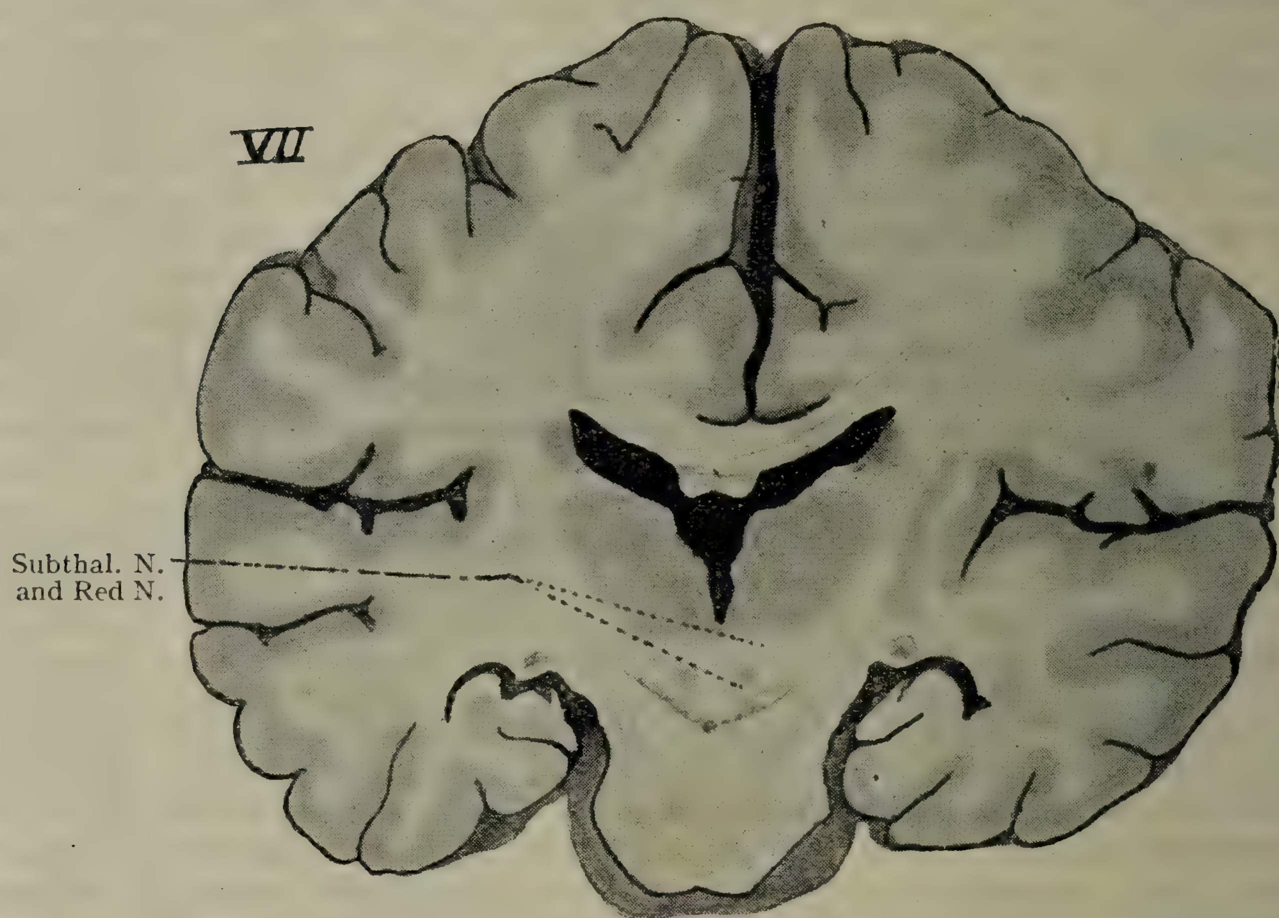


FIG. 947.—SECTION SHOWING THE INTERMEDIATE SUBTHALAMIC AREA, WHERE THE RED NUCLEUS IS APPEARING AND THE SUBTHALAMIC NUCLEUS HAS NOT YET DISAPPEARED.

Pineal Body, or Epiphysis Cerebri.—The pineal body resembles a small pine-cone. It is situated on the dorsal or superior surface of the mesencephalon, and occupies the depression between the upper quadrigeminal bodies. It is of small size, dark red in colour, and somewhat conical in shape. *Superiorly* it is intimately related to the pia mater as that membrane passes through the transverse cerebral fissure to form the tela chorioidea, and the splenium of the corpus callosum lies above it with the intervention of the pia mater. *Inferiorly* it is in contact with the depression between the upper quadrigeminal bodies. Its *apex*, which is directed downwards and backwards, is free. Its *base* is directed upwards and forwards, and contains the pineal recess, which is continuous anteriorly with the cavity of the third ventricle. The portion of the base which lies below this recess is

connected with the posterior commissure, which separates it from the upper opening of the cerebral aqueduct. The portion above the recess contains the habenular commissure.

Structure of the Pineal Body.—The pineal body is free from nervous constituents. It consists of a number of follicles lined with epithelial cells, and containing a variable amount of calcareous matter, called *acervulus cerebri* or *brain-sand*, which is composed of calcium phosphate, calcium carbonate, magnesium phosphate, and ammonium phosphate.

Development.—The pineal body is developed as a diverticulum of the posterior part of the dorsal aspect of the thalamencephalon or diencephalon. This diverticulum for the most part becomes solid, but a portion of its cavity persists as the pineal recess of the third ventricle.

The pineal body is usually regarded as the representative of one of the stalks of the two median eyes of some of the higher arthropods, such as the king crab, among the Invertebrata, and is important in suggesting the possible line of evolution of the Vertebrata. In many of the reptiles the pineal eye as well as the eye-stalk is present, though it is never functional.

Striæ Thalami or Habenulæ.—Each stria is a narrow strip of white longitudinal fibres lying along the upper part of the medial surface of the corresponding thalamus. It constitutes the *habenula*. *Anteriorly* most of its fibres are derived from the olfactory lobe, more particularly the olfactory bulb and anterior perforated substance. Some, however, may be derived from the anterior pillar of the fornix, and through the fornix from the cells of the hippocampus. *Posteriorly* the fibres are disposed in two ways: (1) The lateral fibres enter the ganglion habenulæ, and terminate in connection with its cells. (2) The medial fibres curve inwards towards the base of the pineal body, in which they cross to the opposite side, lying above the pineal recess. As they cross the median line they decussate with the medial fibres of the opposite stria medullaris, and they terminate in the ganglion habenulæ of the side to which they have crossed. Their decussation is known as the **habenular commissure.**

Trigonum Habenulæ.—This is a small triangular area (Fig. 948) which is bounded *posteriorly* by the upper quadrigeminal body, *internally* by the posterior part of the stria thalami, and *laterally* by the adjacent part of the thalamus. It contains an important group of multipolar nerve-cells, known as the **ganglion habenulæ.** This ganglion belongs to the medial area of the thalamus. It receives some of the fibres of the stria, which come from the olfactory lobe, and, it may be, from the anterior pillar of the fornix. The axons of the ganglionic cells issue from the ventral surface of the ganglion and form a bundle, called the *fasciculus retroflexus*. This bundle passes downwards and forwards in the tegmentum of the crus cerebri, lying on the medial side of the red nucleus. Its fibres terminate in connection with the cells of the *ganglion interpedunculare*, which is situated in the lower part of the posterior perforated substance directly above the pons.

The ganglia habenularum are connected with each other by fibres which constitute the *habenular commissure* or *commissure of the habenular*

ganglia. These fibres cross in the dorsal part of the base of the pineal body, and are on a higher plane than the posterior commissure.

The striæ thalami, or habenulæ, and the ganglia habenularum are associated with the rhinencephalon or olfactory brain.

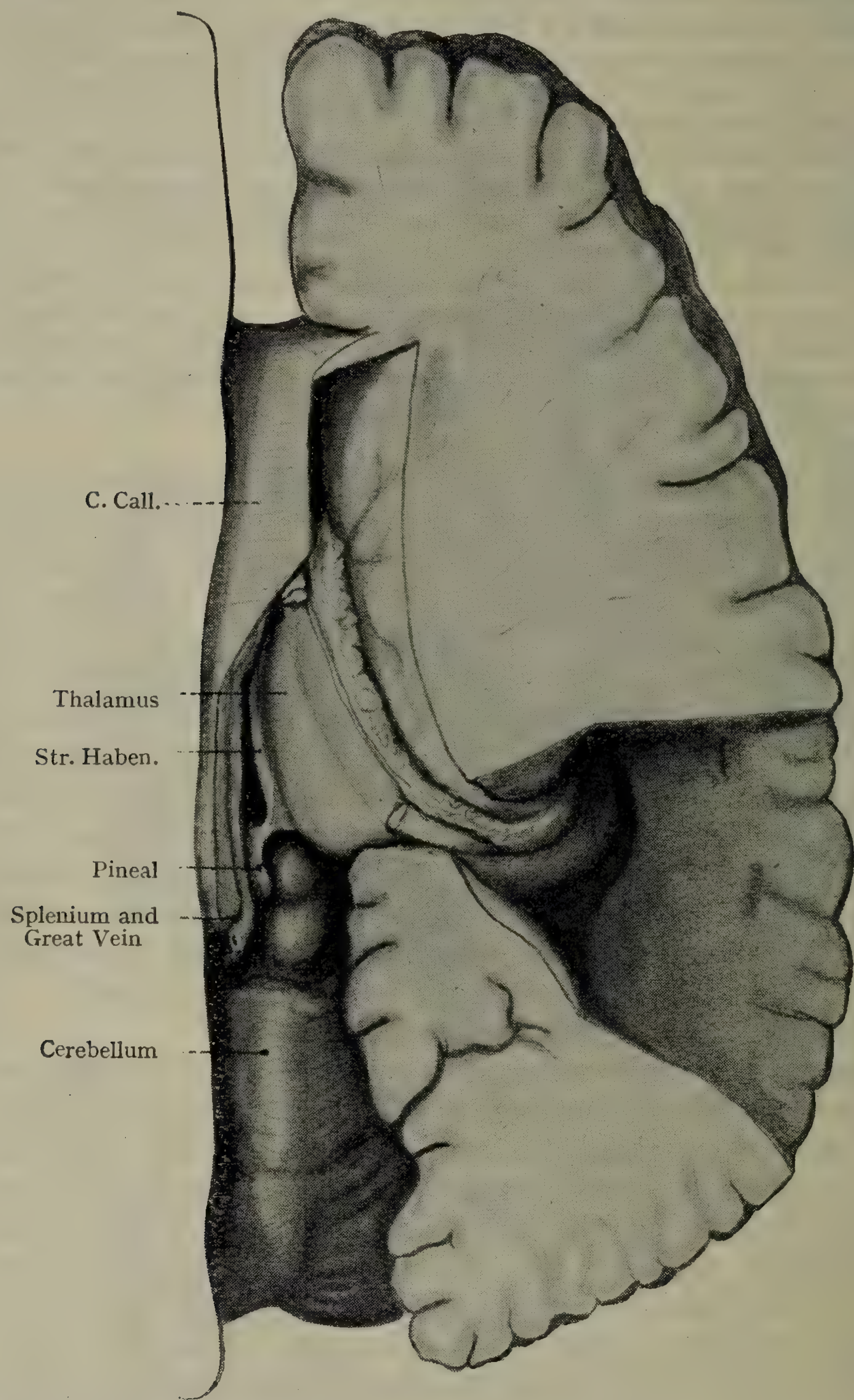


FIG. 948.—THALAMUS PARTLY EXPOSED BY REMOVAL OF PORTIONS OF CORPUS CALLOSUM AND FORNIX, WITH TELA CHORIOIDEA.

Shows trigonum and stria habenulæ.

Posterior Commissure.—This is a band of white fibres which is situated at the back part of the third ventricle. It lies in the posterior wall of the ventricle directly above the upper opening of the aqueduct and underneath the base of the pineal body. Its fibres are regarded

as arising from a nucleus in the grey matter of the lateral wall of the third ventricle near the upper opening of the aqueduct. Some of the fibres of either side, after crossing, may descend in the tegmentum of the crus cerebri as part of the medial longitudinal bundle of that side, and so reach the medulla oblongata.

Hypothalamus.—The hypothalamus consists of two parts—mammillary and optic. The *pars mamillaris hypothalami* represents the

FIG. 949.—DIAGRAM TO SHOW POSITION AND RELATIONS OF STRUCTURES IN TEGMENTAL SUBTHALAMUS.

Supposed to be viewed from the medial aspect. R, red nucleus. The subthalamic nucleus is shown antero-lateral to this. *Dotted line* shows course of fasciculus retroflexus from habenula to interpeduncular ganglion. Course of anterior pillar of fornix is indicated, also mamillo-thalamic tract (bundle of Vicq d'Azyr) passing up medial to front part of subthalamic nucleus. Substantia nigra is seen near pontine level, but passes upwards and laterally out of the section higher up.

two corpora mamillaria. The *pars optica hypothalami* includes the following structures:

1. Tuber cinereum.
2. Infundibulum.
3. Posterior or cerebral lobe of the hypophysis.
4. Optic chiasma.
5. Lamina terminalis.

The **corpora mamillaria** are two small, white, pea-like bodies, which lie side by side directly in front of the posterior perforated area. Each is composed of white matter externally, and of a grey nucleus internally. The white matter is derived from the corresponding anterior pillar of the fornix, the fibres of which terminate in connection with the cells of the grey nucleus. This grey nucleus contains many cells, the axons of which give rise to two fasciculi—namely, the mamillo-thalamic tract (or bundle of Vicq d'Azyr) and the peduncle of the corpus mamillare. The **mamillo-thalamic tract,** which is

apparently a continuation of the anterior pillar of the fornix, enters the thalamus, and its fibres terminate in connection with the cells of the anterior nucleus. The **peduncle of the corpus mamillare** passes downwards and backwards in the grey matter of the floor of the third ventricle to the tegmental region of the mesencephalon, but the mode of termination of its fibres is not known.

Development.—The corpora mamillaria are developed from the ventral aspect of the thalamencephalon or diencephalon. Up to the third month of intra-uterine life they are represented by a single corpus mamillare, but after that period this divides into two corpora.

The **tuber cinereum** is an elevated area of grey matter which lies in front of the corpora mamillaria and behind the optic commissure, the anterior portion of each optic tract being on either side. It is continuous anteriorly with the lamina terminalis, and on either side with the grey matter of the anterior perforated substance.

In the lateral part of the tuber cinereum, in the vicinity of the optic tract, there is a collection of nerve-cells, which is variously spoken of as the **basal ganglion of Meynert** or the **supra-optic nucleus of Cajal,** and which is connected with the fibres of the *commissure of Gudden.*

Behind the tuber cinereum, and in front of the corpora mamillaria, there is a small prominence, medially placed, called the **eminentia saccularis of Retzius,** who regards it as the homologue of the *saccus vasculosus* of some lower vertebrates—*e.g.*, fishes.

The **infundibulum** is a funnel-shaped stalk which extends downwards from the anterior part of the inferior surface of the tuber cinereum to the posterior lobe of the hypophysis, or pituitary body. Its upper part is hollow, and contains the infundibular recess or diverticulum of the cavity of the third ventricle. The infundibulum is the peduncle of the posterior lobe of the hypophysis.

Hypophysis (Pituitary Body).—As this structure is seldom removed in the course of dissection with the brain, it has already been described on p. 1171 with the pituitary fossa, in which it lies. It may be well, however, to repeat in this place the fact that the anterior lobe is a derivative of the ectodermal lining of the primitive mouth; that the posterior lobe, which is connected to the infundibulum, is a downgrowth from the brain (hypophysis cerebri); and that, between the two, lies the pars intermedia, which is only the posterior wall of the ectodermal pouch. The name (pituitary) was derived from the old belief that the gland secreted the pituita or mucus of the nose.

Lamina Terminalis.—This is a thin plate of grey matter which extends between the upper surface of the optic commissure and the rostrum of the corpus callosum near the genu. On either side it is connected with the grey matter of the anterior perforated substance. It forms the lower part of the anterior wall of the third ventricle.

Development.—The lamina terminalis represents the terminal part of the ventral wall of the embryonic neural tube.

Optic Nerve, Optic Chiasma, Optic Tract, and Optic Radiation.

The **optic nerves,** or nerves of sight, in the cranial cavity are onnected together at the optic commissure or *chiasma,* where some f the fibres decussate. From the back part of the commissure each erve, under the name of the optic tract, passes backwards round he crus cerebri to its cerebral connections.

The **optic chiasma** rests upon the tuberculum sellæ and above the ptic groove of the sphenoid bone. It lies in front of the tuber cinereum nd infundibulum, and its superior surface is connected with the lamina erminalis, and is intimately related to the anterior part of the floor f the third ventricle. On either side of the commissure is the anterior erforated substance. Most of the fibres of the commissure proceed rom each retina in the corresponding optic nerve, being afferent or entripetal; but at the back part of the commissure there are the ibres of the medial roots of the optic tracts, which have no connection vith either retina. The decussation of fibres in the commissure is nly partial. The fibres which arise in the nasal or medial half of he retina cross and enter the optic tract of the opposite side. The ibres which arise in the temporal or lateral half of the retina take no art in the decussation, but pass directly backwards into the optic tract f the same side (see Fig. 950).

Occupying the back part of the commissure there are, as stated, ome fibres which have no connection with either retina. These ibres constitute the **commissure of Gudden.** They lie behind the ecussating fibres, and represent the fibres of the medial root of the ptic tract of each side. They form the innermost fibres of each ptic tract, and connect one medial geniculate body with its fellow f the opposite side.

Summary.—The fibres which arise in the nasal half of one retina cross in he optic commissure, and enter the optic tract of the opposite side. The fibres which arise in the temporal half of one retina pass directly backwards into the ptic tract of the same side. The fibres of the 'inner' root of each optic tract ross in the back part of the commissure, and form the *commissure of Gudden,* he fibres of which have no connection with the optic nerves, but connect the wo medial geniculate bodies, right and left. The optic commissure therefore onsists of the following groups of fibres: (1) The **crossed fibres,** which arise n the nasal portion of each retina; (2) the **uncrossed fibres,** which arise in the emporal portion of each retina, and occupy the outer part of the commissure; nd (3) the fibres of the commissure of Gudden, which occupy the back part of he commissure.

The **optic tract** of each side is a flattened white band which passes ackwards from the optic chiasma. It curves round the crus cerebri, nd in the region of the posterior extremity of the thalamus it ivides into two roots, lateral and medial. The **lateral** or **visual** **oot** is the larger of the two. It is chiefly composed of afferent fibres, which pass from the retina to the brain; but it also contains efferent ibres, which pass from the brain to the retina. The efferent fibres re derived from (1) the temporal half of the retina of the same side,

and (2) the nasal half of the retina of the opposite side, the latter having crossed in the optic chiasma. The fibres of the lateral root terminate in the lateral geniculate body and the upper quadrigeminal body, reaching the last-named body through the superior brachium. They form arborizations around the cells of these bodies which constitute the terminal nuclei or *lower visual centres* of the

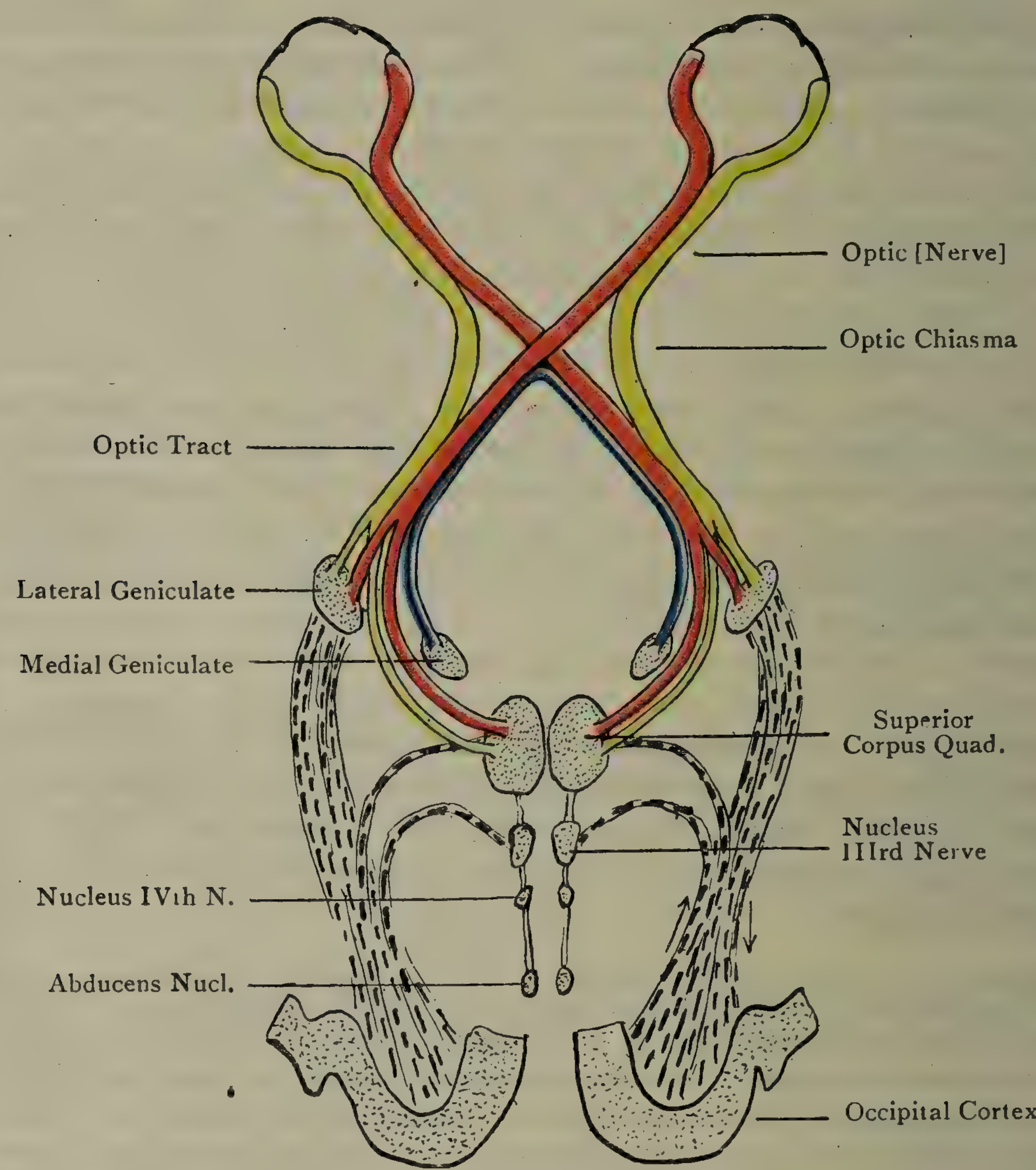


FIG. 950.—DIAGRAM OF VISUAL PATHS.

Yellow, uncrossed fibres; red, crossed fibres; blue, Gudden's commissure. Interrupted lines, connections with occipital pole—that is, within the hemisphere; mainly afferent, but some efferent fibres here.

outer or visual root. These lower visual centres are connected with the higher or cortical visual centre by the strand of fibres forming the **optic radiation,** the higher visual centre being situated in the cortex of the cuneate and lingual gyri of the medial surface of the occipital lobe. The **medial** or **commissural root** of the optic tract passes beneath the medial geniculate body, which represents the nucleus of most of its fibres. As stated, these fibres have no connection with the optic

nerve. Having traversed the inner part of the optic tract, they cross in the back part of the optic commissure behind the decussating fibres, and are continuous with the corresponding fibres of the opposite side. These are the fibres which constitute the commissure of Gudden.

Optic Radiation.—The strand of fibres which forms the **optic** (or **thalamo-occipital**) **radiation** of either side establishes a connection between the lower visual centres (lateral geniculate body and upper quadrigeminal body) and the higher or cortical visual centre, which is situated (1) on the medial surface of the occipital lobe close to the calcarine fissure in the region of the cuneus and lingual gyrus, and (2) on the adjacent part of the postero-lateral surface of the occipital lobe. The strand passes through the post-lenticular part of the internal capsule, and then backwards in the medullary substance of the occipital lobe, lying on the lateral side of the posterior horn of the lateral ventricle. Thereafter the fibres pass in a radiating manner to the higher or cortical visual centre.

This visual area in the neighbourhood of the calcarine fissure is distinguishable to the naked eye in a section of a fresh brain by the white band of Gennari which traverses it.

The optic radiation consists of afferent or corticipetal and efferent or corticifugal fibres. The *corticipetal fibres* for the most part arise as the axons of the nerve-cells within the lateral geniculate body, which are terminal nuclei of the retinal nerve-fibres, and they end in the higher or cortical visual centre. Some corticipetal fibres arise in the higher or cortical visual centre *of the opposite side* and cross in the splenium of the corpus callosum. These fibres are of a commissural character. The *corticifugal fibres* arise as the axons of the pyramidal cells of the cortex of the visual area of the occipital lobe, and they terminate in the pulvinar, geniculate, and upper quadrigeminal body.

The lower visual centres are connected with the nuclei of origin of the nerves which supply the ocular muscles, probably through the medial longitudinal bundle.

Mesencephalon.

The mesencephalon is composed of the corpora quadrigemina, which form its upper or dorsal portion; the crura cerebri, which form its lower or ventral portion; and the aqueduct, which passes through it from the fourth ventricle below to the third ventricle above.

Corpora Quadrigemina.—These are four rounded eminences, which, as just stated, form the dorsal portion of the mesencephalon. They are covered by the splenium of the corpus callosum, and are arranged in pairs, upper and lower, the upper pair being larger than the lower pair, but not quite so prominent. The four eminences are separated from each other by two grooves, longitudinal and transverse, which are arranged in a cruciform manner. The longitudinal groove extends upwards as far as the posterior commissure, and it separates the upper and lower quadrigeminal bodies of one side from those of the other side.

Its upper part lodges the pineal body, and from its lower part a band of white fibres, called the *frenulum veli*, passes downwards to the superior medullary velum, which lies below the lower pair of eminences. The transverse groove separates the upper pair of quadrigeminal bodies from the lower pair. Laterally each eminence is connected with a white band, called the **brachium,** the two brachia being separated by a continuation of the transverse groove.

The **superior brachium** extends outwards and forwards from the upper quadrigeminal body to the lateral geniculate body and the lateral root of the optic tract. It passes between the pulvinar of the thalamus and the medial geniculate body.

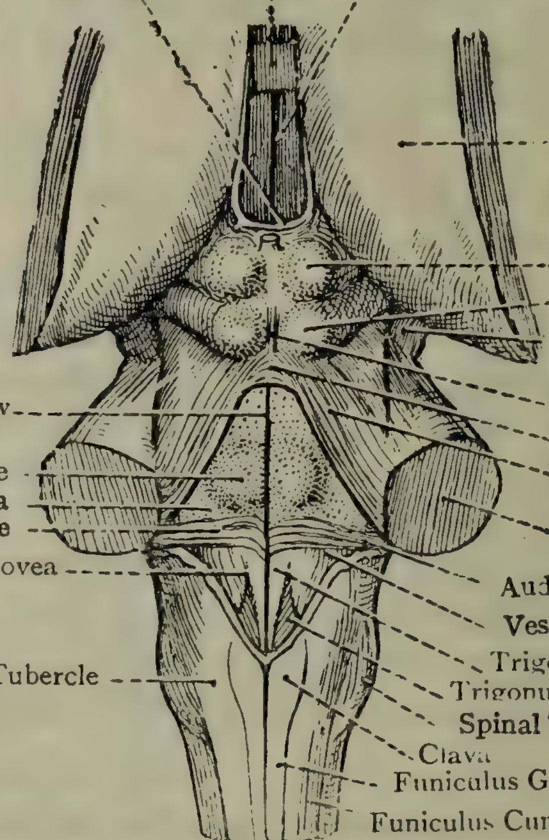


FIG. 951.—THE FLOOR OF THE FOURTH VENTRICLE AND ADJACENT PARTS. The pineal body has been removed to show the upper quadrigeminal bodies.

The *superior* brachium is associated with the *visual apparatus*. The *inferior* brachium, though connected with the medial geniculate body, with which body the inner or commissural root of the optic tract (commissure of Gudden) is also connected, is associated with the *acoustic apparatus*.

The superior brachium contains two sets of fibres—namely, **retinal fibres,** derived from the lateral root of the optic tract; and **occipital fibres,** from the cortex of the occipital lobe of the cerebrum.

The **inferior brachium** passes upwards from the lower quadrigeminal body to the under aspect of the medial geniculate body, which is a small oval mass on the lateral aspect of the mesencephalon, under cover of the pulvinar of the thalamus. Though the inner root of the optic tract is connected with this geniculate body, the inferior brachium

passes clear of it, and most of its fibres are traceable to the thalamus through the tegmentum.

Structure of Corpora Quadrigemina.—The **lower quadrigeminal body** (*colliculus inferior*) is composed of the following parts:

1. A central nucleus of grey matter.
2. A dorsal layer of white matter.
3. A ventral layer of white matter.

The **central grey nucleus** consists of many multipolar cells and nerve-fibres. The axons of the cells pass partly to the dorsal and partly to the ventral layers

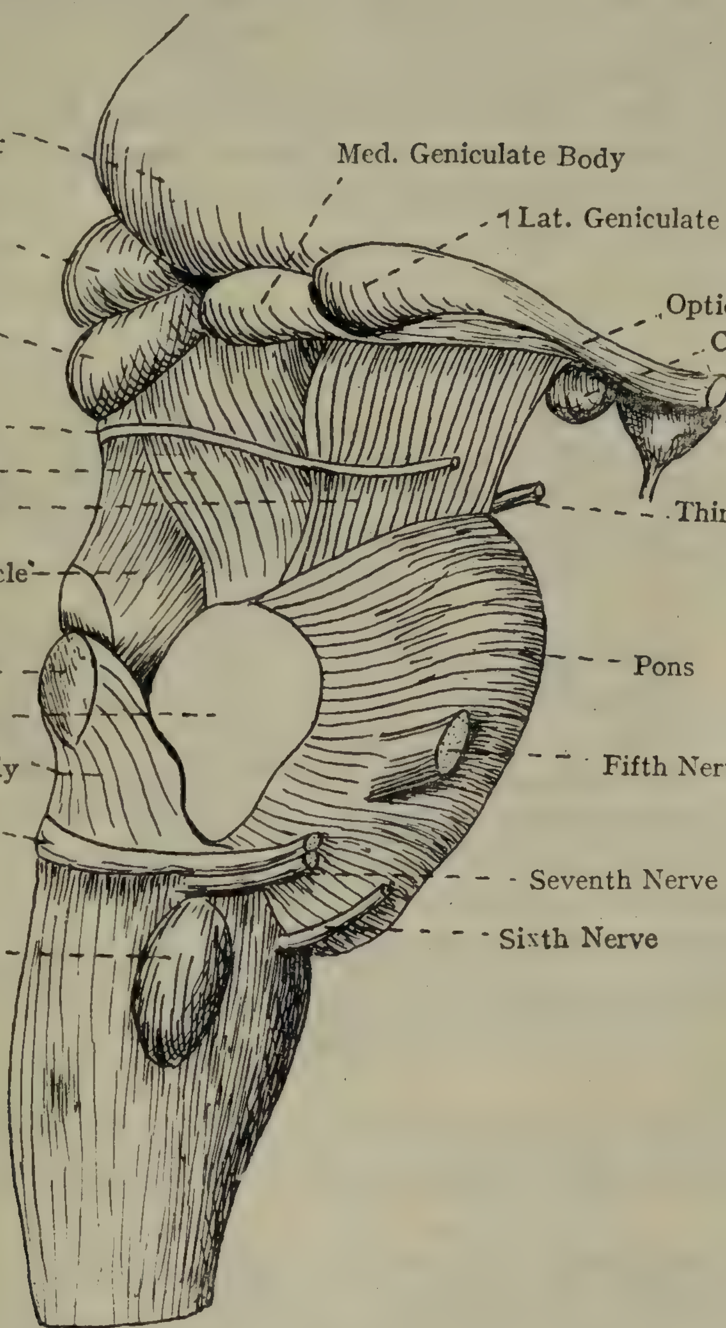


Fig. 952.—Side View of the Mesencephalon.

of white matter. The nerve-fibres are derived from the *lateral* or *acoustic lemniscus*, and terminate in arborizations around the cells of the central nucleus.

The **dorsal white layer** derives its fibres from the lateral lemniscus and from the axons of the cells of the central grey nucleus. The fibres pass into the inferior brachium, by which they are conducted to the medial geniculate body.

The **ventral white layer** also derives its fibres from the lateral lemniscus and from the axons of the cells of the central grey nucleus. This layer separates the central nucleus from the subjacent grey matter of the aqueduct. Some of the fibres cross the median plane, and decussate with corresponding fibres of the opposite side superficial to the roof of the aqueduct. Others enter the tegmentum of the crus of the same side and also of the opposite side, in which their course is downwards in the lateral lemniscus.

The lower quadrigeminal body (*colliculus inferior*), which receives its fibres from the lateral or acoustic lemniscus, is associated with the *acoustic apparatus*.

The **upper quadrigeminal body** (*colliculus superior*) is composed of the following layers:

1. Stratum zonale.
2. Stratum cinereum.
3. Stratum opticum.
4. Stratum lemnisci.

The **stratum zonale** is the most superficial layer, and probably consists of retinal fibres which are derived from the outer root of the optic tract. Many of these fibres pass into the stratum cinereum and terminate in connection with its cells. Others cross the median plane and decussate with corresponding fibres from the opposite side superficial to the roof of the aqueduct.

The **stratum cinereum,** or second layer, lies beneath the stratum zonale, and consists of a crescentic layer of grey matter containing many nerve-cells. It represents the grey nucleus of the upper quadrigeminal body, and the axons of its cells pass to the more deeply seated strata.

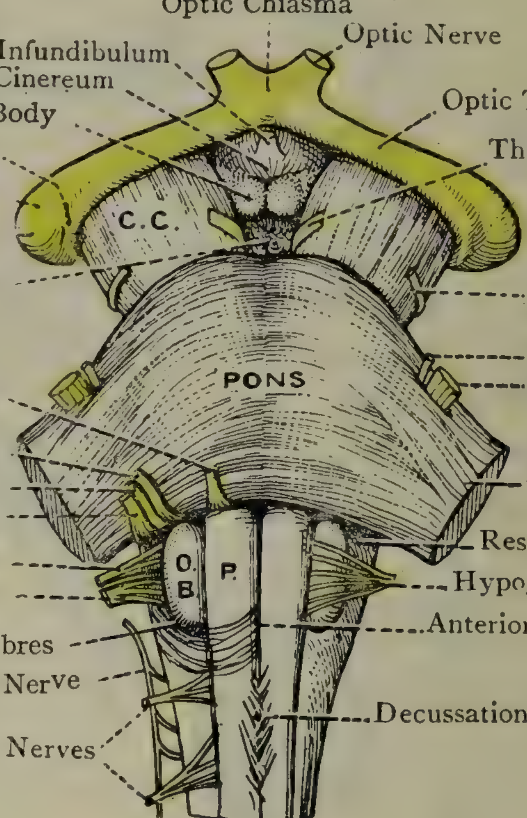


FIG. 953.—THE MEDULLA OBLONGATA, PONS, AND INTERPEDUNCULAR REGION. C.C., crus cerebri; P., pyramid; O.B., olivary body.

The **stratum opticum** is the third layer, and consists of grey matter which contains numerous nerve-cells and nerve-fibres. The *fibres* are conducted to this stratum by the superior brachium, and are of two kinds: (1) Many are *retinal fibres*, and are derived from the outer root of the optic tract. (2) Others are *corticifugal fibres*, which come from the higher visual centre in the cortex of the occipital lobe, and form part of the optic radiation. The fibres pass into the stratum cinereum, and terminate in arborizations around its cells. The axons of the cells of the stratum opticum pass into the stratum lemnisci.

The **stratum lemnisci** is the deepest layer. Like the stratum opticum, it consists of grey matter, which contains numerous nerve-cells and nerve-fibres. The *fibres* are derived from the following sources: (1) Many are derived from the medial or main lemniscus; and (2) some are the axons of cells belonging to the stratum opticum and stratum lemnisci. The lemniscal fibres terminate in the stratum lemnisci. The fibres formed by the axons of the cells of the stratum opticum and stratum lemnisci cross the median plane, below the aqueduct, and decussate with the corresponding fibres of the opposite side. This

decussation is known as the **fountain decussation (of Meynert).** The fibres, after crossing, form the *tecto-spinal tract* of that side, and this bundle or tract descends through the pons and medulla oblongata into the corresponding ventral or anterior column of the spinal cord.

The upper quadrigeminal body, by means of the superior brachium, is one of the *lower visual centres*, the other being the external geniculate body.

Development of Corpora Quadrigemina.—The corpora quadrigemina are developed from the dorsal wall or roof of the mesencephalon. They are at first in the form of elongated paired swellings, later divided transversely.

Dorsal Tegmental Decussation (or Commissure of Meynert).—This commissure or decussation consists of fibres which issue from each upper quadrigeminal body, and cross partly to the opposite posterior longitudinal bundle, but mostly form tecto-spinal tracts, in which they descend towards the pons.

Crura Cerebri.—The crura or **pedunculi** cerebri are two large strands which are situated above the pons. They lie at first near each other, being separated by the interpeduncular fossa, but afterwards diverge as they pass upwards and laterally to the cerebral hemisphere. The *medial surface* of each crus bounds the interpeduncular region, and has a furrow, the *oculo-motor sulcus*, through which the roots of the third nerve emerge near the pons. The *lateral surface* looks towards the temporal lobe of the brain, which to a large extent overlaps the crus, and this surface also has a furrow, the *sulcus lateralis*. The slender fourth cranial nerve lies upon this surface. Close to the cerebral hemisphere the ventral and lateral aspects of the crus are embraced by the optic tract of the corresponding side.

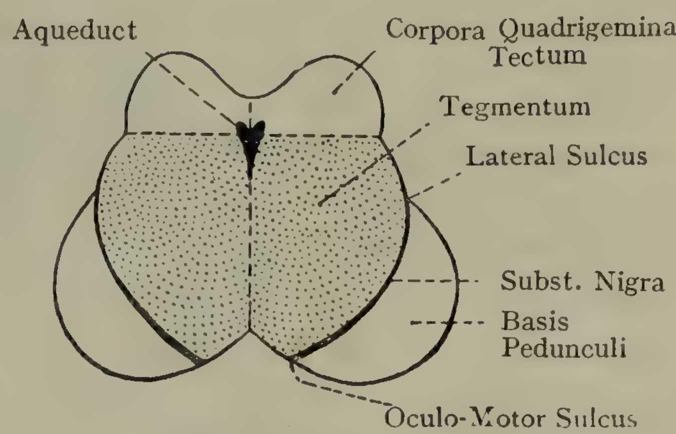


FIG. 954.—TOPOGRAPHY OF THE CRUS CEREBRI (AFTER POIRIER).

Each crus is composed of two parts—ventral and dorsal. The *ventral part* is the **basis** (or **crusta**), and the *dorsal* the **tegmentum.** The separation between these is indicated superficially by the sulcus lateralis and the oculo-motor sulcus. Within the crus the two parts are separated by a mass of dark grey matter, called the **substantia nigra.**

The **basis pedunculi (crusta)** is continuous superiorly with the internal capsule of the corpus striatum, and inferiorly its fibres enter the ventral part of the pons.

Structure of the Basis.—The crusta, or basis, as seen in transverse section, presents a crescentic outline, the concavity of the crescent being occupied by the convexity of the substantia nigra. It consists of longitudinal corticifugal fibres which arise in the cells of the cerebral cortex. These fibres form two groups—pyramidal and cortico-pontine.

The **pyramidal fibres** form the motor tract from the precentral motor region of the cortex of the frontal lobe, and they arise for the

most part from the cells of that region, which control the voluntary muscles of the body.

The cortico-pontine fibres lie on each side of the pyramidal tract, those coming from the frontal region of the cortex being on the medial and those from the temporal region on the lateral side; the basis of each peduncle, therefore, is formed, from within outward, by fronto-pontine, pyramidal, and temporo-pontine tracts (see Fig. 958).

Tegmentum.—The tegmentum is continuous inferiorly with the formatio reticularis of the dorsal portion of the pons, which in turn is continuous inferiorly with the formatio reticularis of the medulla oblongata; the upward prolongation of the tegmentum makes the tegmental subthalamic region. The two tegmenta, right and left, are separated from each other by a median raphé, which is continuous with

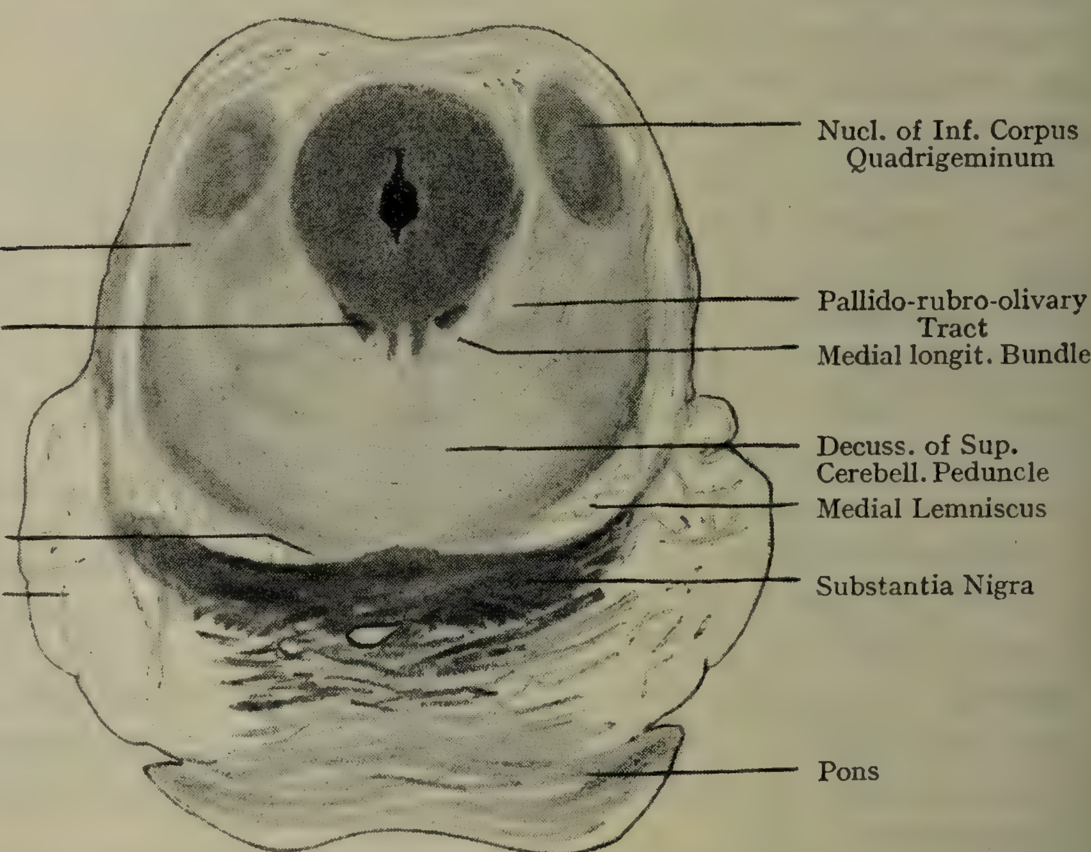


FIG. 955.—SECTION THROUGH INFERIOR CORPORA QUADRIGEMINA.

that of the pons. In the lower part of the mesencephalon this raphé is indistinct on account of the decussation which takes place across the median plane between the superior cerebellar peduncles, underneath the lower pair of quadrigeminal bodies.

The dorsal surface of each tegmentum extends on either side of the grey matter of the aqueduct, and becomes continuous with the basal parts of the upper and lower quadrigeminal bodies of the corresponding side, which constitute the *tectum*. The ventral surface is separated from the crusta by the substantia nigra.

Structure of the Tegmentum.—Each tegmentum, besides being continuous inferiorly with the formatio reticularis of the dorsal portion of the pons, consists of bundles of longitudinal and transverse fibres, the intervals between which are occupied by grey matter.

Grey Matter.—The grey matter of the tegmentum contains the red nucleus.

The **red nucleus** (**nucleus ruber**) is a round reddish mass, which is situated in the centre of the upper part of the tegmentum, and lies in the path of the superior cerebellar peduncle of the opposite side. It is on the same level as the upper quadrigeminal body, and is prolonged upwards into the subthalamic tegmental region. Some of the fibres of the superior cerebellar peduncle of the opposite side surround the red nucleus in the form of a capsule on their way to the thalamus. Other fibres of that peduncle enter the red nucleus, and terminate in arborizations around its cells.

The axons of the cells of the red nucleus form two sets of nerve-fibres—ascending and descending. The *ascending fibres* pass to the thalamus in company with those fibres of the superior cerebellar peduncle which encapsule the red nucleus. These ascending fibres form relays which carry on those fibres of the superior cerebellar peduncle which terminate within the red nucleus, that nucleus being a cell-station in their path. The *descending fibres* constitute the **rubro-spinal tract** (or **bundle of Monakow**). The fibres of this tract cross the median plane in the raphé, and by their decussation with those of the opposite side they constitute the *ventral fountain decussation* (*of Forel*), in contradistinction to the *dorsal fountain decussation* (*of Meynert*). The latter decussation is on a higher level, and involves the fibres of the *ventral longitudinal bundles*, or *tecto-spinal tracts*, which derive their fibres from the cells of the stratum opticum and stratum lemnisci of the upper quadrigeminal bodies. The rubro-spinal tract of either side descends through the pons and medulla oblongata into the lateral column of the spinal cord, where each constitutes the *prepyramidal tract*, which lies on the ventro-lateral aspect of the lateral cortico-spinal tract. (The tecto-spinal tract, or ventral longitudinal bundle, on either side descends into the anterior column of the spinal cord.)

White Matter of the Tegmentum.—The principal tracts of the white matter on either side are as follows:

1. Superior cerebellar peduncle.
2. Medial (posterior) longitudinal bundle.
3. Ventral longitudinal bundle, or tecto-spinal tract.
4. Pallido-rubro-olivary tract.
5. Rubro-spinal tract.
6. Medial lemniscus (chief sensory tract).
7. Lateral (acoustic) lemniscus.

Superior Cerebellar Peduncle.—The fibres of this peduncle emerge for the most part through the hilum of the nucleus dentatus in the cerebellar hemisphere. The two peduncles, right and left, having emerged from the hemispheres, pass upwards on the lateral parts of the dorsal surface of the pons in a converging manner towards the lower pair of the quadrigeminal bodies, being connected

by the superior medullary velum. On entering the mesencephalon, the two peduncles decussate across the raphé beneath the lower quadrigeminal bodies. This decussation extends as high as the upper quadrigeminal bodies, and it involves almost all the fibres of the two peduncles. Each peduncle, having gained the opposite side, ascends in the upper part of the tegmentum as a longitudinal tract, and soon comes into contact with the red nucleus. Many of its fibres enter this nucleus and terminate in arborizations around its cells. Other fibres of the peduncle encapsule the nucleus, and then ascend through the subthalamic tegmental region to the anterior part of the thalamus, within which they terminate in arborizations around the cells of the anterior nuclear area (chief sensory nucleus). From the cells of the red nucleus relays of fibres proceed upwards, which carry on those fibres of the peduncle which terminate within the nucleus, and these relays ascend with those fibres of the peduncle which encapsule the red nucleus to the thalamus.

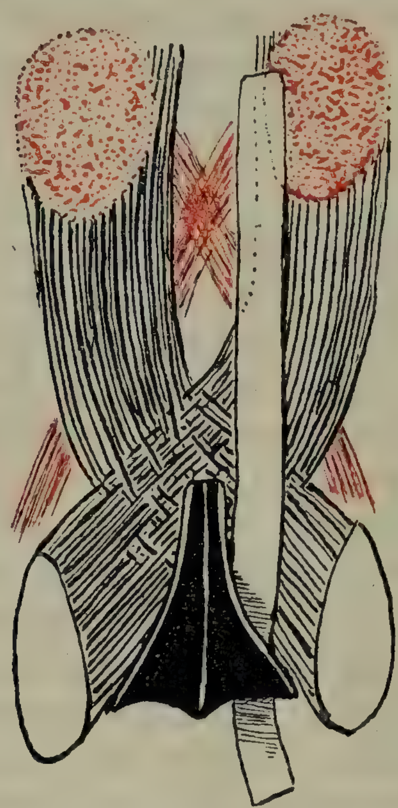


FIG. 956.—PLAN OF RELATIONS OF CERTAIN FIBRE-TRACTS IN THE MID-BRAIN, AS IT MIGHT BE SEEN FROM ABOVE.

Fibres of superior peduncles are shown decussating and reaching red nucleus, from which the rubro-spinal tracts emerge, decussate, and pass below the cerebellar fibres to enter the pons laterally. On the right the pallido-rubro-olivary tract is shown in white, indicating its relation to the peduncular fibres; it sinks deeply in the pons, turning somewhat laterally. It is not shown in front of the red nucleus.

The superior cerebellar peduncle of one side connects the cerebellar hemisphere of that side with the postcentral region of the cerebral cortex of the opposite side, the red nucleus and the thalamus being cell-stations in the path of the fibres.

A few of the fibres of each superior cerebellar peduncle do not take part in the decussation beneath the lower pair of quadrigeminal bodies, but ascend to the red nucleus of their own side.

Before the fibres decussate, or after the decussation has taken place, each of them furnishes a descending branch. These descending branches form the *descending cerebellar bundle* (*of Cajal*), which traverses the dorsal part of the pons and the medulla oblongata, giving off collaterals to the motor nuclei of these parts. According to Cajal, the fibres of this bundle enter the anterior column of the spinal cord, and are connected with the cells of the ventral column of grey matter.

The superior cerebellar peduncle also contains the indirect or ventral spino-cerebellar tract (of Gowers).

Medial or Posterior Longitudinal Bundle.—This bundle occupies he dorsal part of the tegmentum, and is intimately related to the rey matter which forms the ventral wall or floor of the aqueduct. t lies close to the median raphé, as does its fellow of the opposite ide, and across the raphé an interchange of fibres takes place between he two bundles. In the spinal cord it is represented by the anterior ntersegmental fibres and the anterior marginal bundle (of Lowenthal). n the medulla oblongata it traverses the dorsal part of the pyramid, eing separated from the pyramidal (motor) fibres by the medial emniscus or chief sensory tract. Thereafter it traverses the formatio eticularis of the dorsal part of the pons, and is continued upwards s one of the tracts of the tegmentum of the crus cerebri.

The fibres of the medial longitudinal bundle are regarded as being he axons of cells belonging to (1) the nucleus of Deiters, which is ne of the terminal nuclei of the vestibular root of the auditory nerve, 2) the formatio reticularis of the medulla oblongata and pons, 3) the formatio reticularis of the tegmentum, (4) the sensory nucleus f the fifth cranial nerve, and (5) the nucleus of the longitudinal undle. *Inferiorly* the fibres of the bundle ramify within the nterior column of the spinal cord in connection with the motor cells f the ventral horn of grey matter. *Superiorly* its fibres are intimately elated to the following important nuclei—namely, (1) the oculo-notor nucleus, or nucleus of the third cranial nerve; (2) the trochlear ucleus, or nucleus of the fourth cranial nerve; and (3) the abducent ucleus, or nucleus of the sixth cranial nerve, these being the nuclei which control the muscles of the eyeball and upper eyelid. The undle furnishes numerous collaterals to each of these nuclei, which erminate in arborizations around their cells. The bundle also estab-ishes connections with the motor nuclei in the pons and medulla oblongata.

The medial longitudinal bundle extends as high as a special nucleus, called the *nucleus of the posterior longitudinal bundle*, which is situated n the grey matter of the ventro-lateral portion of the third ventricle ear the upper opening of the aqueduct, from the cells of which nucleus some of its fibres arise.

The bundle consists of *ascending* and *descending association fibres*, which form connections between the important nuclei just referred to. Probably the chief use of the bundle is to maintain a functional association between these nuclei, and insure harmonious action of the muscles which are supplied by the nerves arising from them.

Tecto-spinal Tract (Ventral Longitudinal Bundle).—This bundle lies on the ventral aspect of the medial longitudinal bundle. Its fibres are derived from the stratum opticum and stratum lemnisci of the upper quadrigeminal body of the opposite side. These fibres, as stated in connection with the upper quadrigeminal bodies, descend beside the grey matter round the aqueduct, cross the median plane, and decussate with the corresponding fibres of the opposite side, the decussation being known as the *dorsal fountain decussation* (*of Meynert*). The

fibres descend through the tegmentum, lying close to the red nucleus, to which they furnish collaterals. Thereafter they traverse the formatio reticularis of the pons and medulla oblongata, still lying on the ventral aspect of the medial longitudinal bundle. From the medulla oblongata the fibres pass into the anterior ground-bundle of the lateral column of the spinal cord, where they lie just in front of the rubro-spinal tract, and they form arborizations around the motor cells of the ventral horn of grey matter.

The **pallido-rubro-olivary tract** (Figs. 955 and 956) is a well-formed and marked bundle of fibres which can be found in sections through the mid-brain and pons. The fibres lie between the red nucleus and the olive, above the medial part of the red nucleus and the cerebellar peduncular fibres in the crura, within the concavity of these fibres as they pass between their decussation and the superior peduncle, more laterally in the middle and lower parts of the pontine tegmentum, and gain the inferior olive just below the lower border of the pons; they may be visible in part on the surface here (Fig. 883). The exact path of the tract between the red nucleus and the globus pallidus is not certainly known; the tract is probably in great part interrupted at the red nucleus, from which the rubro-olivary fibres take origin, but direct pallido-olivary fibres are known to be present also.

> This tract is essentially a structure belonging to the brains of the higher vertebrates, in which the inferior olive replaces or reinforces the primitive olivary formation; this is represented in the human brain by the medial and other accessory olives.

Rubro-spinal Tract (or Bundle of Monakow).—The fibres of this tract are derived, as previously stated, from the axons of the cells of the red nucleus. They cross the median plane, decussating with the corresponding fibres of the opposite side, and constituting the *ventral fountain decussation* (*of Forel*). The tract then descends through the pons and medulla oblongata into the lateral column of the spinal cord, in which it constitutes the *prepyramidal tract* on the ventro-lateral aspect of the lateral cortico-spinal tract.

Medial Lemniscus.—The medial or main lemniscus of either side begins in the lower part of the medulla oblongata. It is here the only lemniscus on either side, and its fibres are derived from the *deep lemniscal arcuate fibres,* which arise from the cells of the *nucleus gracilis* and *nucleus cuneatus* of the opposite side. The main lemniscus therefore represents the upward continuation of the *posterior column* of the spinal cord (gracile and cuneate fasciculi), and it is spoken of as the **chief sensory tract.** The deep lemniscal arcuate fibres cross the median plane directly above the decussation of the pyramids (*motor decussation*), thus constituting the *decussation of the lemnisci* (main fillets or chief sensory tracts), or the *sensory decussation.* The fibres, after crossing the median plane, form the tract of the side to which they have crossed. In the medulla oblongata it lies close to the median raphé, and at first is in front of the medial longitudinal bundle, and

lirectly behind the pyramid. The main lemniscus then ascends through he dorsal part of the pons, its relative position remaining unchanged. In this situation the lateral lemniscus, to be presently described, takes up its position on the outer or lateral aspect of the main or medial band. The main tract, on leaving the pons, enters the ventral part of the tegmentum, still having the lateral tract on its outer side. As it encounters the red nucleus it is displaced laterally and backwards, and then occupies the dorso-lateral part of the tegmentum, lying almost beneath the medial geniculate body.

The fibres of the main or medial lemniscus (chief sensory tract) terminate in two ways: (1) Some enter the upper quadrigeminal body, and these probably terminate in the stratum lemnisci; (2) others traverse the subthalamic tegmental region, and enter the anterior part of the thalamus, within which they terminate in arborizations around the cells of the ventro-lateral nuclear area (chief sensory nucleus). From these cells relays of thalamo-corticipetal fibres proceed to the cerebral cortex.

It is convenient to refer to the main or medial band as the *sensory lemniscus*.

Lateral Lemniscus.—The main or medial band being the sensory lemniscus, it is convenient to refer to the lateral one as the *auditory fillet or lemniscus*. The fibres of this fillet are derived from the following sources: (1) The corpus trapezoides, the fibres of which come from the ventral cochlear nucleus, the nucleus trapezoides, and the superior olive of the opposite side, as well as from the superior olive of the same side; (2) the auditory striæ, which are derived from the lateral cochlear nucleus of the opposite side; and (3) the nucleus of the lateral lemniscus.

The fibres of the right and left lateral lemnisci decussate across the median plane. Having crossed to the opposite side, the fibres become longitudinal and form a well-marked ascending tract in the dorsal part of the pons, which takes up a position on the lateral or outer side of the main or medial tract. In this part of its course the lateral lemniscus encounters a collection of grey matter, called its *nucleus*. Some of its fibres end in this nucleus. Others pursue their upward course, and are reinforced by relays of fibres which arise from the nerve-cells of the nucleus. On leaving the pons the lateral band enters the tegmentum, and its fibres terminate in (1) the nuclei of the lower quadrigeminal body, and (2) the cells of the medial geniculate body. The fibres destined for the lower quadrigeminal body, having curved round the lateral aspect of the superior cerebellar peduncle, become superficial on the outer side of the tegmentum. The fibres destined for the medial geniculate body reach it through the inferior brachium partly directly and partly through the intervention of the lower quadrigeminal body. The axons of the cells of the geniculate body form corticipetal fibres which pass to the cortex of the first or superior temporal gyrus of the temporal lobe.

The lateral lemniscus, therefore, is associated with the *auditory apparatus*. It is chiefly composed of ascending fibres. There are,

however, some descending fibres which are probably derived from the lower quadrigeminal bodies.

In addition to the foregoing, there are other tracts.

Fasciculus Retroflexus.—The fibres of this bundle, already described, arise from the cells of the *ganglion habenulæ*. They descend in the upper part of the tegmentum internal to the red nucleus, and they terminate in arborizations around the cells of the interpeduncular ganglion.

Bundle of Munzer.—The fibres of this tract descend from the lower quadrigeminal body to the formatio reticularis of the lateral part of the pons.

Spino-thalamic Tract.—The fibres of this tract, as stated in connection with the tracts of the spinal cord, arise from the cells of the dorsal grey column of the opposite side. Having crossed in the ventral or white commissure, they enter the antero-lateral or indirect cerebellar tract (tract of Gowers), in which they ascend through the medulla oblongata, pons, and tegmentum of the crus cerebri to the thalamus of the side to which they have crossed.

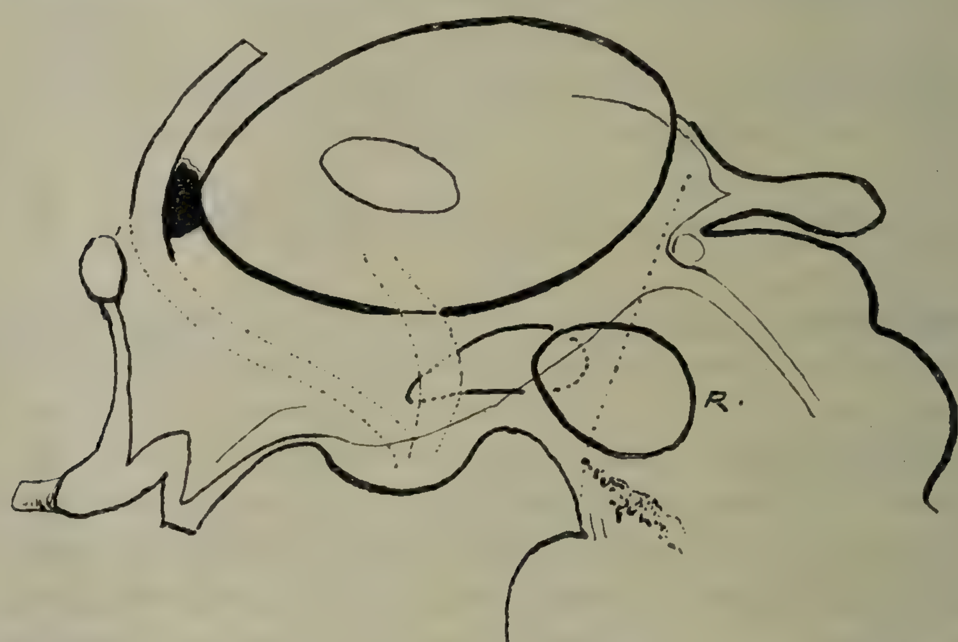


FIG. 957.—DIAGRAM TO SHOW POSITION AND RELATIONS OF STRUCTURES IN TEGMENTAL SUBTHALAMUS.

Supposed to be viewed from the medial aspect. R, red nucleus. The subthalamic nucleus is shown antero-lateral to this. *Dotted line* shows course of fasciculus retroflexus from habenula to interpeduncular ganglion. Course of anterior pillar of fornix is indicated, also mamillo-thalamic tract (bundle of Vicq d'Azyr) passing up medial to front part of subthalamic nucleus. Substantia nigra is seen near pontine level, but passes upwards and laterally out of the section higher up.

Subthalamic Tegmental Region.—This region represents the upward prolongation of the tegmentum of the crus cerebri beneath the posterior part of the inferior or ventral surface of the thalamus. The prolongation contains (1) an upward extension of the red nucleus of the tegmentum, (2) the fibres of the superior peduncle of the cerebellum, and (3) the main or medial lemniscus (chief sensory tract).

The *upward extension of the red nucleus* ceases about the level of the corresponding corpus mamillare. Some of the fibres of the *superior peduncle of the cerebellum* terminate, as stated, in the red nucleus, and others encapsule it, as they do in the tegmentum. Many fibres issue from the cells of the red nucleus, and these, along with the investing fibres of the superior cerebellar peduncle, enter the inferior or ventral surface of the thalamus.

The *main lemniscus* (chief sensory tract), which lies on the dorso-lateral aspect of the red nucleus, also enters the inferior or ventral surface of the thalamus.

Development of the Crura Cerebri.—The crura cerebri are developed in the ventral wall of the mesencephalon.

Basis Pedunculi (Crusta or Pes).—The basis is the ventral portion of the crus cerebri, and is separated from the tegmentum of the crus by a mass of dark grey matter, called the substantia nigra, which is situated in the interior. Externally the separation is indicated on the outer aspect by the lateral sulcus, and on the inner aspect by the oculo-motor sulcus, through which the fasciculi of the oculo-motor nerve emerge. The basis is continuous with the internal capsule of the corpus striatum, and it consists of longitudinal centrifugal fibres, which arise in the cells of the cerebral cortex. These fibres are arranged in two sets, pyramidal and cortico-pontine. The pyramidal fibres form

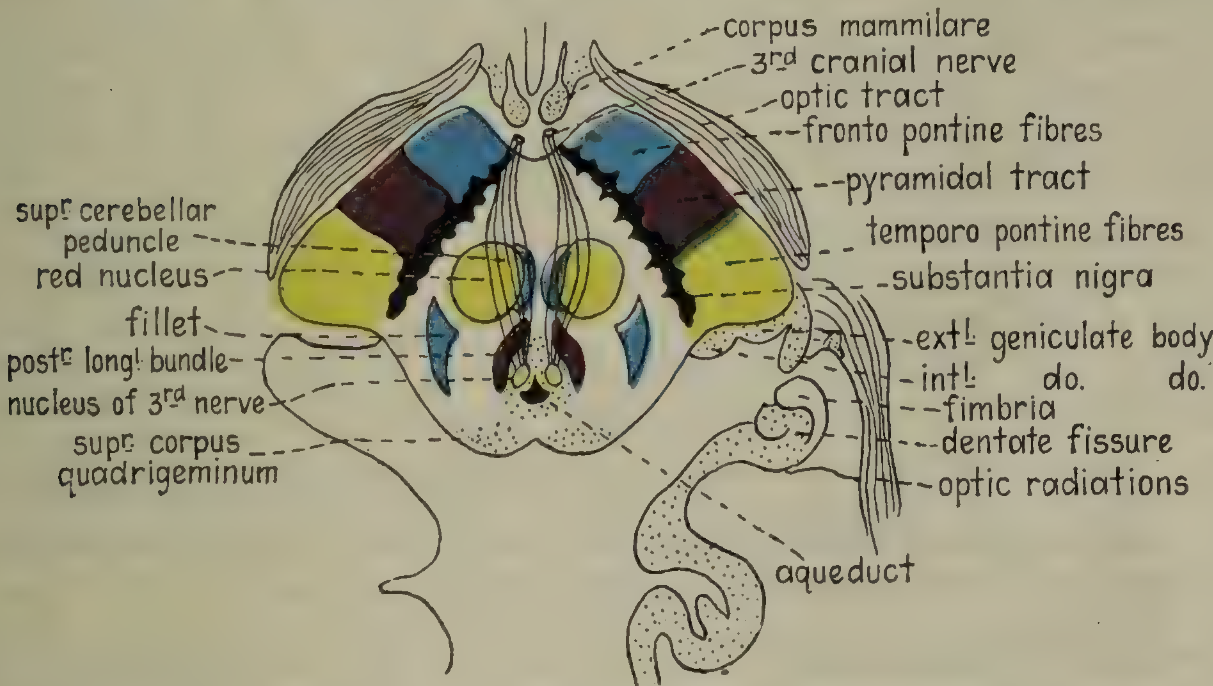


FIG. 958.—THE CRURA CEREBRI AND THEIR RELATIONS.

the motor tract from the precentral region of the cerebral cortex; and the cortico-pontine fibres are arranged in two strands—namely, fronto-pontine and temporo-pontine.

The **pyramidal fibres** form the motor tract from the precentral region of the cerebral cortex. They traverse the lenticular portion of the posterior limb of the internal capsule, and then occupy the *middle three-fifths* of the crusta. Thereafter they descend through the ventral portion of the pons and the pyramid of the medulla oblongata. In the lower part of the pyramid they give rise to the crossed and direct pyramidal tracts. The crossed pyramidal tract, having taken part in the decussation of the pyramids, descends in the spinal cord as the *lateral cortico-spinal tract*, occupying the posterior part of the lateral column of the opposite side. The direct pyramidal tract descends (anterior cortico-spinal tract) in the spinal cord, occupying the medial part of the anterior column of the same side. Its fibres, however, cross at intervals to the opposite side.

As the pyramidal tract descends through the pons and medulla oblongata, some of its fibres pass to the motor nuclei of the cranial nerves in these regions.

The **cortico-pontine fibres** are arranged in two strands, fronto-pontine and temporo-pontine. The fibres of the **fronto-pontine strand** arise from the cells of the cortex of the anterior part of the frontal lobe, and, having traversed the anterior limb of the internal capsule, they are regarded as occupying the *medial fifth* of the basis pedunculi. The fibres of the **temporo-pontine strand** arise from the cells of the cortex of the temporal lobe, and having traversed the post-lenticular part of the internal capsule, they occupy the *lateral fifth* of the crusta. In the ventral part of the pons both the fronto-pontine and the temporo-pontine fibres terminate in arborizations around the cells of the nucleus pontis, whereas the pyramidal fibres pass uninterruptedly through the ventral part of the pons.

Substantia Nigra.—This is a mass of dark grey matter which is situated between the tegmentum and the basis of the crus cerebri. Like the basis, it is semilunar or crescentic, as seen in transverse section. It contains many multipolar nerve-cells, which are deeply pigmented, and it extends from the upper border of the pons into the subthalamic tegmental region. Laterally it reaches the lateral sulcus on the lateral aspect of the crus, where it is thin, and the oculo-motor sulcus on the medial aspect, where it is thick, and is traversed by the fasciculi of the third cranial or oculo-motor nerve. Its tegmental surface is concave, and the surface directed towards the basis is convex. From the latter surface prolongations extend into the basis.

The substantia nigra does not acquire its pigment before the second or third year after birth.

Aqueduct of Mid-brain.—The aqueduct is the narrow passage which leads through the mesencephalon from the third to the fourth ventricle (*iter a tertio ad quartum ventriculum*). It lies nearer the dorsal than the ventral aspect of the mesencephalon; its direction is from above downwards, and its length is rather more than $\frac{1}{2}$ inch. Its upper opening is situated on the posterior boundary of the third ventricle immediately underneath the posterior commissure, and its lower opening occupies the superior median angle of the floor of the fourth ventricle. In transverse section the aqueduct is T-shaped in its upper part near the third ventricle, and triangular in its lower part near the fourth ventricle. The passage is lined with ciliated columnar epithelium, external to which there is a thick layer of grey matter, which is spoken of as the **central (Sylvian) grey matter.** This is continuous superiorly with the grey matter of the floor and lateral walls of the third ventricle, and inferiorly with that which covers the floor of the fourth ventricle. It contains numerous nerve-cells disposed in a scattered manner, but, in addition to these, there are certain definite cell-groups. These groups constitute the nuclei of origin of the following cranial nerves: the third or oculo-motor, the

fourth or trochlear, and the mesencephalic root of the fifth nerve. The **oculo-motor nucleus** is situated in the ventral portion of the grey matter underneath the upper quadrigeminal body, and it extends upwards into the layer of grey matter on the adjacent portion of the lateral wall of the third ventricle. The **trochlear nucleus** is also situated in the ventral portion of the grey matter, but at a lower level than the oculo-motor nucleus, being placed underneath the upper part of the lower quadrigeminal body. The **nucleus of the mesencephalic root of the fifth nerve** is extensive, and is situated in the lateral portion of the grey matter.

Development.—The aqueduct is the persistent remains of the cavity of the mesencephalon.

Posterior Perforated Substance.—This area has been previously described in a general way in connection with the base of the encephalon. It will here be considered more fully. It lies at the bottom of a deep depression, called the *interpeduncular fossa,* which forms the back part of the interpeduncular space. The fossa is bounded *posteriorly* by the median portion of the upper border of the pons, and *laterally* by the crura cerebri. *Anteriorly* it is limited by the corpora mamillaria.

The locus perforatus is a perforated lamina of grey matter which forms the floor of the interpeduncular fossa, the openings being for the passage of the postero-medial ganglionic branches of the posterior cerebral arteries. This grey lamina extends between the tegmenta of the crura cerebri.

Ganglion Interpedunculare.—This is a collection of nerve-cells situated medially in the lower part of the grey lamina which constitutes the posterior perforated substance. On either side it receives the fibres of the *fasciculus retroflexus,* which are derived from the ganglion habenulæ.

Structure of the Cerebral Hemispheres.

The cerebral hemisphere is composed of grey and white matter. The grey matter is disposed externally, and forms the cerebral *cortex,* which, *with the exception of the rhinencephalon,* is known as the neopallium. The white matter occupies the interior, and constitutes the *medullary centre.*

Cerebral Cortex.—The grey matter forms a continuous covering to the entire hemisphere, dipping into the sulci, so as to cover the opposed surfaces of the gyri, as well as the bottom of the sulci. It is thicker over the superficial surfaces of the gyri than at the bottom of the sulci, and attains its greatest thickness over the upper portions of the precentral and postcentral gyri, whilst it is thinnest over the occipital lobe.

The cerebral cortex is indistinctly divided into strata by means of layers of a whitish substance. When examined in section it therefore presents a stratified appearance, and is seen to consist of successive

grey and white layers alternating with each other. In most parts of the cerebral cortex there are four superimposed strata; but in certain situations—*e.g.*, over the precentral gyrus—there are as many as six. These strata are as follows, from without inwards:

1. Molecular layer, a superficial white layer (pale and narrow).
2. Superficial grey layer, the outer granular.
3. Outer white band of Baillarger.
4. Middle grey layer.
5. Inner white band of Baillarger.
6. Inner or deep grey layer, the polymorphous layer, subjacent to which is the white matter of the **medullary centre.**

Layers 3, 4, and 5 are included in the **pyramidal layer,** in which the cells tend to increase in size as they lie more deeply; the largest lie over the inner band of Baillarger.

The medullated fibres of the medullary centre pass into the stratified grey cortex in a radiating manner, and within the cortex their course for the most part is perpendicular to the superficial surface, and between the component cells of the cortex.

Minute Structure of the Cerebral Cortex.—The cortex is composed of nerve-cells and nerve-fibres.

Nerve-cells.—These are arranged in four layers, which are, from without inwards: (1) the molecular layer; (2) the layer of small pyramidal cells; (3) the layer of large pyramidal cells; and (4) the layer of polymorphous cells.

The **molecular** or **plexiform layer,** which is the most superficial, is thin, and consists of cells and fibres. Many of the cells are neuroglia-cells, the others being nerve-cells. These nerve-cells are for the most part fusiform, and are disposed horizontally. They are known as the **horizontal cells of Cajal.** Their dendrons and axons are long, the latter forming medullated fibres which are disposed horizontally or parallel to the surface. These furnish minute branches which pass vertically towards the surface. The horizontal cells, according to Cajal, receive impulses from the corticipetal fibres which extend from the thalamus to the cerebral cortex.

In addition to these fibres there are many others which enter the molecular layer from deeper sources, and form a dense interlacement by their ramifications. The sources from which these extraneous fibres are derived are: (1) the terminal ramifications of the apical dendrons of the pyramidal cells (small and large); (2) the axons of the cells of Martinotti, which lie in the polymorphous layer; and (3) corticipetal fibres derived from the medullary centre of the gyrus.

The **pyramidal layers** represent the second and third layers, and are composed of characteristic pyramidal cells which are peculiar to the cerebral cortex, those of the second layer being small, whilst those of the third layer are large. The layer of small pyramidal cells is narrow, but the layer of large pyramidal cells is of considerable thickness. The giant pyramidal cells of the motor cortex are known as cells of Betz. There is no well-marked line of demarcation between

these two layers, the one passing imperceptibly into the other. They constitute the chief part of the cerebral cortex.

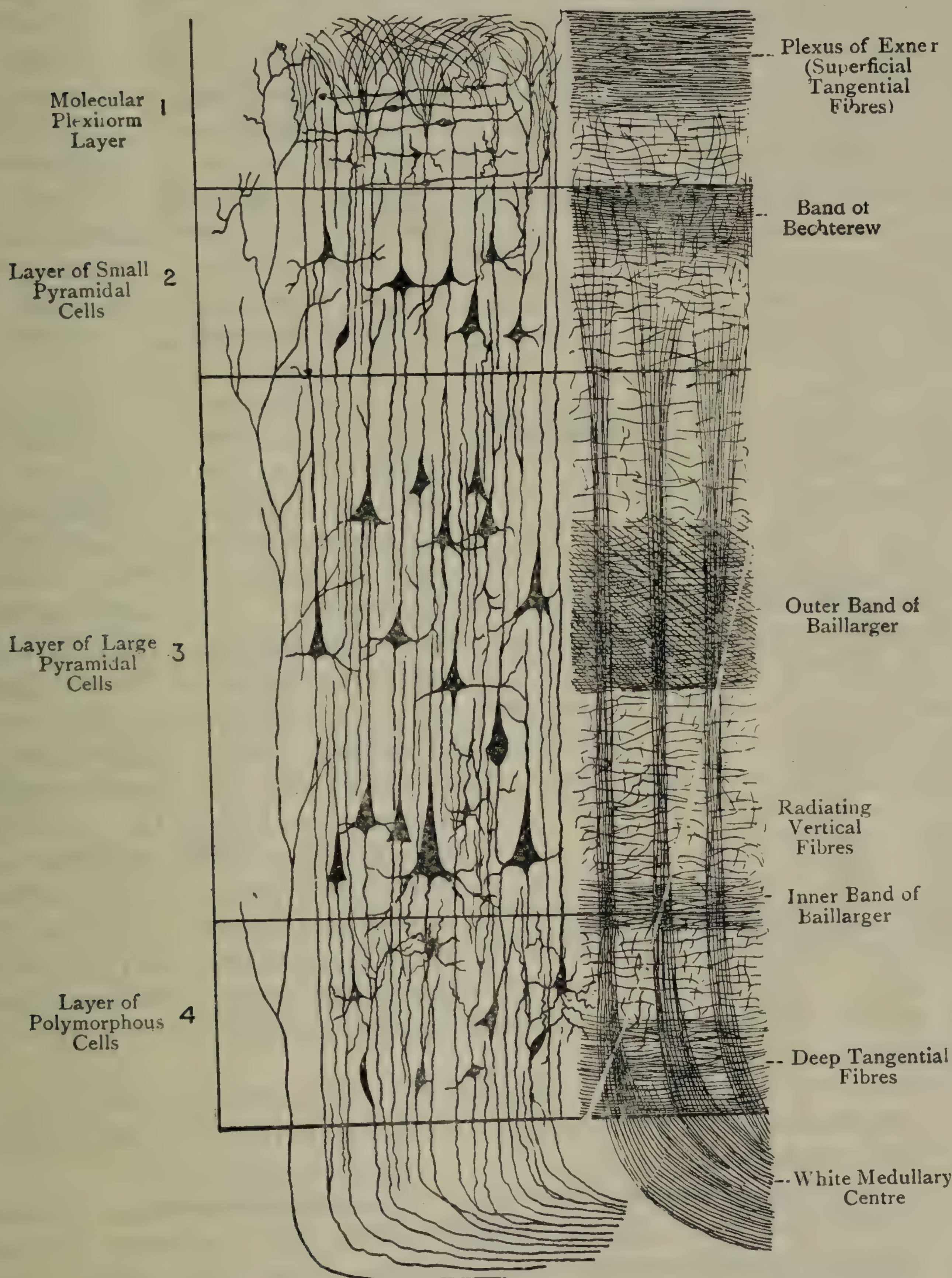


FIG. 959.—DIAGRAM SHOWING THE MINUTE STRUCTURE OF THE CEREBRAL CORTEX (POIRIER).

The fibres are shown on the right, and the cells on the left.

The apex of each **pyramidal cell** is directed towards the surface of the gyrus, and is prolonged into a long tapering dendrite, which (Fig. 960) passes into the molecular layer, giving off delicate collaterals

in its course. Near the surface of the molecular layer it divides into terminal filaments, which are disposed horizontally and mingle with the tangential fibres. The base of the pyramidal cell is directed towards the medullary centre of the gyrus, and from its centre an axon is given off, which enters the medullary centre, giving off collaterals in its course. From each side of the body of the cell, as well as from each lateral angle of its base, dendrites are given off.

The **polymorphous layer** is the deepest layer, and is composed of cells which have different shapes. Each cell gives off several dendrites, which pass towards, but do not enter, the molecular layer. The axon of each cell enters the medullary centre as a nerve-fibre.

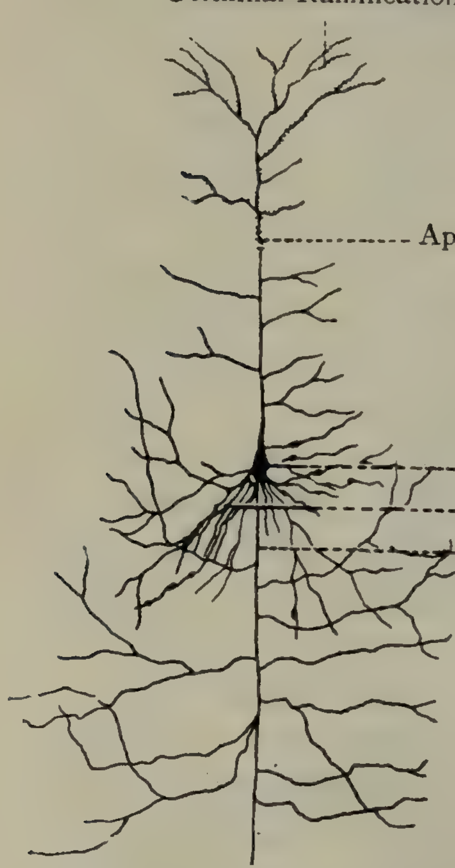


Fig. 960.—A Pyramidal Cell of the Human Cerebral Cortex (Ramon y Cajal).

In addition to the foregoing cells of the cerebral cortex, two other kinds of cells are met with amongst the pyramidal and polymorphous cells—namely, the cells of Golgi and the cells of Martinotti. The **cells of Golgi** are characterized by the fact that the axon of each almost immediately divides into several branches, which pass towards the surface, but soon terminate without entering the molecular layer. The **cells of Martinotti** are chiefly met with in the polymorphous layer. The axon of each cell passes towards the surface, and enters the molecular layer, where it divides into terminal branches, which form part of the tangential fibres of this layer.

Nerve-fibres of the Cortex.—These are arranged in two groups—vertical and tangential.

The **vertical (radial) fibres** are disposed in radiating bundles, which issue from the medullary centre, and traverse the polymorphous and large pyramidal layers, after which they become indistinguishable. The polymorphous and large pyramidal cells lie in the spaces between these bundles, and assume a columnar arrangement. The fibres of the radiating bundles gradually become less numerous, some of them becoming the axons of the polymorphous cells, but most of them becoming the axons of the large pyramidal cells. The radiating bundles contain centripetal cortical fibres, which pass into the molecular layer and end in terminal ramifications, forming part of its tangential fibres.

The **tangential fibres** are disposed horizontally at different levels, and form the following strata: (1) the **superficial tangential fibres (plexus of Exner)**, which occupy the superficial part of the molecular layer; (2) the **band of Bechterew**, which is situated in the superficial part of the small pyramidal layer; (3) the **outer band of Baillarger (band of Vicq d'Azyr)**, which intersects the large pyramidal layer; (4) the **inner band of Baillarger**, which is situated between the large pyramidal and polymorphous layers; and (3) the **deep tangential fibres (intracortical association fibres)**, which are situated in the deep part of the polymorphous layer.

The tangential fibres are formed by (1) the collaterals of the polymorphous and pyramidal cells and of the cells of Martinotti; (2) the ramifications of the axons of the cells of Golgi; and (3) association fibres.

Medullary Centre of Cerebral Hemisphere.—The white matter of the medullary centre consists of medullated nerve-fibres, which pursue different courses, and are arranged in three groups—namely, projection fibres, commissural fibres, and association fibres.

The **projection fibres** connect the cerebral cortex with parts at a lower level, and they are of two kinds—corticipetal or afferent, and corticifugal or efferent. The **commissural fibres** pass from one hemisphere to the other, and connect portions of the cerebral cortex of opposite hemispheres. The **association fibres** are confined to one side of the median plane, and they bring different parts of the cerebral cortex of the same hemisphere into association with one another.

Projection Fibres.—These fibres, as stated, are both corticipetal and corticifugal, and the majority of them constitute the internal capsule of the corpus striatum, and the diverging arrangement of its fibres known as the *corona radiata*, which passes to all parts of the cerebral cortex. Some projection fibres, however, do not traverse the internal capsule and corona radiata—*e.g.*, the fibres of the *ansa peduncularis*.

Corticifugal Fibres.—The corticifugal or efferent fibres constitute the following tracts:

1. **Pyramidal or motor.**
2. **Cortico-thalamic.**
3. **Fronto-pontine.**
4. **Temporo-pontine.**
5. **Optic radiation (portion).**

The **pyramidal** or **motor tract** derives its fibres from the axons of the pyramidal cells of the cortex of the *precentral gyrus*, which is situated in front of the central fissure. Having traversed the corona radiata, these fibres pass in succession through (1) the posterior limb of the internal capsule, (2) the middle three-fifths of the basis of the crus cerebri, (3) the ventral portion of the pons, and (4) the pyramid of the medulla oblongata. The motor strand enters the spinal cord in three ways—partly as the direct or ventral cortico-spinal tract, partly as the uncrossed lateral tract, but chiefly as the crossed lateral

cortico-spinal tract. Ultimately the fibres terminate at different levels in arborizations around the motor-cells of the ventral column of grey matter of the opposite side, from which cells the fibres of the motor nerve-roots proceed.

The efferent fibres which pass to the **motor nuclei of the cranial nerves** do not, as a whole, run in the cortico-spinal pathway through the basis pedunculi and basis pontis. They leave this path, usually in the upper part of the mid-brain, and pass down (Fig. 961) in the tegmentum of the mid-brain and pons. They reach the tegmentum also at lower levels, passing usually either medial or lateral to the substantia nigra, but they are not constant in this matter. These cortico-pontine or cortico-bulbar fibres are thus *aberrant* or *extra-pyramidal* fibres. The figure, which is modified from Déjèrine, shows the nuclei supplied by this group, the remnant of which rejoins the main tract in the medullary pyramid. Each central supply to the nuclei decussates, crossing the middle line nearly at the level of the nucleus to which it is going.

FIG. 961.—PLAN OF EXTRA-PYRAMIDAL FIBRES RUNNING IN THE TEGMENTUM TO NUCLEI OF CRANIAL NERVES (MODIFIED FROM DÉJÈRINE).

The **cortico-thalamic tract** extends only between the cerebral cortex and the thalamus. Its fibres arise as the axons of the pyramidal cells of various parts of the cerebral cortex, and they terminate in arborizations around the cells of the thalamus.

The **fronto-pontine tract** does not extend lower than the pons. It consists of fibres which arise as the axons of the pyramidal cells of the cortex of the prefrontal region—that is to say, the region of the frontal lobe in front of the precentral sulcus. These fibres traverse the anterior limb of the internal capsule, and then descend through the inner or medial fifth of the basis of the crus cerebri into the pons. Within the pons they terminate in arborizations around the cells of the *nucleus pontis*.

The **temporo-pontine tract,** like the preceding, does not extend lower than the pons. It consists of fibres which arise as the axons of the pyramidal cells of the cortex of the first and second temporal gyri. These fibres traverse the postlenticular part of the posterior limb of the internal capsule, and then descend through the outer fifth of the basis of the crus cerebri into the ventral part of the pons. Within this part of the pons they terminate in arborizations around the cells of the *nucleus pontis*.

The *corticifugal fibres* of the **optic radiation** consist of fibres which arise as the axons of the pyramidal fibres of the cortex of the occipital

lobe. They traverse the postlenticular part of the posterior limb of the internal capsule, and thereafter pass to the lower visual centres—namely, the lateral geniculate body and the upper quadrigeminal body. Within these bodies they terminate in arborizations around their component cells.

Corticipetal Fibres.—The corticipetal or afferent fibres belong to the following tracts:

1. **Medial lemniscus.**
2. **Superior cerebellar peduncle.**
3. **Thalamic radiation.**
4. **Auditory radiation.**
5. **Optic radiation.**

The **medial lemniscus,** or *principal sensory tract,* arises from the nucleus gracilis and nucleus cuneatus of the medulla oblongata, and is the upward prolongation of the posterior column of the spinal cord. Having decussated with its fellow, it ascends through the dorsal part of the pons through the tegmentum of the crus cerebri, and through the subthalamic tegmental region to the thalamus. Within this body its fibres terminate in arborizations around the thalamic cells. As the medial lemniscus ascends towards the thalamus some of its fibres enter the upper quadrigeminal body, in which they end. From the thalamus the fillet-fibres are continued to the cerebral cortex by relays of thalamo-cortical fibres.

The **superior cerebellar peduncle,** having decussated with its fellow, soon comes into contact with the red nucleus. Many of the fibres of the peduncle enter this nucleus and terminate in arborizations around its cells. Numerous fibres encapsule the nucleus, and continue their course upwards, traversing the subthalamic tegmental region, and finally entering the ventral aspect of the thalamus, within which they terminate in arborizations around the thalamic cells. As in the case of the fillet-fibres, they are continued to the cerebral cortex by relays of thalamo-cortical fibres.

The **thalamic radiation** is composed of thalamo-cortical fibres which arise as the axons of the cells within the thalamus, that body being regarded as an aggregation of cell-stations in the path of such corticipetal fibres as those of the medial lemniscus and superior cerebellar peduncle. These thalamo-cortical fibres, as stated in the description of the thalamus, issue from that body in four groups or stalks—frontal, parietal, occipital, and inferior or ventral. The fibres of the frontal stalk traverse the anterior limb of the internal capsule, and most of them pass to the cortex of the frontal lobe. The fibres of the parietal stalk pass partly through the internal capsule and partly through the external capsule to the cortex of the parietal lobe and of the central region of the frontal lobe. The fibres of the occipital stalk belong to the optic radiation, to be presently described. The fibres of the inferior or ventral stalk form the ansa lenticularis and ansa peduncularis. The *ansa lenticularis* enters the nucleus lentiformis, within which its fibres terminate. The *ansa peduncularis* passes beneath the nucleus lentiformis and traverses the external capsule, the

destination of its fibres being the cortex of the temporal lobe and insula.

The **auditory radiation** consists of fibres which arise as the axons of the cells of the medial geniculate body. Having issued from that body, they traverse the postlenticular part of the posterior limb of the internal capsule, and pass to the cortex of the middle part of the first temporal gyrus of the temporal lobe.

The *corticipetal fibres* of the **optic radiation** are associated with the corticifugal fibres, already described. The corticipetal fibres arise as the axons of the cells of the corpus geniculatum laterale and upper quadrigeminal body. They traverse the postlenticular part of the posterior limb of the internal capsule, and then pass to the cortex of the occipital lobe.

Commissural Fibres.—These fibres are disposed transversely, and serve to connect the grey cortex of one hemisphere with that of the other. They constitute the following commissures: (1) the *corpus callosum*; (2) the *anterior commissure*; and (3) the lyra, which is known as the *hippocampal commissure*. The fibres of the **corpus callosum,** as they enter each hemisphere, are disposed so as to form an extensive **callosal radiation,** and serve to connect the cortex of one hemisphere with that of the other. The individual portions of cortex so connected may be symmetrical, but to a large extent are not. The fibres arise on one side as (1) the axons of pyramidal or of polymorphous cells, or (2) collaterals of projection or of association fibres; and on the opposite side they terminate in delicate arborizations.

The **anterior commissure,** which crosses from side to side in front of the anterior pillars of the fornix, divides on either side into two parts, olfactory and temporal. The *olfactory portion* enters the olfactory tract. Some of its fibres serve to connect the olfactory bulb of one side with that of the other side; and other fibres connect the olfactory bulb of one side with the temporal lobe of the opposite. The *temporal portion* enters the white matter of the temporal lobe on either side.

The **hippocampal commissure** lies below the splenial portion of the corpus callosum, and is separated from the roof of the third ventricle by the tela chorioidea. It is a thin layer of arched fibres connecting the posterior pillars and sides of the fornix, and derived mainly from the hippocampus of each side; it is shown in Fig. 933. The commissure, which is not well developed in the human brain, was known as the 'lyra' in former days.

The corpus callosum is the great commissure of the neopallium; the hippocampal and anterior commissures, phylogenetically much older, are connections of the rhinencephalon, and hence archipallial.

Association Fibres.—These fibres serve to connect different parts of the cortex of the same hemisphere, and they are of two kinds, short and long.

The **short association fibres** pass between neighbouring gyri, extending in their course across the bottom of the sulci. Some of them

lie beneath the grey cortex, whilst others are contained within its deep part.

The **long association fibres** pass between portions of the grey cortex, which are at some distance from each other. They are arranged in bundles, the chief of which are as follows: (1) the superior longitudinal fasciculus; (2) the interior longitudinal fasciculus; (3) the perpendicular fasciculus; (4) the uncinate fasciculus; (5) the cingulum; (6) the occipito-frontal fasciculus; and (7) the fornix.

The **superior longitudinal fasciculus** consists of fibres which extend from the frontal to the occipital lobe. Posteriorly many of its fibres sweep downwards and forwards into the temporal lobe, and from this circumstance it is sometimes spoken of as the **arcuate fasciculus.**

The **inferior longitudinal fasciculus** connects the occipital and temporal lobes, its fibres being disposed upon the lateral walls of the posterior and inferior horns of the lateral ventricle.

The **perpendicular fasciculus** connects the inferior parietal lobule with the occipito-temporal gyrus.

The **uncinate fasciculus** crosses the stem of the lateral fissure, and connects the frontal and temporal lobes.

The **cingulum** is connected with the rhinencephalon, and lies upon the under surface of the callosal gyrus and the upper surface of the hippocampal gyrus. Its fibres connect the gyri of the lobe with the cerebral cortex.

The **occipito-frontal fasciculus** connects the frontal with the occipital and temporal lobes. It lies internal to the corona radiata, in intimate relation to the nucleus caudatus, and as the fibres pass backwards they lie on the outer walls of the inferior and posterior horns of the lateral ventricle.

The **fornix** connects the hippocampus major of one side with the corresponding corpus mamillare, and through the latter with the thalamus by means of the *mamillo-thalamic tract* (bundle of Vicq d'Azyr), the fibres of which arise in the corpus mamillare.

Peculiarities of the Cerebral Cortex—1. **Calcarine Area.**—This area is situated on the medial surface of the occipital lobe in close proximity to the calcarine fissure, and it is known as the **visual area.** In this region the outer band of Baillarger is very conspicuous, and is known as the **white band of Gennari,** whilst the inner band of Baillarger is absent.

2. **Central Area.**—In this region, more especially in the cortex of the pre-central gyrus, there are groups of very large pyramidal cells, which are known as the **giant-cells of Betz,** and nerve-fibres are present in large numbers.

3. **Hippocampal Area.**—The hippocampus corresponds to the hippocampal or dentate fissure, and is produced by an infolding of the cerebral cortex. It is therefore composed chiefly of grey matter, and is covered superficially by a thin layer of white matter, called the **alveus,** which is *continuous with the fimbria.* The hippocampus is composed of the following layers, named in order from the ventricular surface outwards: (1) the **alveus,** composed of white matter, and covered by the ventricular ependyma; (2) **neuroglial layer,** consisting of neuroglia fibres and cells; (3) **pyramidal layer,** composed of large pyramidal cells; (4) **stratum radiatum,** which is the outer part of the pyramidal layer, and is composed of the dendrites of the apical parts of the pyramidal cells, being thereby rendered striated in appearance; (5) **stratum laciniosum,** composed of the ramifications

of the foregoing apical dendrites intimately intermixed; (6) **stratum granulosum,** composed of many small cells; and (7) the **involuted medullary lamina,** consisting of white fibres.

Olfactory Tract and Olfactory Bulb.—These are developed as a hollow outgrowth from the anterior cerebral vesicle, more particularly from the part of it which ultimately gives rise to the lateral ventricle, and is known as the **telencephalon.** In many animals the central cavity persists, and maintains its connection with the lateral ventricle; but in man the cavity disappears, though traces of its ependymal lining remain. External to the vestigial ependyma there is a layer of white matter, and superficial to this there is a layer of grey matter. In the **olfactory tract** the layer of grey matter is very thin over the ventral or inferior aspect, but over the dorsal or superior aspect it is fairly thick. In the **bulb** the reverse is the case, the grey matter being thick over the ventral aspect, where it receives the olfactory filaments, but thin over the dorsal aspect.

Structure of the Ventral Grey Matter of the Olfactory Bulb.—The grey matter consists of three layers—namely, (1) the nerve-fibre layer, (2) the glomerular layer, and (3) the granular layer.

The **nerve-fibre layer** is the most superficial layer, and is composed of olfactory nerve-fibres. These fibres are non-medullated, and arise as the axons of the olfactory cells of the olfactory mucous membrane of the nasal fossa. Having passed through the foramina of one half of the cribriform plate of the ethmoid bone, they enter the grey matter on the ventral aspect of the bulb, where they break up and form arborizations. These intermingle with the arborizations formed by the dendrites of the mitral cells, to be presently described.

The **glomerular layer** is composed of round bodies or *glomeruli,* which are formed by the interlacements between the arborizations of the olfactory nerve-fibres and those of the dendrites of the mitral cells.

The **granular layer** lies next to the layer of white matter, and is chiefly characterized by the presence of large **mitral cells.** These are pyramidal, and one dendrite from each cell passes into the glomerular layer, where it gives rise to a glomerulus in the manner just described in connection with the glomerular layer. Other dendrites intermingle with those of adjacent mitral cells. The axon of each mitral cell enters the white layer of the bulb, and passes along the olfactory tract to the cerebrum.

Weight of the Brain.—The average weight of the brain of the adult male is about 48 ounces (1,360 grammes), and that of the adult female about 44 ounces.

Arteries of the Encephalon.

Cerebral Part of the Internal Carotid Artery.—The internal carotid artery, having pierced the roof of the cavernous sinus internal to the anterior clinoid process of the sphenoid bone, ascends between the second and third cranial nerves to the inner end of the stem of the

lateral fissure. Here it divides into its terminal branches, anterior and middle cerebral.

Branches are posterior communicating, anterior choroidal, anterior cerebral, and middle cerebral.

The **posterior communicating artery** arises from the back part of the internal carotid, and passes backwards to anastomose with the

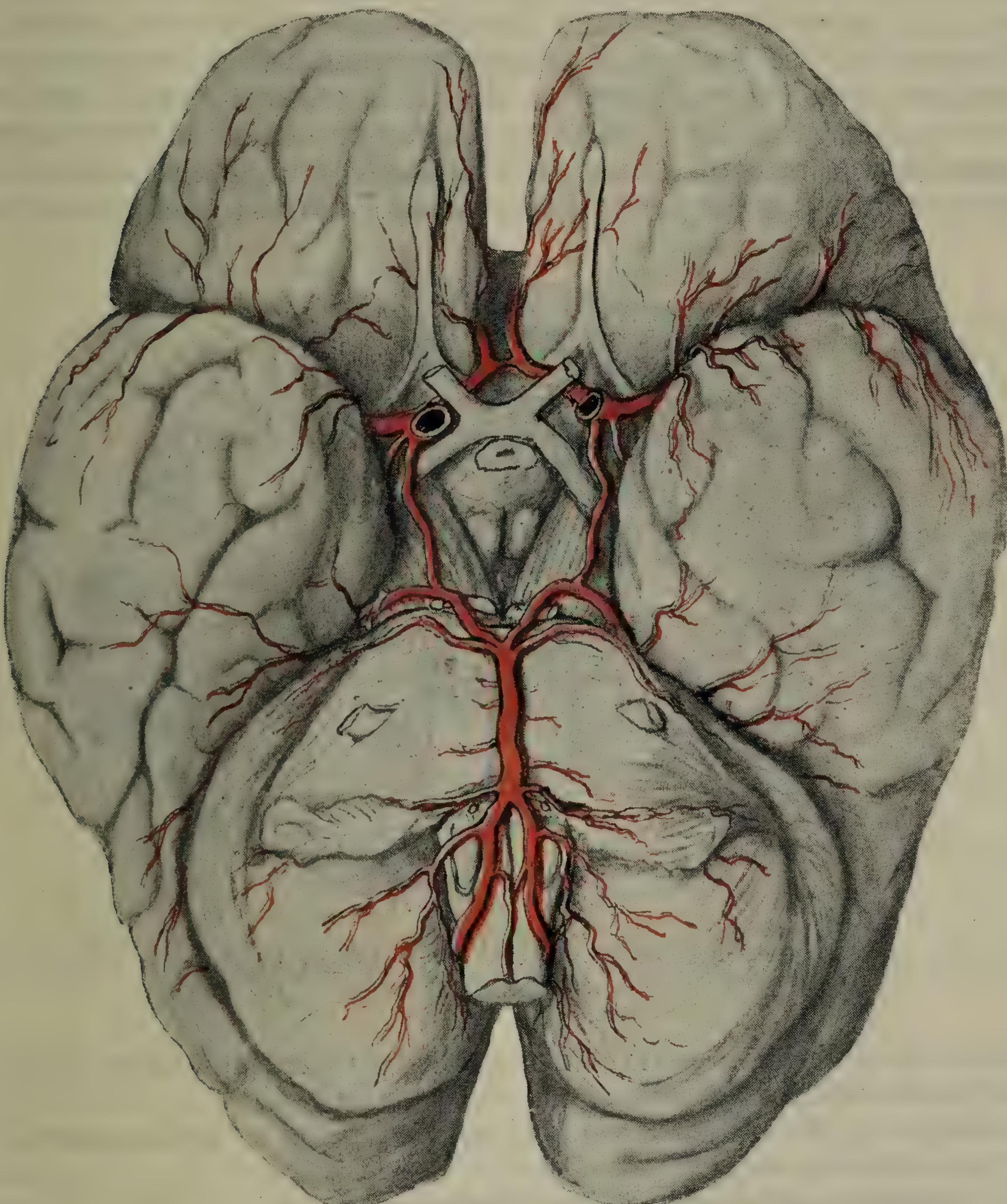


FIG. 962.—ARTERIES ON THE BASE OF THE BRAIN.

posterior cerebral artery. It is usually small, but is often larger on one side than the other. Occasionally it is absent.

The **anterior choroidal artery** arises from the back part of the internal carotid close to its termination. It passes backwards and outwards between the crus cerebri and the hippocampal gyrus, and enters the lower and anterior extremity of the descending horn of the

lateral ventricle by passing through the choroidal fissure. In its course it passes just above the uncus, gives twigs to the hippocampal gyrus and crus cerebri, and terminates in the choroid plexus of the lateral ventricle.

Anterior Cerebral Artery.—This is the smaller of the two terminal branches of the internal carotid artery, and it has a more limited distribution than the other terminal branch—namely, the middle cerebral artery. It passes forwards and inwards above the optic nerve, and just internal to the roots of the olfactory tract, to the commencement of the great longitudinal fissure, where it is connected with its fellow of the opposite side by a short transverse vessel, called the **anterior communicating artery.** After this it enters the great longitudinal fissure, turns round the genu of the corpus callosum, and passes back-

FIG. 963.—MEDIAN SECTION OF BRAIN WITH DISTRIBUTION OF ANTERIOR CEREBRAL ARTERY.

wards over the upper surface of that body to the splenium, where it anastomoses with the posterior cerebral artery.

Branches.—These are arranged in two groups, antero-medial or ganglionic and cortical.

The **antero-medial** or **ganglionic branches,** small in size, pass through the lamina cinerea along with twigs from the anterior communicating artery, and supply the front part of the caudate nucleus.

The **cortical branches** are as follows: (1) **medial orbital,** to the medial orbital gyrus, olfactory lobe, and gyrus rectus; (2) **anterior medial frontal,** to the superior frontal gyrus, the anterior two-thirds of the middle frontal gyrus, and the anterior part of the marginal gyrus; (3) **middle frontal,** to the collosal gyrus, the posterior part of the marginal gyrus, and the upper part of the precentral gyrus; and (4) **posterior**

frontal, to the precuneus and the corpus callosum, the branch of the latter being known as the *artery of the corpus callosum.*

Anterior Communicating Artery.—This vessel connects the two anterior cerebral arteries at the entrance to the great longitudinal fissure, and lies over the lamina terminalis in front of the optic commissure. It gives off a few twigs, which accompany the antero-medial branches of each anterior cerebral artery.

Middle Cerebral Artery.—This is the larger of the two terminal branches of the internal carotid artery, and it has a wider distribution than the anterior cerebral artery. It enters the stem of the lateral fissure, in which it passes outwards.

Branches.—These are arranged in two groups, antero-lateral or ganglionic and cortical. The **antero-lateral** or **ganglionic branches**

FIG. 964.—DISTRIBUTION OF THE LEFT MIDDLE CEREBRAL ARTERY (CHARCOT).

F.1. Superior Frontal Gyrus
F.2. Middle Frontal Gyrus
F.3. Inferior Frontal Gyrus
F.A. Ascending Frontal Gyrus
P.A. Ascending Parietal Gyrus
L.P.S. Superior Parietal Gyrus
L.P.I. Inferior Parietal Gyrus
P.C. Angular Gyrus
L.O. Occipital Lobe
L.T. Temporal Lobe
S. Middle Cerebral Artery entering Lateral Fissure
P. Lenticulo-striate Arteries
1. Artery to Inferior Frontal Gyrus
2. Ascending Frontal Artery
3. Ascending Parietal Artery
4. Parieto-Temporal Artery
5. Arteries to Temporal Lobe

pass through the anterior perforated substance, and form two sets, medial striate and lateral striate. The **medial striate arteries** represent the ‘ lenticular arteries ’ of Duret, and they supply the globus pallidus (inner part) of the lentiform nucleus, the internal capsule, and the caudate nucleus. The **lateral striate arteries** represent the ‘ lenticulo-striate ’ and ‘ lenticulo-optic ’ arteries of Duret. The **lenticulo-striate arteries** supply the putamen (outer part) of the lentiform nucleus and the external capsule. One of the lenticulo-striate arteries is said to be larger than the others, and is subject to rupture in cases of cerebral hæmorrhage. It is often termed the *artery of cerebral hæmorrhage* (Charcot). Its course is laterally and upwards round the outer aspect of the lentiform nucleus, between it and the external capsule, and then through the internal capsule to the caudate nucleus. The **lenticulo-**

thalamic arteries supply the posterior part of the lentiform nucleus and the anterior part of the thalamus on its lateral aspect.

The most important point to notice about all the ganglionic arteries of the brain is that they are 'end arteries,' and their branches, once having divided, never anastomose again; hence, if one of them is blocked by an embolus, which is often a piece of fibrin from a diseased heart valve, the area of brain supplied will be cut off from all blood-supply, and the clinical effects may be very grave.

The **cortical branches** arise in the vicinity of the insula, and are: (1) **inferior lateral orbital,** to the orbital surface of the frontal lobe lateral to the internal orbital sulcus, and to the inferior frontal gyrus;

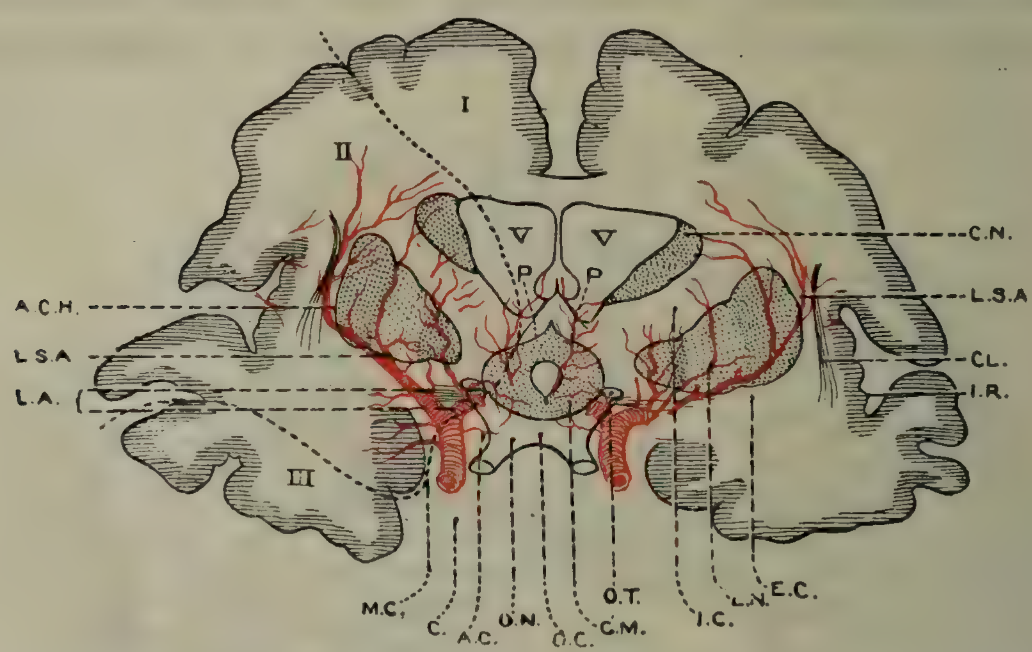


FIG. 965.—CORONAL SECTION OF THE CEREBRAL HEMISPHERES MADE ONE CENTIMETRE BEHIND THE OPTIC COMMISSURE (CHARCOT, FROM DURET).

The arteries of this region are shown.

I. Area of Cerebral Artery
II. Area of Middle Cerebral Artery
III. Area of Posterior Cerebral Artery
V.V. Sections of Anterior Cornua of Lateral Ventricles
P.P. Anterior Pillars of Fornix
C.N. Caudate Nucleus
L.S.A. Lenticulo-Striate Arteries
CL. Claustrum
I.R. Insula
E.C. External Capsule
L.N. Lentiform Nucleus
I.C. Internal Capsule
O.T. Optic Tract (cut)
G.M. Grey Matter of Third Ventricle
O.C. Optic Chiasma
O.N. Optic Nerve
A.C. Anterior Cerebral Artery
C. Internal Carotid Artery
M.C. Middle Cerebral Artery
L.A. Lenticular Arteries
A.C.H. Artery of Cerebral Hæmorrhage

(2) **ascending frontal,** to the posterior third of the middle frontal gyrus, and to the lower and greater part of the precentral gyrus; (3) **ascending parietal,** to the postcentral gyrus and superior parietal gyrus; (4) **parieto-temporal,** which traverses the posterior horizontal limb of the lateral fissure, and supplies the inferior parietal lobule and the posterior parts of the superior and middle temporal gyri; and (5) the **temporal branches,** which emerge from the posterior horizontal limb of the fissure, and supply the anterior and greater parts of the superior and middle temporal gyri.

Fourth or Intracranial Part of the Vertebral Artery.—The vertebral artery, on leaving the suboccipital triangle, pierces the dura mater and arachnoid, and enters the cranial cavity through the foramen

magnum. As it ascends, it lies at first on the side of the medulla oblongata, between the hypoglossal nerve and the anterior root of the suboccipital nerve. It then passes upwards on the ventral surface of the medulla, and on reaching the lower border of the pons it unites with its fellow of the opposite side to form the basilar artery. It will generally be found that one vertebral artery is larger than the other.

Branches.—Posterior meningeal, posterior spinal, posterior inferior cerebellar, anterior spinal, and bulbar.

The **posterior meningeal artery** arises from the vertebral artery just before it pierces the dura mater, and it enters the cerebellar fossa of the occipital bone where it supplies the dura mater.

The **posterior spinal** artery arises from the vertebral artery immediately after it has pierced the dura mater. It descends upon the side of the spinal cord in front of the posterior roots of the spinal nerves, and it gives off a branch which descends behind these roots. These two arteries, in themselves small, are reinforced by the spinal branches of the second part of the vertebral artery and of the dorsal branches of the intercostal arteries. In this manner lateral anastomotic arterial chains are formed upon each side of the spinal cord in front of and behind the posterior nerve-roots.

The **posterior inferior cerebellar artery,** of large size, arises a little above the preceding branch. It passes backwards between the vagus and accessory nerves, and then over the restiform body to the vallecula of the cerebellum, where it divides into branches. Some of these supply the inferior vermis, and others ramify on the inferior surface of the cerebellar hemisphere, at the periphery of which they anastomose with branches of the superior cerebellar artery. The artery furnishes branches to the corresponding choroid plexus of the fourth ventricle and to the medulla oblongata.

The **anterior spinal branch** of the vertebral artery arises from that vessel near its termination. It passes obliquely downwards and inwards over the ventral aspect of the medulla oblongata, and at the median line it unites with its fellow of the opposite side to form the **anterior spinal artery** of the spinal cord. It furnishes twigs to the medulla oblongata.

The **bulbar branches** are distributed to the medulla oblongata.

Basilar Artery.—This vessel is formed by the union of the two vertebral arteries. It extends from the lower to the upper border of the pons, occupying the median basilar groove on its ventral surface. It lies deep to the arachnoid membrane within the *cisterna pontis,* and at the upper border of the pons it divides into the two posterior cerebral arteries.

Branches.—These are as follows, on either side: transverse, internal auditory, anterior inferior cerebellar, superior cerebellar, and posterior cerebral.

The **transverse** or **pontine arteries** are numerous, and pass outwards on either side to supply the pons, the sensory and motor roots of the fifth cranial nerve, and the middle peduncle of the cerebellum.

The **internal auditory artery,** long and slender, accompanies the auditory nerve through the internal auditory meatus, and is distributed to the internal ear.

The **anterior inferior cerebellar artery** arises from the centre of the basilar, and passes backwards to be distributed to the anterior part of the inferior surface of the cerebellar hemisphere. It anastomoses with the posterior inferior cerebellar artery, which is a branch of the vertebral.

Fig. 966.—The Areas of Distribution on the Surface of the Three Main Cerebral Arteries.

The **superior cerebellar artery** arises from the basilar close to its termination. It passes outwards parallel to the posterior cerebral artery, from which it is separated by the third cranial nerve. It then winds round the outer side of the crus cerebri below the fourth cranial nerve, and so reaches the superior surface of the cerebellar hemisphere, where it divides into branches. These supply the superior vermis, the upper medullary velum, the tela chorioidea, and the superior surface of the cerebellar hemisphere, at the periphery of which they anastomose with branches of the inferior cerebellar arteries.

Posterior Cerebral Artery.—This is one of the terminal branches of the basilar artery at the upper border of the pons. It passes at first outwards beneath the crus cerebri, and parallel to the superior cerebellar artery, from which it is separated by the third cranial nerve. It then winds round the outer side of the crus cerebri, lying between it and the hippocampal gyrus, and above the fourth cranial nerve. In this manner it reaches the tentorial or inferior and medial surfaces of the occipital lobe of the cerebral hemisphere. It receives, not far from its commencement, the posterior communicating artery.

Branches.—These are arranged in three groups—ganglionic, choroidal, and cortical.

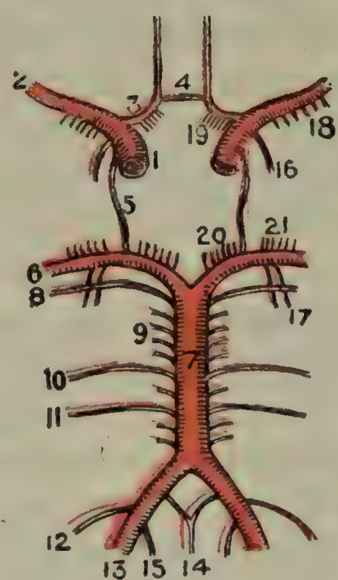
The **ganglionic group** includes two sets of branches, postero-medial and postero-lateral.

The **postero-medial ganglionic arteries** pass medial to the crus cerebri, and pierce the posterior perforated substance. They supply the inner part of the crus cerebri and the posterior part of the thalamus.

The **postero-lateral ganglionic arteries** pass on the lateral side of the crus cerebri, and supply the outer part of the crus, the posterior part of the thalamus, the corpora quadrigemina, and the corpora geniculata.

The **posterior choroidal arteries** are two or three in number, and pass through the choroidal fissure to the tela chorioidea, which they supply, together with the choroid plexus of the lateral ventricle, and the corresponding choroid plexus of the third ventricle.

The **cortical branches** are: (1) **anterior temporal,** to the anterior parts of the occipito-temporal and hippocampal gyri; (2) **posterior temporal,** to the posterior parts of the occipito-temporal and hippocampal gyri, and the inferior temporal gyrus; and (3) **occipital,** to the occipital lobe. One of the occipital branches is called the **calcarine artery.** It lies in the calcarine fissure, and supplies the lingual or infra-calcarine gyrus and the cuneus.



1. Internal Carotid
2. Middle Cerebral
3. Anterior Cerebral
4. Anterior Communicating
5. Posterior Communicating
6. Posterior Cerebral
7. Basilar
8. Superior Cerebellar
9. Transverse Pontine
10. Internal Auditory
11. Anterior Inferior Cerebellar
12. Posterior Inferior Cerebellar
13. Vertebral
14. Anterior Spinal
15. Posterior Spinal
16. Anterior Choroid
17. Posterior Choroid
18. Central or Ganglionic
19. Central or Ganglionic
20. Central or Ganglionic (Postero-mesial)
21. Central or Ganglionic (Postero-lateral)

FIG. 967.—THE ARTERIES AT THE BASE OF THE BRAIN, AND THE ARTERIAL CIRCLE.

Circulus Arteriosus (Circle of Willis).—This circle or (to be more exact) heptagon is formed *in front* by the anterior communicating artery, which connects the two anterior cerebral arteries; *behind* by the basilar artery as it divides into the two posterior cerebral arteries; and *on either side* by (1) the anterior cerebral artery, (2) the trunk of the internal carotid artery, (3) the posterior communicating artery, and (4) the posterior cerebral artery, in this order from before backwards. The circle furnishes twigs to the grey cortex of the interpeduncular region. It serves to equalize the blood-pressure in the cerebral arteries, and it also provides for the regular supply of blood to the brain in cases where one of the main arterial trunks may be obstructed.

The following parts are contained within the circulus arteriosus, in order from behind forwards: (1) the posterior perforated area; (2) the corpora mamillaria; (3) the tuber cinereum and infundibulum; and (4) the optic chiasma.

Veins of the Encephalon.

The **cerebral veins** are arranged in two groups—superficial and deep.

The **superficial cerebral veins** are divided into two sets—superior and inferior.

The **superior cerebral veins** return the blood from the upper parts of the outer surfaces of the cerebral hemispheres. They lie in the pia mater, and pierce the arachnoid membrane and inner layer of the dura mater, after which they open into the superior longitudinal sinus, having previously received the veins from the medial surface of either hemisphere. Their direction for the most part is forwards and medially, whilst the direction of the blood-current in the superior longitudinal sinus is backwards.

The **inferior cerebral veins** return the blood from the lower parts of the cerebral hemispheres, and they terminate in the cavernous, superior petrosal, and lateral sinuses. One of these veins is known as the **superficial middle cerebral** or **superficial Sylvian vein.** It passes along the lateral fissure, and opens into the front part of the cavernous sinus or else into the spheno-parietal sinus. This vein communicates posteriorly with (1) the superior longitudinal sinus by means of the great or *superior anastomotic vein* (of Trolard); and (2) the transverse sinus by means of the *inferior anastomotic vein* (of Labbé).

The **deep cerebral veins** are as follows: (1) the choroidal veins; (2) the veins of the corpora striata; (3) the internal cerebral veins (veins of Galen); (4) the anterior cerebral veins; (5) the deep middle cerebral veins; and (6) the basilar veins.

The **choroidal vein** of each side begins in the choroid plexus of the inferior horn of the lateral ventricle. It ascends at first, and then passes forwards in the lateral margin of the tela chorioidea to the interventricular foramen, where it unites with the vein of the corpus striatum to form the corresponding internal cerebral vein (vein of Galen).

The **vein of the corpus striatum** is formed by branches which issue from the corpus striatum and thalamus. It runs forwards in the groove between these two bodies, lying superficial to the tænia semicircularis, and at the interventricular foramen it joins the choroidal vein to form the corresponding internal cerebral vein.

The **internal cerebral vein (vein of Galen)** of each side is formed close to the interventricular foramen by the union of the choroidal vein, the vein of the corpus striatum, and the vein of the septum lucidum. The two veins, right and left, pass backwards between the two layers of the tela chorioidea, and they unite beneath the splenium of the corpus callosum to form one vessel, called the **great cerebral vein,** which opens into the front part of the straight sinus. Each vein receives tributaries from the thalamus, the corresponding choroid plexus of the third ventricle, the corpus callosum, and the corpora quadrigemina; and, before joining its fellow, it takes up the basilar vein of its own side. The **great cerebral vein** receives tributaries from the upper surface of the cerebellum.

The **anterior cerebral vein** of each side is situated in the great longitudinal fissure, along with the corresponding artery. Having curved round the genu of the corpus callosum, it passes to the anterior perforated region, where it joins the deep middle cerebral vein to form the basilar vein.

The **deep middle cerebral vein** returns the blood from the insula and lies deeply within the stem of the lateral fissure.

The **basilar vein** of each side begins at the anterior perforated area, where it is formed by the union of the anterior cerebral and deep middle cerebral veins. It passes backwards round the crus cerebri, and opens into the internal cerebral vein of its own side just before that vessel joins its fellow to form the great cerebral vein. The basilar vein receives, close to its commencement, one or more inferior striate veins, which descend from the corpus striatum through the anterior perforated substance. It also receives tributaries from the parts within the interpeduncular space.

The **cerebellar veins** are arranged in two groups—superior and inferior.

The **superior cerebellar veins** terminate in the great cerebral vein, and in the straight, transverse, and superior petrosal sinuses. The **inferior cerebellar veins** pass to the sigmoid, inferior petrosal, and occipital sinuses.

Blood-supply of the Different Parts of the Encephalon.

The **medulla oblongata** is supplied by the vertebral, anterior spinal, and posterior inferior cerebellar arteries.

The **pons** is supplied by the transverse or pontine branches of the basilar artery.

The **cerebellum** is supplied *inferiorly* by the posterior inferior cerebellar branches of the vertebral arteries, and the anterior inferior cerebellar branches of the basilar artery. *Superiorly* it is supplied by the superior cerebellar branches of the basilar artery, and to a limited extent by the posterior inferior cerebellar arteries.

The **crus cerebri** is supplied by the postero-medial and postero-lateral branches of the posterior cerebral artery, and by the posterior communicating artery.

The **posterior perforated substance** is pierced by the postero-medial branches of the posterior cerebral arteries.

The **corpora quadrigemina** are supplied by the postero-lateral ganglionic branches of the posterior cerebral arteries.

The **thalamus** is supplied *posteriorly* by the postero-medial and postero-lateral ganglionic branches of the posterior cerebral artery. *Anteriorly* its outer part is supplied by the lenticulo-thalamic branches of the middle cerebral artery, and its inner part by the posterior communicating artery.

The **anterior perforated substance** is pierced by the antero-lateral ganglionic branches of the middle cerebral artery.

Frontal Lobe.—The superior frontal gyrus, the anterior two-thirds of the middle frontal gyrus, and the upper portion of the precentral gyrus are supplied by cortical branches of the anterior cerebral artery. The posterior third of the middle frontal gyrus, the inferior frontal gyrus, and the lower and greater part of the precentral gyrus are supplied by cortical branches of the middle cerebral artery. On the orbital surface the internal orbital gyrus, olfactory lobe, and gyrus rectus are supplied by the anterior cerebral artery, whilst the remainder is supplied by the middle cerebral artery.

Parietal Lobe.—The whole of this lobe, practically, is supplied by the middle cerebral artery.

Occipital Lobe.—This lobe is supplied by the posterior cerebral artery.

Temporal Lobe.—The superior and middle temporal gyri and the pole are supplied by the middle cerebral artery, and the remainder is supplied by the posterior cerebral artery.

Medial Surface of the Cerebral Hemisphere.—The anterior cerebral artery has an extensive distribution to this surface, which it supplies as far back as the internal part of the parieto-occipital fissure. The parts behind this fissure—namely, the cuneus and the parts around the calcarine fissure—are supplied by the posterior cerebral artery.

The **corpus callosum** is supplied by the anterior cerebral arteries.

Corpus Striatum.—The **nucleus caudatus** and **nucleus lentiformis** are supplied for the most part by the antero-lateral or ganglionic branches of the middle cerebral artery, which pass through the anterior perforated substance. According to Duret they form three sets—lenticular, lenticulo-striate, and lenticulo-thalamic. The **lenticular** (internal striate) **arteries** supply the globus pallidus (inner part)

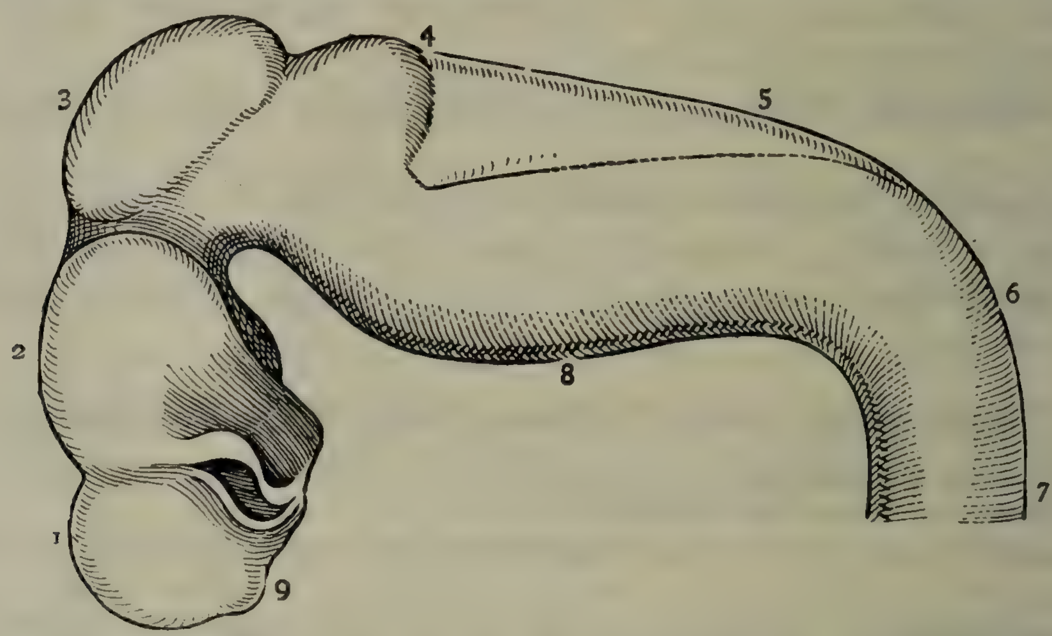


FIG. 968.—BRAIN OF AN EMBRYO ABOUT FOUR WEEKS OLD (FROM QUAIN'S 'ANATOMY') (HIS).

1. Telencephalon
2. Thalamencephalon
3. Mesencephalon
4. Metencephalon
5. Myelencephalon
6. Cervical Flexure
7. Spinal Cord
8. Pontine Flexure
9. Olfactory Lobe

1, 2=prosencephalon; 3=mesencephalon; 4, 5=rhombencephalon

of the lentiform nucleus, the internal capsule, and the caudate nucleus. The **lenticulo-striate** (external striate) **arteries** supply the putamen (outer part) of the lenticular nucleus, and the external capsule. One of the lenticulo-striate arteries is larger than the others, and is subject to rupture in cases of cerebral hæmorrhage. It is known as the *artery of cerebral hæmorrhage* (Charcot). Its course is outwards and upwards round the lateral aspect of the lentiform nucleus, between it and the external capsule, and then through the internal capsule to the caudate nucleus. The **lenticulo-thalamic arteries** supply the posterior part of the lentiform nucleus, and the anterior part of the thalamus on its lateral aspect.

The front part of the caudate nucleus is supplied by the antero-medial ganglionic branches of the anterior cerebral and anterior communicating arteries.

The larger arteries occupy the subarachnoid space, where they divide into branches which enter the pia mater. These in turn give off smaller branches, which enter the cerebral substance, some of them being cortical and others medullary in their distribution.

Blood-supply of the Choroid Plexuses.—The **choroid plexus of the lateral ventricle** derives its blood from (1) the anterior choroidal artery, which is a

branch of the internal carotid or the middle cerebral; and (2) the posterior choroidal arteries, which are branches of the posterior cerebral. The **choroid plexuses of the third ventricle** derive their blood from the posterior choroidal arteries. The **choroid plexuses of the fourth ventricle** are supplied from the posterior inferior cerebellar arteries.

The **tela chorioidea** derives its blood from the posterior choroidal arteries and from the superior cerebellar arteries.

Lymphatics of the Brain.—There are no lymphatic vessels in the brain. Their place is taken by spaces in the outer coat of the arteries, called **perivascular spaces,** which are in communication with the subarachnoid space.

Development of the Encephalon.

A brief outline of the formation of the brain has been given on pp. 55-59, in which can be followed the development of the primary cerebral divisions into fore-, mid- and hind-brain, the formation of the cerebral vesicles, the appearance of the brain flexures, and in general the changes which lead to the existence in their proper positions of the main structures in the brain. The student is advised to read this general account before proceeding to the following descriptions, which deal with the conditions in the developing brain in a more detailed manner.

Metamorphoses of the Hind-brain.

The *pontine flexure* begins to show about the beginning of the fourth week, is well marked at the beginning of the second month, and has its two limbs very close to one another by the end of this month. The posterior limb of the flexure, down to the nuchal bend, is termed the **myelencephalon,** the anterior limb the **metencephalon,** and the narrow junction with the mid-brain is the **isthmus.**

Myelencephalon.—The walls, opened out in their upper parts, with a wide roof-plate, give origin to the *medulla oblongata,* and the cavity forms the lower half of the *fourth ventricle*; at the extreme lower end the cavity is not enlarged. The development of this lower or hinder portion of the myelencephalon proceeds in general on the lines of development already described for the spinal cord, with certain modifications due to the opening out and change in direction in certain tracts passing to the brain, the crossing of pyramidal fibres, and the presence of certain tracts and nuclei (to be described later) associated with the existence of visceral arches.

A little higher up the myelencephalon broadens to make the lower part of the *fourth ventricle.* The alar and basal laminæ are now in the floor of the wide cavity. The broad **roof-plate,** a single layer of epithelium, is attached at the sides to an everted edge of the alar lamina, known as the **rhombic lip,** and overhanging the outer parts of the laminæ. Such a definite rhombic lip, however, is only found in the cranial part of the myelencephalon, where, as will be seen later, the great enlargements appear which are due to growth of the vestibular nuclei.

The widened roof-plate is covered by vascular mesenchyme, representing pia mater. At the level of the pontine flexure the ependymal or epithelial roof is invaginated into the fourth ventricle in the form of a transverse fold—*plica chorioidea,* containing pia mater—which extends between the lateral recesses of the ventricle. From this transverse fold two vertical folds—*plicæ chorioideæ,* likewise containing pia mater—extend vertically downwards into the ventricle close to the median line. These ependymal folds, containing pia mater, form the two **choroid plexuses** of the lateral ventricle.

At a comparatively early stage the afferent fibres of the seventh, ninth and tenth nerves pass into the marginal zone of the alar lamina, and form a bundle here, the *tractus solitarius*; this bundle becomes deeply buried by subsequent thickening of the marginal layer.

The **hypoglossal nucleus** develops, as has been mentioned already on p. 1440, practically within the ependymal zone, in the upper part of the column of

loosened nuclei seen here in the cervical region formed from the ependymal zone ventro-laterally. The *sixth* nucleus possibly arises from the extreme cranial end of the same column, but this is not certainly known. In the young embryo the efferent nuclei (except that of the hypoglossal) lie in the basal lamina, where they cause internal depressions by their rapid growth in the thin wall (Fig. 970). These depressions are known as **neuromeres,** and are a marked though temporary feature of most embryonic brains. In the illustration they are seen from within, and have a curious distribution, in that the sixth neuromere is placed *behind* the seventh. The *fifth* has two neuromeres, of which the most cranial is much the deeper; the line of flexure of the hind-brain, which has not yet begun in this specimen, will pass through this deep neuromere of the fifth nerve.

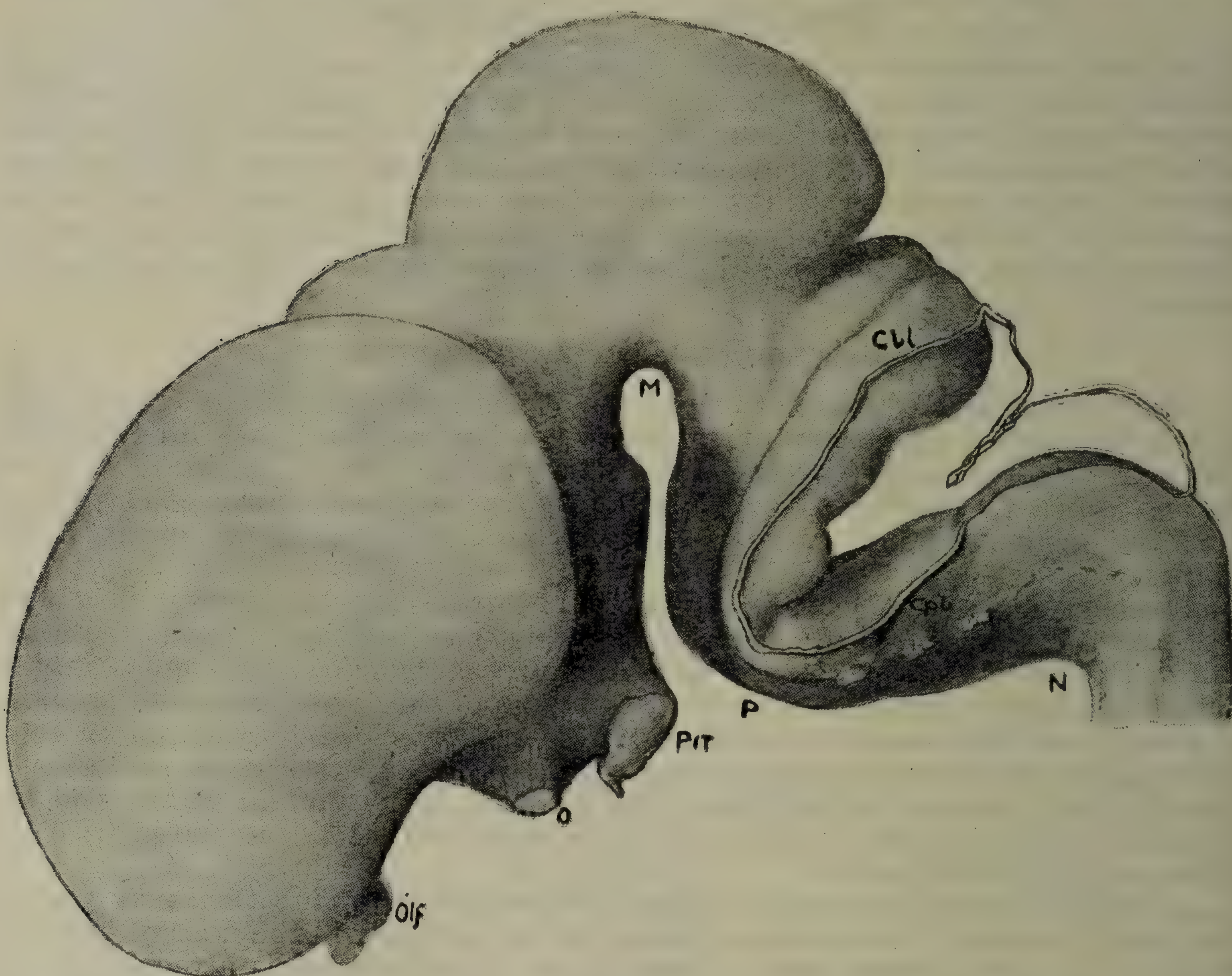


FIG. 969.—LATERAL VIEW OF BRAIN, END OF SECOND MONTH.

Cbl, cerebellar rudiment; P, N, pontine and nuchal flexures; M, mid-brain flexure; Pit, hypophysis; Cpb, corpus ponto-bulbare. Roof-plate of hind-brain is only shown in outline.

A little later a neuromere will mark, rather indefinitely, the ninth efferent nucleus, but is not seen in the figure.

It must be understood that the neuromeres are present only in the basal lamina; this, for practical purposes, is the one seen in the figure, the thin and narrow strip (D) being the only representative of the alar lamina.

Behind the region of neuromeres the myelencephalon narrows down to its continuity with the spinal cord, and it is here, extending cranially, that the olive is laid down.

The **inferior olive,** with its medial and dorsal accessory formations, is developed as a modification of the upper part of the ventro-lateral column of neuroblasts in the mantle zone, from which the ventral column is formed at a lower level. The early stages of this development are shown in Fig. 971, while Fig. 972

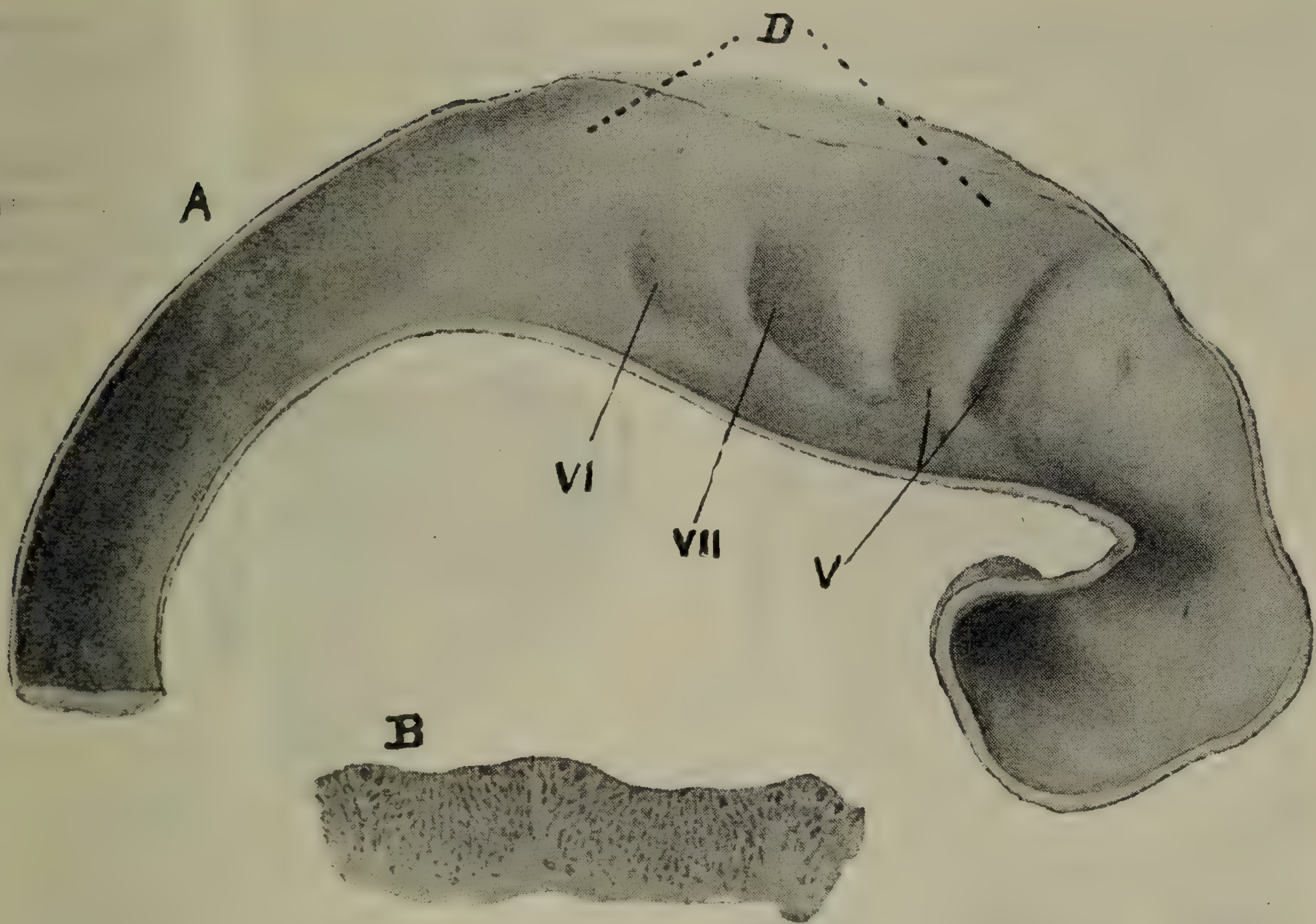


FIG. 970.

A, sagittal section of brain of 4·9 mm. embryo; B, section through two adjacent neuromeres.

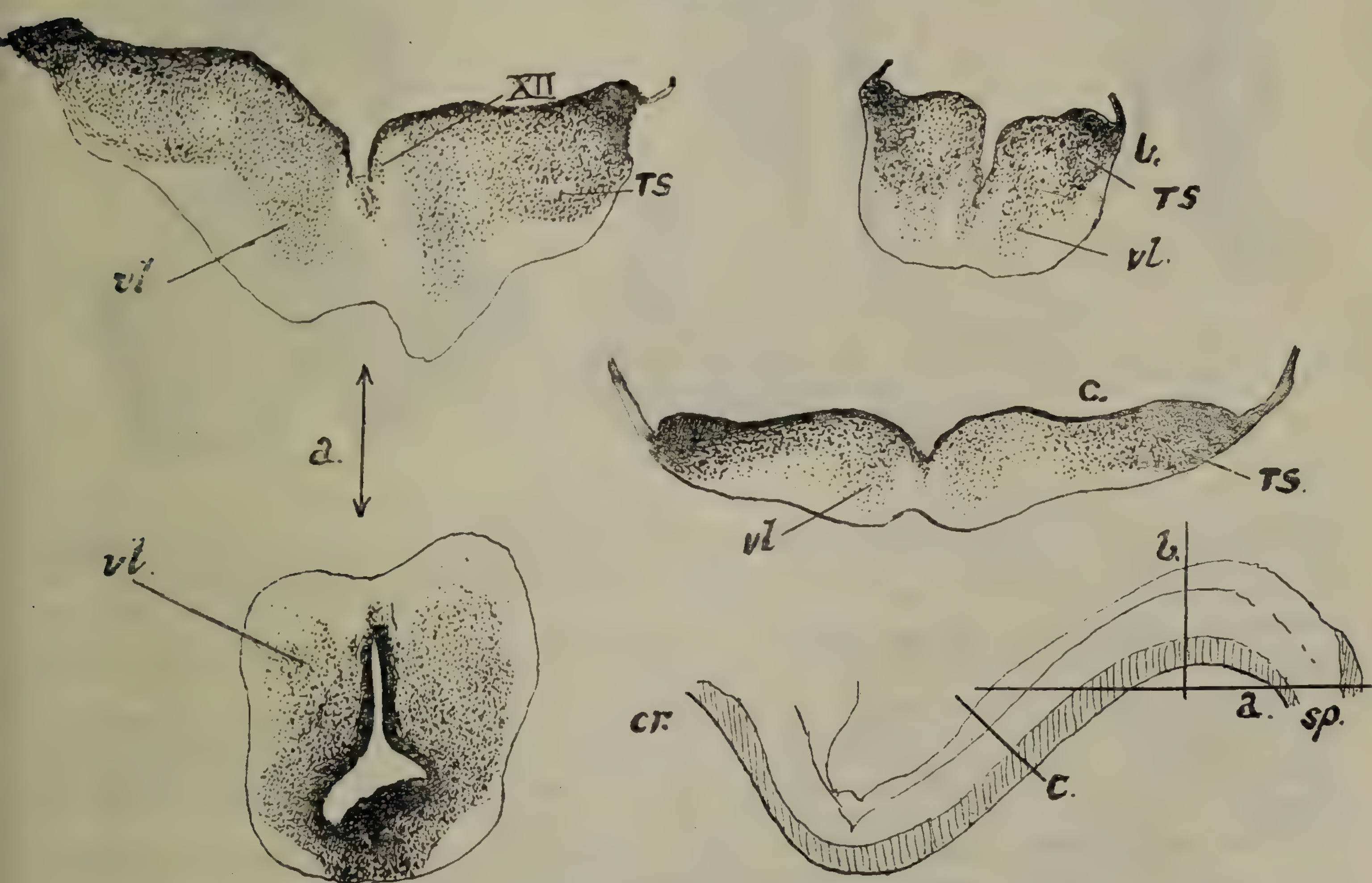


FIG. 971.—HIND-BRAIN, 13·5 MM. EMBRYO.

Outline of longitudinal median section on right below; in this cr. is the cranial slope and sp. the spinal cord; *TS*, tractus solitarius; *vl*, ventro-lateral nuclei. Planes of sections *a*, *b*, and *c* correspond with those shown on the outline.

gives the appearances in subsequent stages. In these it can be seen that the *median accessory olive* (m.o.) is first defined, the main olivary mass being constructed from the more lateral condensations.

It must be said here that the classical and accepted account of olivary development refers it to the ventral migration of neuroblasts from the 'rhombic lip.' The account given above is put forward because it is in accord with observed facts, whereas the older story is very unsatisfactory in several particulars.

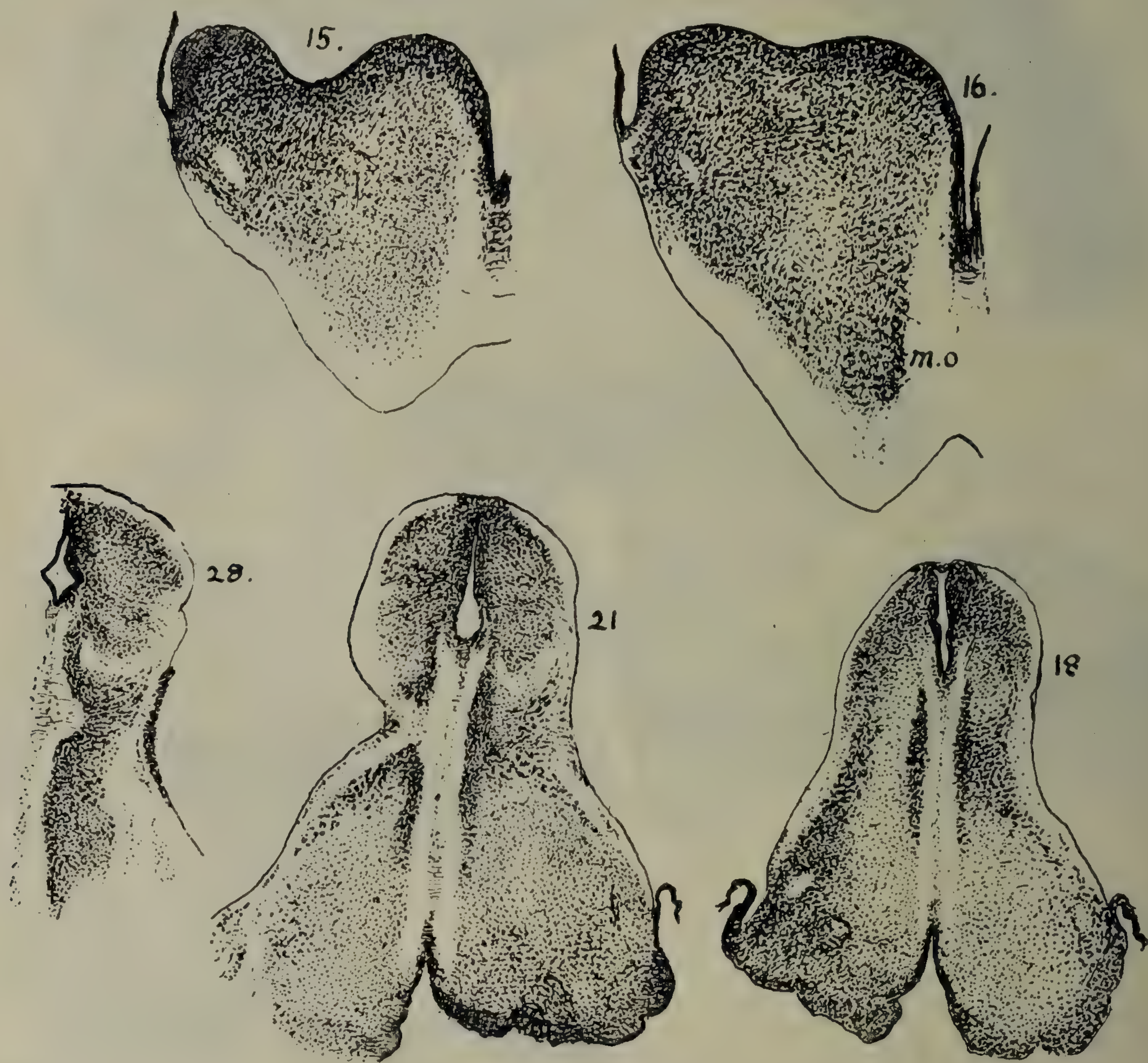


FIG. 972.

Transverse sections through olivary region in embryos of 15 and 16 mm.; horizontal sections, 18, 21, and 28 mm. in neighbourhood of nuchal flexure.

The **cuneate** and **gracile nuclei** are formed directly from the dorsal neuroblasts.

Each **pyramid** is a ventral bulging of that part of the basal lamina which is on the mesial side of the olivary body, and it is produced by the *motor tracts* as they descend in the marginal layer from the central area of the cerebral cortex through the pons. This begins in the fourth month.

The **ponto-bulbar body** is represented in the embryo by a collection of small and darkly-staining nuclei lying below the caudal part of the 'rhombic lip.' It appears in the latter part of the second month, and its nuclei spread fairly rapidly over the surface of the myelencephalon, especially ventrally and cranially; here they lay down the beginnings of the *pontine nuclei*. On the myelencephalon further back they appear to be responsible for the various small superficial

arcuate nuclei which may be found on the surface of the pyramid, etc. There is also a possibility that the lateral accessory cochlear nucleus may possess a similar origin.

As the pyramids, right and left, bulge ventralwards, the floor-plate, which connects the basal laminæ, sinks, and the **anterior median fissure** is formed, as in the development of the spinal cord. The spongioblastic floor-plate is now invaded by nerve-fibres, most of which cross from one side to the other, these fibres being (1) the anterior superficial arcuate fibres, (2) the deep arcuate fibres, and (3) the cerebello-olivary fibres. In this manner the *raphé* of the bulb is formed, as in the development of the anterior or white commissure of the spinal cord.

In the more cranial portion of the myelencephalon, where the efferent nuclei have been laid down in the neuromeres, the subsequent growth of the alar lamina affords opportunity for the development of the **vestibular** nuclei, which thus lie just cranial to the great dorsal masses of the gracile and cuneate nuclei. The

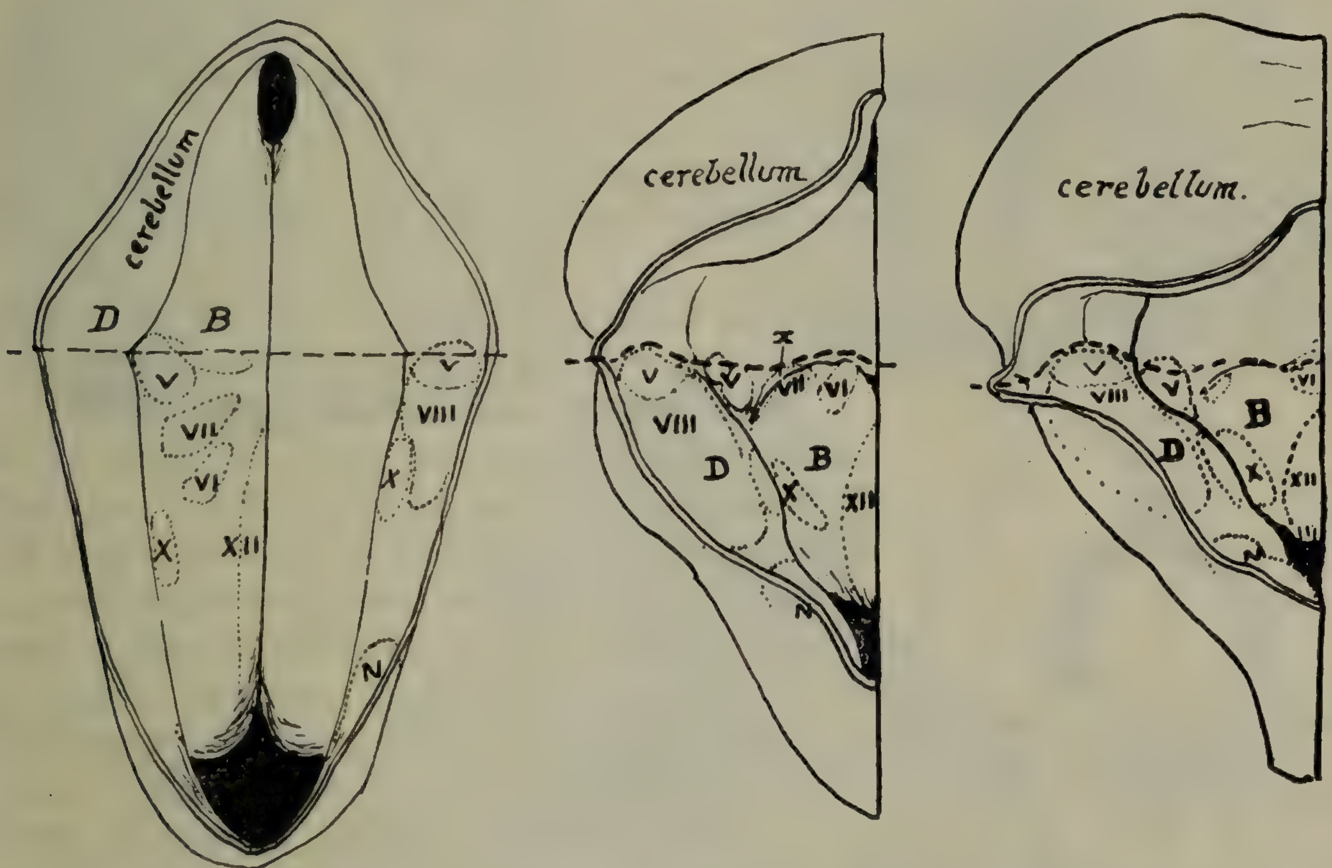


FIG. 973.—PLANS TO SHOW AREAS IN FLOOR OF FOURTH VENTRICLE, WITH POSITION OF DEVELOPING STRUCTURES.

changes which take place in the floor of the ventricle in this part are very complicated and not by any means understood; the plans in Fig. 973 are attempts to show the results of the changes. The first figure gives the positions of the neuromeres on the left, with the sites of the *afferent* nuclei on the right. In the second and third the vestibular masses are associated with considerable widening, but there is apparently a marked forward upgrowth of the floor in the basal area, which carries the sixth and seventh nuclei forward and brings them against the metencephalic surface. This is no doubt associated with the curious relations between the two nuclei and nerves, but the way in which it comes about, as well as the reason for its occurrence, is not known. The positions of the various nuclei are given approximately in the plans, and a general idea of their origins and changes can be obtained by a study of the figures.

Metencephalon.—From this are developed the *pons*, *cerebellum*, its upper and middle *peduncles*, and the superior and inferior *medullary vela*. Its cavity forms the *upper part of the fourth ventricle*.

The **pons** develops as a ventral thickening on the lower end of the region, immediately cranial to the pontine flexure. Its nuclei appear to owe their origin to the neuroblasts which have spread over the surface from the ponto-bulbar body; presumably they increase subsequently *in situ*, but no definite indications of mitotic activity have been found among them. The down-growing cerebro-spinal fibres find their way into and among these nuclei in the third month and subsequently.

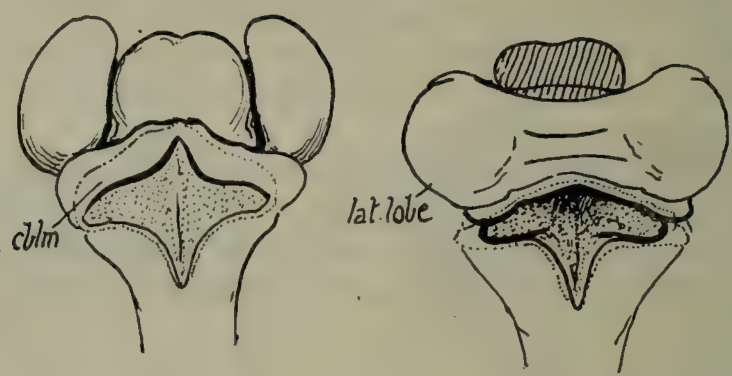


Fig. 974.—Semi-diagrammatic Figures showing Cerebellar Rudiments.

The **cerebellum** is developed from the alar laminæ of the metencephalon, the thickening involving the roof-plate in its growth. The two **lateral cerebellar plates** formed by the laminæ are at first inclined to each other at an angle (Fig. 976), but as the angle of the pontine flexure becomes more closed and the metencephalon widens, the paired cerebellar rudiments come nearly into line with one another (Figs. 974, 977). The lateral plates, being thickenings in the floor of the cavity, project at first into the cavity, covered by the roof-plate, which is attached to the margins outside them; subsequently the attachment of the roof-plate is turned in (Fig. 977) below the bulging lateral formations, so that it becomes attached, descriptively, to the anterior and lower aspect of the transversely disposed cerebellar rudiment. It is in the tænial fold to which the roof-plate is attached here that the **floccular** enlargement occurs a little later.

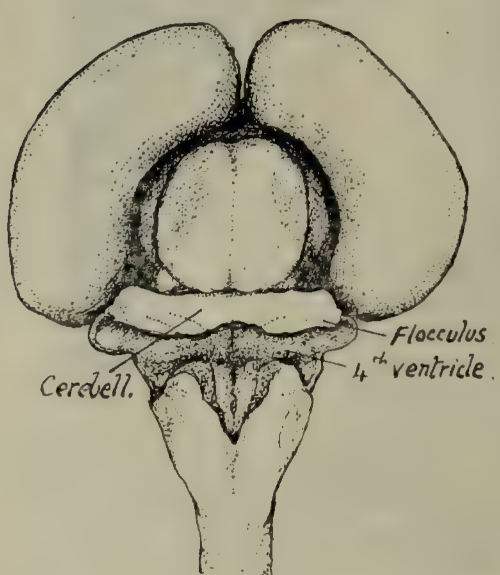


Fig. 975.—Brain of Third Month Embryo seen from behind, to show the Transverse Cerebellar Rudiment.

This stage is between those shown in the previous figure.

In some lower vertebrates the cerebellum develops altogether within the cavity of the hind-brain, as in the early human stage; the later change in the human conditions enables the structure to expand freely outside the ventricle.

The upper part of the roof-plate of the rhombencephalon, at the angle of junction of the lateral plates, is invaded by them, and forms

the basis in which the *vermis* develops; growth here is slow, and the lateral lobes in their enlargement come to overlap it and cover it in.

The lateral plates come into evidence during the second month; the transversely disposed plate (Fig. 975) is well marked in the middle of the third month, when the *flocculus* may be recognized, and after this the development proceeds slowly. After the third month the vermis shows transverse fissures, and in the fifth month these are found also on the lateral lobes.

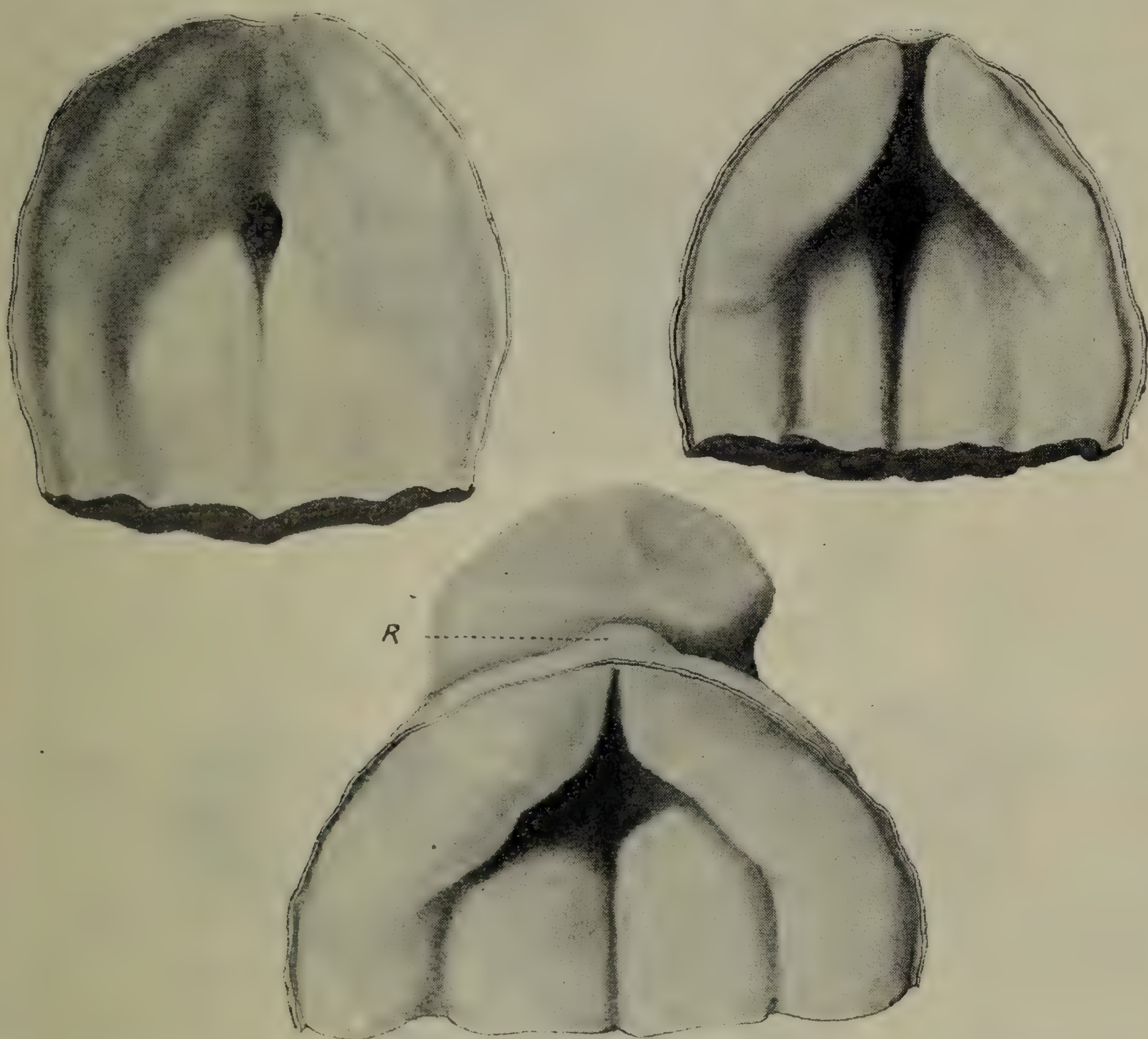


FIG. 976.—VENTRICULAR ASPECT OF CRANIAL SLOPE OF HIND-BRAIN IN EMBRYOS OF 12, 16, AND 28 MM., TO SHOW BEGINNINGS OF CEREBELLAR FOLD.

The fissure cutting off the flocculus extends across the region of the vermis, marking off the nodule here. At the end of the third month a **fissura prima** forms across the vermis, making the lower edge of the future *culmen*, and a little later a **fissura secunda** forms below the future *pyramid*. Other secondary fissures follow, and some of the fissures of the vermis extend into the lateral lobes, but most of the fissures here are separate local formations.

Cerebellar thickening, spreading into the roof-plate above and below the main development, forms the upper and lower *medullary vela*, the first extending (*valve of Vieussens*) to the closed isthmus, the

second being continuous below with the undeveloped ependymal or epithelial roof-plate of the myelencephalon.

On either side of the valve of Vieussens the roof-plate is thickened by the superior cerebellar peduncles.

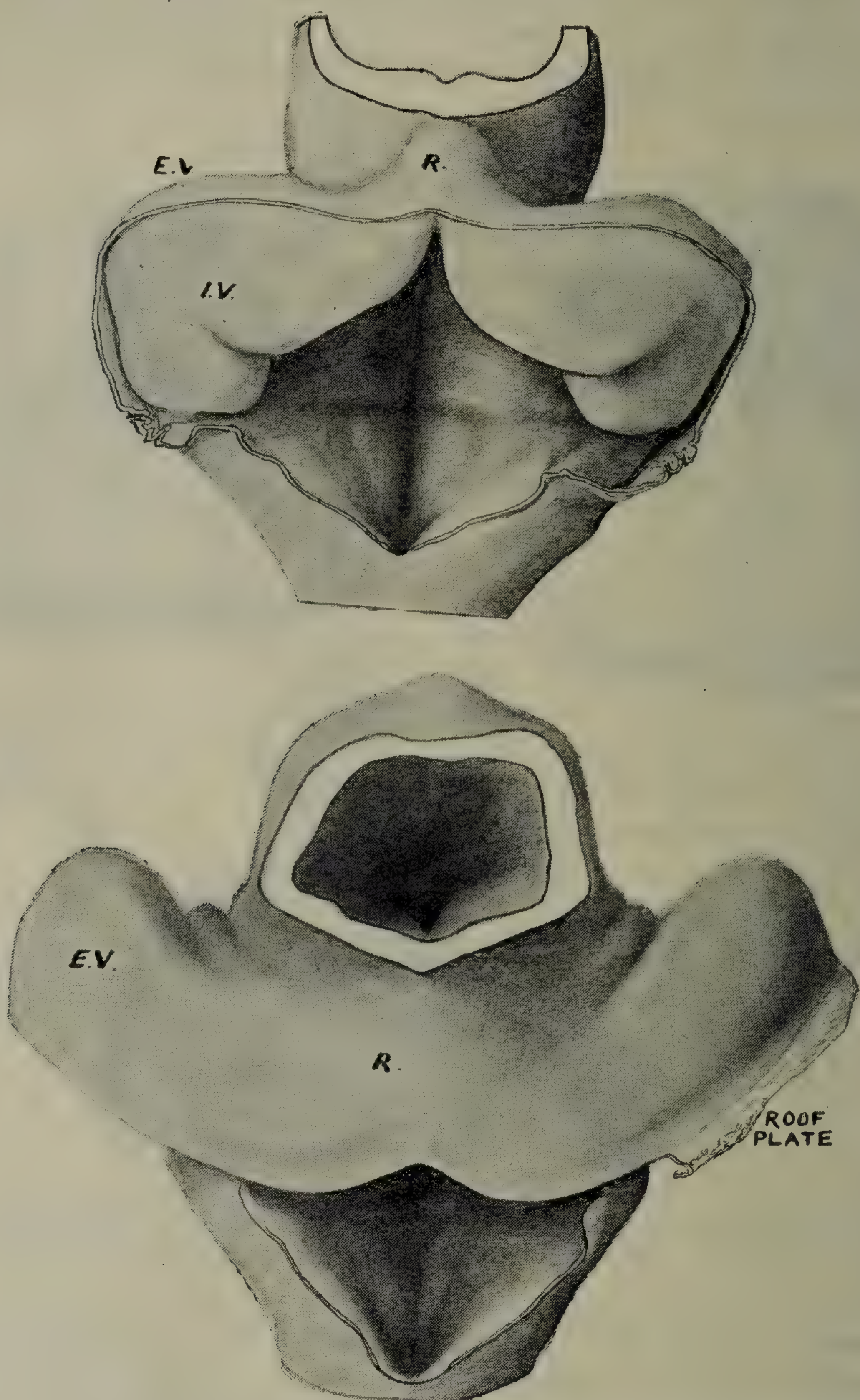


FIG. 977.—VIEWS FROM BEHIND OF THE HIND-BRAIN IN EMBRYOS OF 35 AND 48 MM.

EV, IV, extra- and intra-ventricular surfaces.

The **superior peduncles of the cerebellum,** right and left, arise from the cells of the *nucleus dentatus* of the corresponding lateral cerebellar hemisphere. Emerging from the anterior parts of the dentate nuclei, the peduncles give rise to two thickenings of the *roof-plate* of the metencephalon, one on either side of the valve of Vieussens. Thereafter they enter the mesencephalon or mid-brain,

and, after decussating, each passes to the corresponding *red nucleus* of the tegmentum of either crus cerebri, which constitutes its lower cell-station.

The **middle peduncles of the cerebellum** (*brachia pontis*) are developed from the cells of the *pontine nuclei* of the pons right and left. The fibres of each peduncle issue from the lateral portion of the corresponding pontine nucleus, and enter the adjacent cerebellar hemisphere.

Mesencephalon.—This portion makes a sharp curve (Fig. 969) as it develops. It has a large cavity, which is slowly lessened in size by the growing thickness of the walls, finally remaining as the small *aqueduct.* The thickened walls around this are composed of a floor lamina and roof lamina (tectum); in the former are formed the crura cerebri, while the tectum gives rise to the corpora quadrigemina.

The **isthmus** is a part of some interest; it is essentially a derivative of the hind-brain, so that its name *isthmus rhombencephali* is correct. The isthmus is produced at the spot where the two regions of growth, metencephalic and mesencephalic, meet each other, but there is in addition a definite forward extension of the *basal lamina* from the hind-brain into the opening, of which it makes the immediate wall. This extension carries with it the **trochlear nucleus,** which develops in the basal lamina of the *hind-brain just above the opening*; the decussation of the nerves, originally in the floor-plate of the hind-brain, is carried down also and lies therefore on the dorsum of the isthmus.

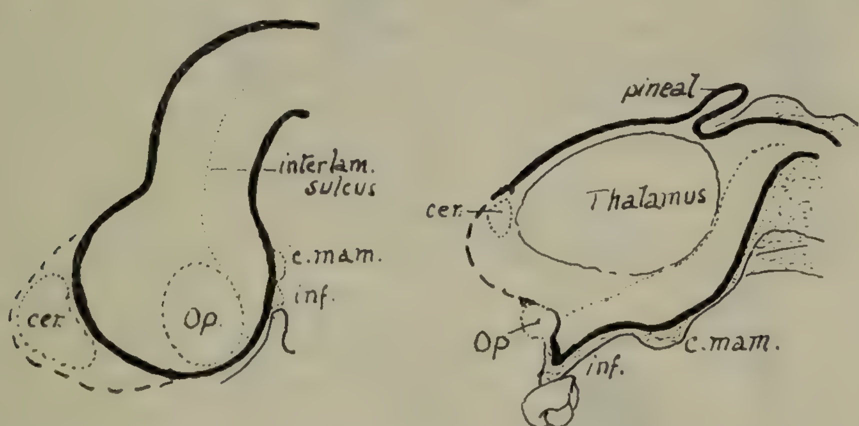


FIG. 978.—SCHEMES TO SHOW THE PARTS OF THE THIRD VENTRICLE FORMED FROM THE THALAMENCEPHALON (BLACK LINE) AND TELENCEPHALON (INTERRUPTED LINE).

A little later there is an extension forwards from the *alar* lamina of the hind-brain, passing on the outer side of the basal extension, and carrying with it (sensory) nuclei from the upper part of the trigeminal nucleus; this appears to be the beginning of the **mesencephalic root** of the nerve, further short connections developing subsequently.

The mid-brain presents dorsally a median longitudinal groove, which separates two rounded eminences, known as the *corpora bigemina.* At a later period a transverse groove appears, which divides each of the corpora bigemina into two, thus giving rise to the **corpora quadrigemina.**

The *third nucleus* forms in the ventral mantle zone, and the *fourth nucleus* gains its position here secondarily. The *red nucleus* is probably formed *in sitû* from the mantle zone of the floor lamina. The *corpora quadrigemina,* formed from the alar laminæ (and probably from the roof-plate secondarily involved), are hollow at first. They become solid in the fourth and fifth months. The *bases peduneulornm* begin to appear in the fourth month in the ventral parts of the marginal zone.

Diencephalon or Thalamencephalon.—This is the anterior primary vesicle (Fig. 978). Its cavity forms the greater part of the *third ventricle* (the anterior portion being derived from the secondary outgrowth, the **telencephalon**). Its walls develop into the *thalamus, corpora mamillaria, tuber cinereum, infundibulum,* and *posterior lobe* of *pituitary,* and from the roof-plate grow the *pineal*

body and the *ependymal roof* of the ventricle. Moreover, when it is first formed, the **thalamencephalon** gives origin to the *optic outgrowth* on each side.

The **pineal body,** or *epiphysis cerebri,* is developed from the dorsal part of the ependymal roof of the third ventricle. It appears as a diverticulum of the ependymal roof close to the mesencephalon, and it is directed backwards, so that it comes to lie over the corpora quadrigemina. The distal end is blind, and in connection with it a number of closed follicles are formed which contain calcareous particles forming the *acervulus cerebri,* or *brain-sand.* The proximal part of the diverticulum forms the **stalk** of the pineal body, which contains the *pineal recess* and opens into the third ventricle.

The **basal** laminæ, smaller than the **alar,** give origin to the *tuber cinereum* and the outgrowth which makes the **infundibular process** of the pituitary formation (see p. 1171). These structures are (Fig. 978) on the lower part of the

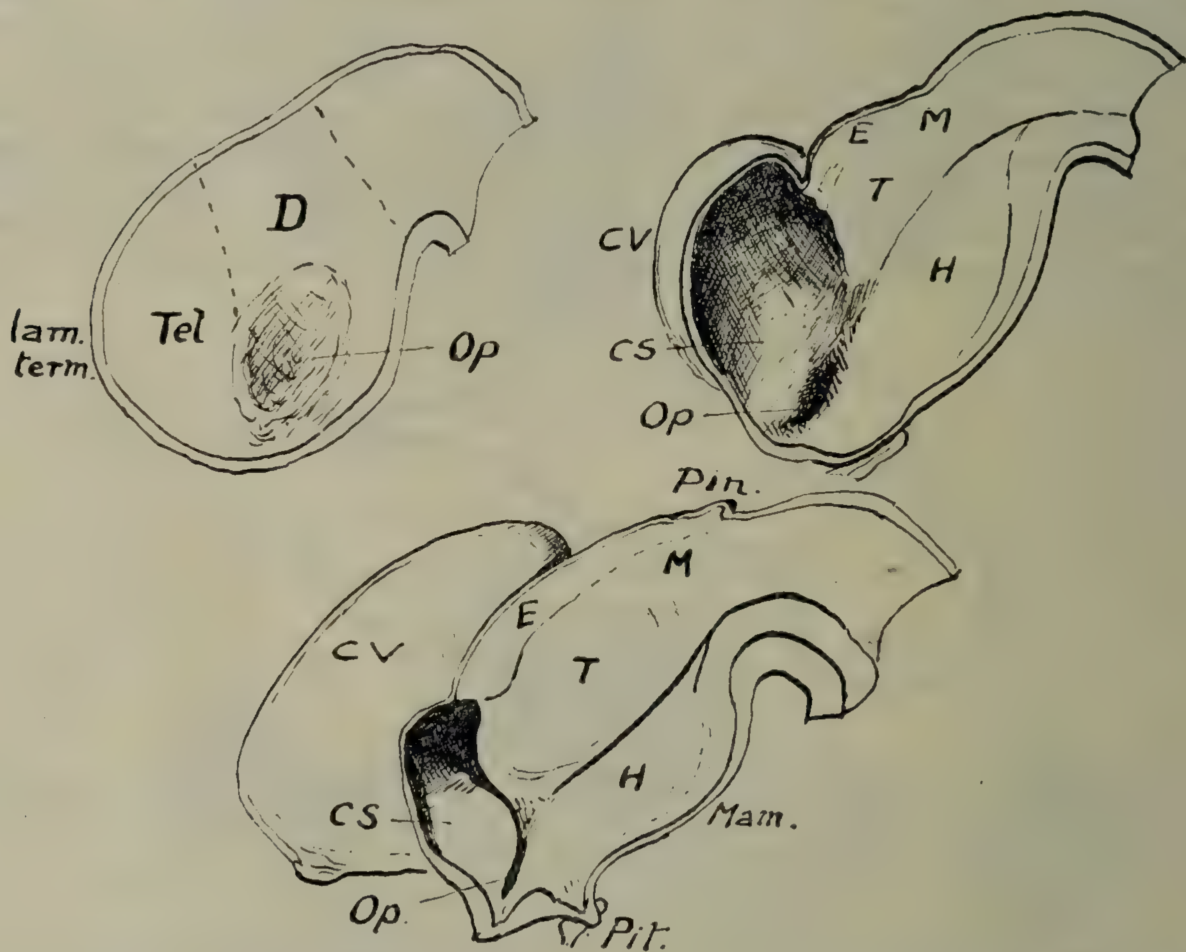


FIG. 979.—DIAGRAM SHOWING PARTS OF THE FORE-BRAIN AND STRUCTURES DERIVED FROM THESE.

D, diencephalon; Tel, telencephalon; T, E, M, are thalamus, epithalamus, and metathalamus; H is hypothalamus; CV, cerebral vesicle; CS, corpus striatum.

posterior aspect of the fore-brain immediately behind the site of the optic outgrowth. *Corpora mamillaria* are formed from basal laminæ just behind and above the tuber. The position of these structures is due to the length and curve of the mid-brain; when this gets relatively shorter, and the nasal fossæ grow upwards from below, the fore-brain is rotated upwards to some extent, and the structures thus come to lie more below the third ventricle.

The **optic outgrowths,** although they are actually low down with reference to the fore-brain, are derivatives from its **alar** region, and the **interlaminar sulcus** (Fig. 978) reaches its lowest or most cephalic point between the optic pouch and the infundibulum. This sulcus is here the *hypothalamic sulcus,* but the continuation of the ' sulcus of Monro ' towards the foramen is a secondary effect produced by the growth of the thalamus.

For **development of the eye,** see next chapter.

The **thalamus** begins early in the second month as an enlargement in

the anterior part of the dorsal lamina due to growth of the mantle cells. It increases rapidly and narrows the ventricle, so that in the fourth or fifth month the two bodies come into contact and fuse to a small extent, leaving as an attachment between them when they draw apart again the *connexus thalami* or *massa intermedia*.

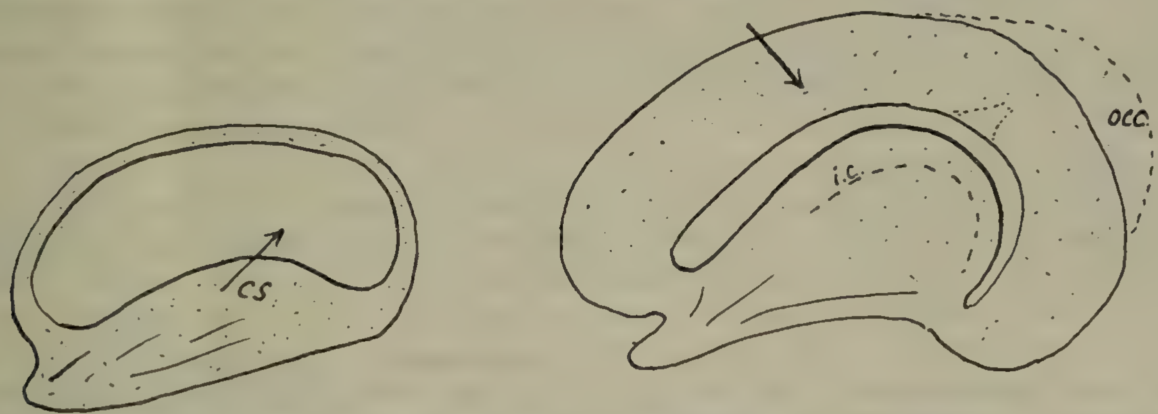


FIG. 980.—SCHEMES TO SHOW HOW THE CORPUS STRIATUM ALTERS BY ITS GROWTH THE SHAPE OF THE CAVITY.

occ, occipital growth, with formation of posterior horn; i.c., line in which pyramidal motor fibres issue through corpus striatum.

Later, in the fourth to fifth month, growth of the alar laminæ farther back than the thalamic formation makes the *pulvinar* and *geniculate bodies*, and becomes secondarily continuous with the thalamus.

Telencephalon.—This (Fig. 979) is an outgrowth or forward bulging of the terminal part of the thalamencephalon; it gives off on each side the two **cerebral vesicles.** These hollow vesicles have cavities widely open into that of the telencephalon, and thus into the third ventricle, of which the **telencephalon** makes the *most anterior part*.

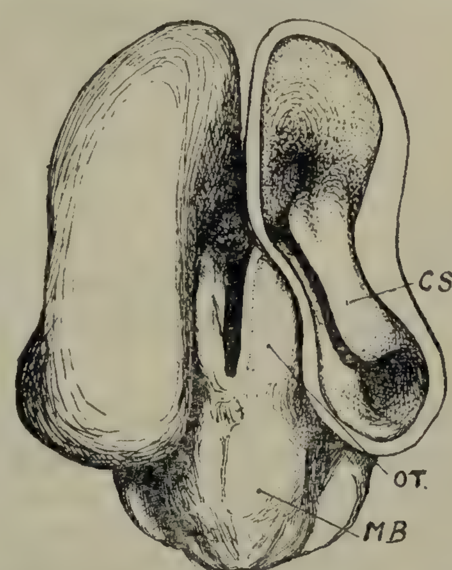


FIG. 981.—BRAIN OF EMBRYO IN MIDDLE OF THIRD MONTH SEEN FROM ABOVE, THE UPPER PART OF THE RIGHT CEREBRAL VESICLE BEING REMOVED TO EXPOSE THE CORPUS STRIATUM (CS), THALAMUS (OT), MIDBRAIN (MB).

The **cerebral vesicles,** growing fairly rapidly, stand up above the general level of the fore-brain, being separated from each other by the rudiment of the *great longitudinal fissure*. The direction of their main growth is upwards and backwards from the interventricular foramen, which is the opening from the telencephalon into a vesicle. They also grow forward for a little distance in front of the foramen, and of course their increasing size leads to an increasing prominence laterally. Thus they cover successively the diencephalon, the mid-brain, and finally the hind-brain and its formations, so that these are not to be seen from above. The vesicles begin to cover the mid-brain (Fig. 981) during the third month, and grow over the cerebellum in the fifth month.

The **interventricular foramen** does not increase in size *pari passû* with the growing brain, hence becomes relatively very small.

The *anterior wall* of the central unpaired or original telencephalic growth is the *lamina terminalis*. This is the direct path from one cerebral vesicle to the other, whence it becomes the path along which **commissural** fibres between the hemispheres will proceed in their primitive stages.

The walls of the cerebral vesicles are very thin at first, and thicken slowly. But the thickening of the **corpus striatum** is visible at an early stage in each vesicle, beginning to stand up into the cavity as a growth of the *floor and lower part of the outer wall*. It grows rapidly, so that in the third month (Fig. 981)

it makes a marked prominence, while the greater part of the remaining wall of the vesicle is still thin. The corpus striatum, thus forming a floor for the lateral ventricle, is the cause, by its further growth, of alteration in the shape of that cavity. This is shown in Fig. 980. The mass, at first low, grows in an upward and backward direction, projecting into the cavity, and thus leading to the formation of an *inferior horn*; the forward-turned end of this horn is the result of further growth of the body. The deep cleft seen on the inner side of the mass in Fig. 981 is obliterated by fusion following on growth of the corpus on one side and of the thalamus on the other, and the floor of the 'body' of the cavity is raised accordingly.

The corpus striatum is one of the primitive formations in the brain connected with its primitive functions. A section across the fore-brain and vesicles in the second month is represented diagrammatically in Fig. 982, where the thick mass of the corpus striatum is in contrast with the thin wall of the rest of the vesicle. This thin wall is the rudimentary **neopallium,** that part of the cerebrum which in man is associated with the higher functions of the brain, and will, when it begins to grow, completely overshadow in size the original portion. The result of neopallial growth is shown in the second diagram; the mass of the corpus is not affected, while the rapid increase of the area of the neopallium leads to its overlapping the inert striate mass. Overlapping cannot take place on the inner and basal aspects, but growth outwards and backwards and downwards

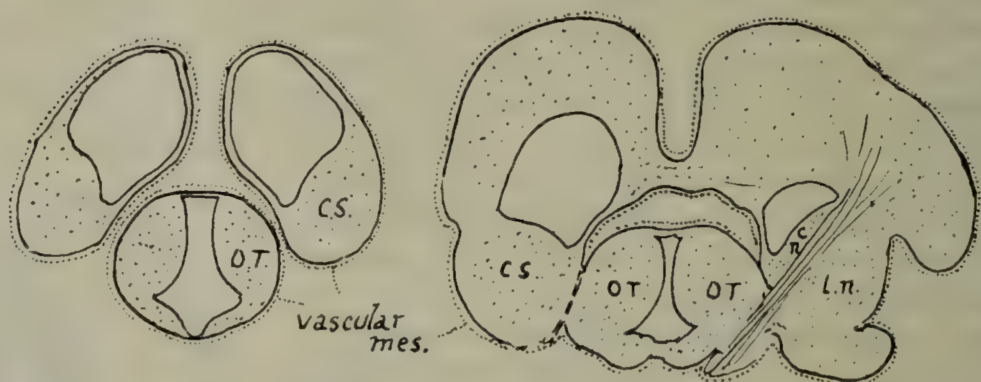


FIG. 982.—SCHEMATIC SECTIONS TO SHOW HOW THE CORPUS STRIATUM (CS) IS OVERLAPPED BY THE GROWTH OF THE NEOPALLIUM, AND IS DIVIDED INTO CAUDATE AND LENTICULAR PARTS BY THE PYRAMIDAL FIBRES. OT, THALAMUS.

is unrestricted, so we find the surface area corresponding with the corpus striatum is overlapped by **opercula** from behind and above and in front. The surface area corresponding with the striate body is the **insula,** and the opercula covering it in make by their presence the **lateral fissure.**

Growth of the neopallial area implies formation of processes from its nerve-cells, and during the third month the *pyramidal motor fibres* begin to extend down toward the lower regions. They pass, as indicated in Fig. 982, through the corpus striatum to reach the marginal region beside the thalamus, and in doing so divide the corpus into **caudate** and **lentiform** masses, the caudate mass lying between them (*internal capsule*) and the ventricular cavity, the lentiform ganglion between them and the surface; hence the *lentiform* and *caudate nuclei* are always separated from one another by fibres of the internal capsule, and these fibres are always separated from the lateral ventricle by the caudate mass, and from the surface by the lentiform body. The mass of fibres, however, passing out of the striate body below and behind, come to separate the lenticular part here from the thalamus, with which they are coming into relation.

The capsular fibres, passing through the corpus striatum, are affected by its upward growth, and thus make their passage and exit in a line (Fig. 980) curved like the surface of the striate body; this being so, it is easily understood that a section downwards, as along the arrow, would cut, in order from above, neopallium, cavity, caudate nucleus, internal capsule, lentiform nucleus, capsule, caudate nucleus, cavity, and finally neopallium again.

In Fig. 982 the medial wall of the cavity of the vesicle is seen to remain thin. This wall is invaginated into the cavity as the *ependymal covering of the choroid plexus of the lateral ventricle.* The line of this thin wall lies just above the floor thickening of the corpus striatum, and is affected by the growth of this body, so that it assumes a curve corresponding with the curved shape of the ventricle, being invaginated into this throughout its length. This thin inner wall is continuous with the roof-plate of the third ventricle at the interventricular foramen, and the invaginations which cover the plexuses of the ventricles thus become continuous at this point.

The anterior part of the hemisphere vesicle corresponds to the **frontal lobe**; the lower part, as far forwards as the stem of the lateral fissure, becomes the **temporal lobe**; and the upper and posterior part represents the **parietal lobe.**

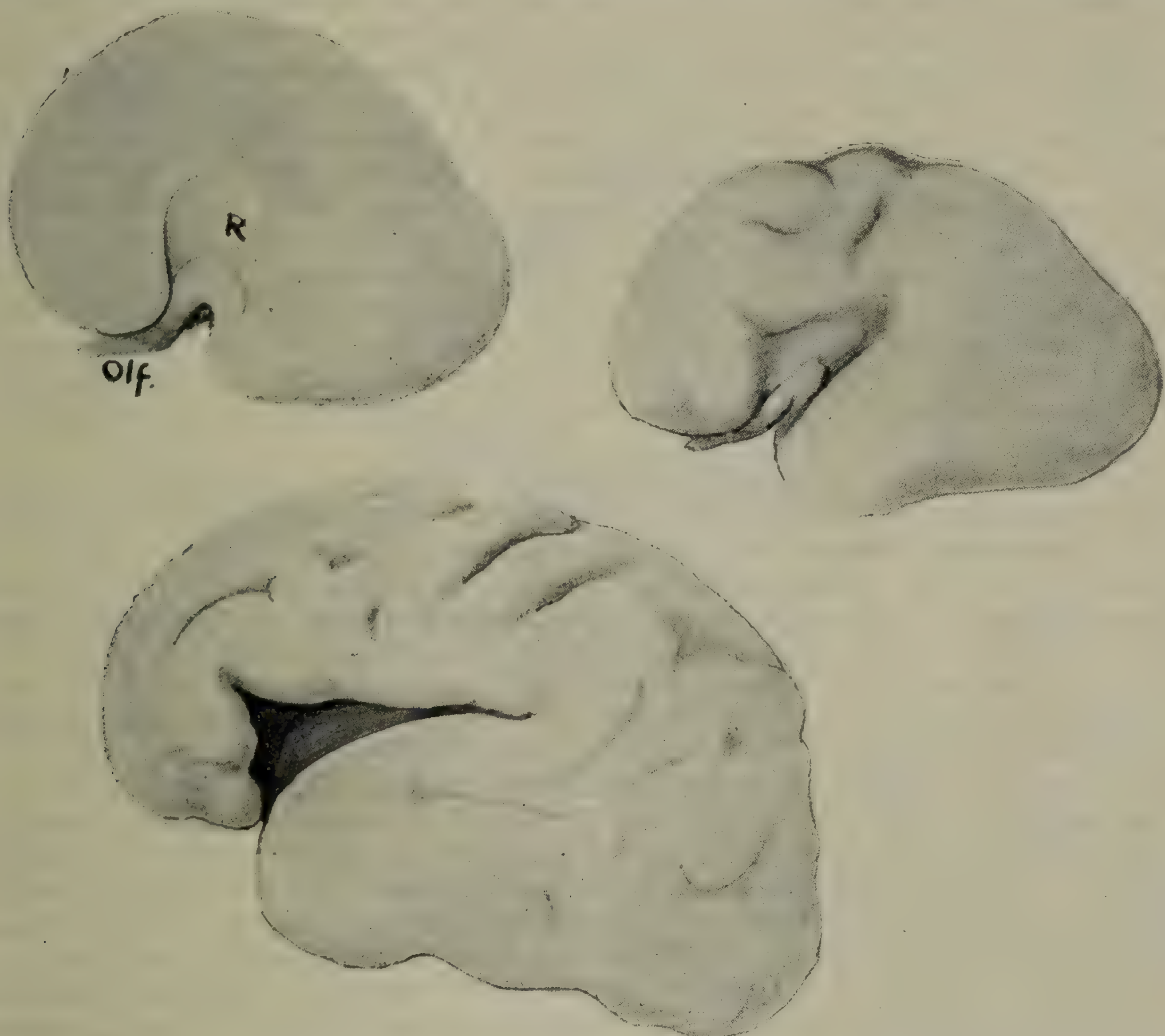


Fig. 983.—Side Views of Left Hemisphere at Beginning of Fifth and End of Sixth and Seventh Months (modified from Kollmann).

The **occipital lobe** is formed at a later period as the hemisphere grows backwards. The **limbic lobe** is developed in connection with the medial surface of the hemisphere. The **olfactory lobe** is developed as a hollow protrusion from the ventral aspect of the frontal portion of the hemisphere vesicle.

The surface of each hemisphere becomes very much broken up into gyri or convolutions, this being effected by means of fissures. The **fissures** are of two kinds—complete and incomplete. The **incomplete fissures** are merely sulci produced by the growth of the gyri, and they do not involve the entire thickness of the walls of the cerebral hemispheres. The **complete** or **primary fissures** are infoldings of the walls of the cerebral hemispheres, and involve their entire thickness. They consequently give rise internally to certain prominences upon the wall of each lateral ventricle—namely, the lateral choroid plexus, hippo-

campus, calcar avis, and eminentia collateralis. The primary fissures are as follows:

Lateral.	Calcarine (anterior part).
Choroidal.	Parieto-occipital.
Hippocampal.	Collateral (central part).

With the exception of the lateral fissure, already described, the other complete fissures appear on the *medial surface* of the vesicle of the cerebral hemisphere.

The **choroidal fissure** is not really a fissure, but merely a groove or sulcus produced by an infolding of the vesicular wall, which is here composed entirely of ependyma. It commences above and behind the interventricular foramen of the corresponding side, and it terminates close to the tip of the temporal pole, where the inferior or descending horn of the lateral ventricle ends. Between these two points it passes backwards, downwards, and then forwards into the future temporal lobe in a crescentic manner, so as to embrace the stalk of the cerebral hemisphere. After the ependymal infolding has taken place, vascular mesenchyme dips in between its two folds, and so a *plica chorioidea* is formed. From this choroidal fold the **lateral choroid plexus** of the corresponding side is formed. This plexus projects into the lateral ventricle, but is excluded from the ventricular cavity by the ependyma of the wall, previously infolded. When the lateral choroid plexus is withdrawn, the thin ependymal covering of the plexus comes away with it, or is broken down. Under these circumstances the choroidal fissure is really a fissure, inasmuch as the lateral ventricle now opens upon the surface through it. The internal prominence produced by the choroidal fissure is the lateral choroid plexus covered by ependyma, this prominence being very conspicuous.

The other complete fissures will be found described in connection with the cerebral hemispheres. All the primary fissures are formed before the fourth month.

The **incomplete fissures** are very numerous. The first two to make their appearance are the **calloso-marginal fissure,** or **sulcus cinguli,** on the *medial surface* of the cerebral hemisphere, and the **central sulcus,** or **fissure of Rolando,** on the *external surface.* These, along with the other incomplete fissures, will be found described in connection with the cerebral hemispheres. These are developed in the later fœtal months, and inconstant **tertiary** fissures appear for years after birth.

The cavity of the vesicle of the cerebral hemisphere forms on either side the **lateral ventricle,** which is very much curtailed by the thickening undergone by the vesicular walls, and the internal prominences produced by the complete fissures. As the frontal lobe undergoes development the *body* of the ventricle extends forwards into it, and so the *anterior horn* of the ventricle is formed. As the occipital lobe becomes developed at a later period the body of the ventricle extends backwards into it, and so the *posterior horn* is formed. Meanwhile the interventricular foramen on either side, originally large, is being gradually much diminished in size.

Basal Ganglia.—The basal ganglia of each cerebral hemisphere are as follows:

Corpus striatum.
Claustrum.
Amygdaloid nucleus.

They are all developed from the deep part of the much thickened cortical substance which forms the floor of the lateral fossa. The claustrum and amygdaloid nucleus remain of small size, but the nucleus caudatus of the corpus striatum forms a conspicuous prominence in the lateral ventricle as it bulges into that cavity.

Commissures.—The commissures are as follows:

1. Corpus callosum.	4. Anterior.
2. Fornix.	5. Posterior.
3. Hippocampal.	6. Middle.

7. Habenular.

At an early period in the development of the cerebral hemispheres the inter-hemispherical (great longitudinal) fissure leads directly down to the roof of the diencephalon. At a later period the roof of the diencephalon is separated from the great longitudinal fissure by two commissures placed one above the other. The upper commissure is the corpus callosum, and the lower one is the fornix. These may be looked on as drawn back from the lamina terminalis by the growing vesicles, although this is not quite an accurate statement of their formation.

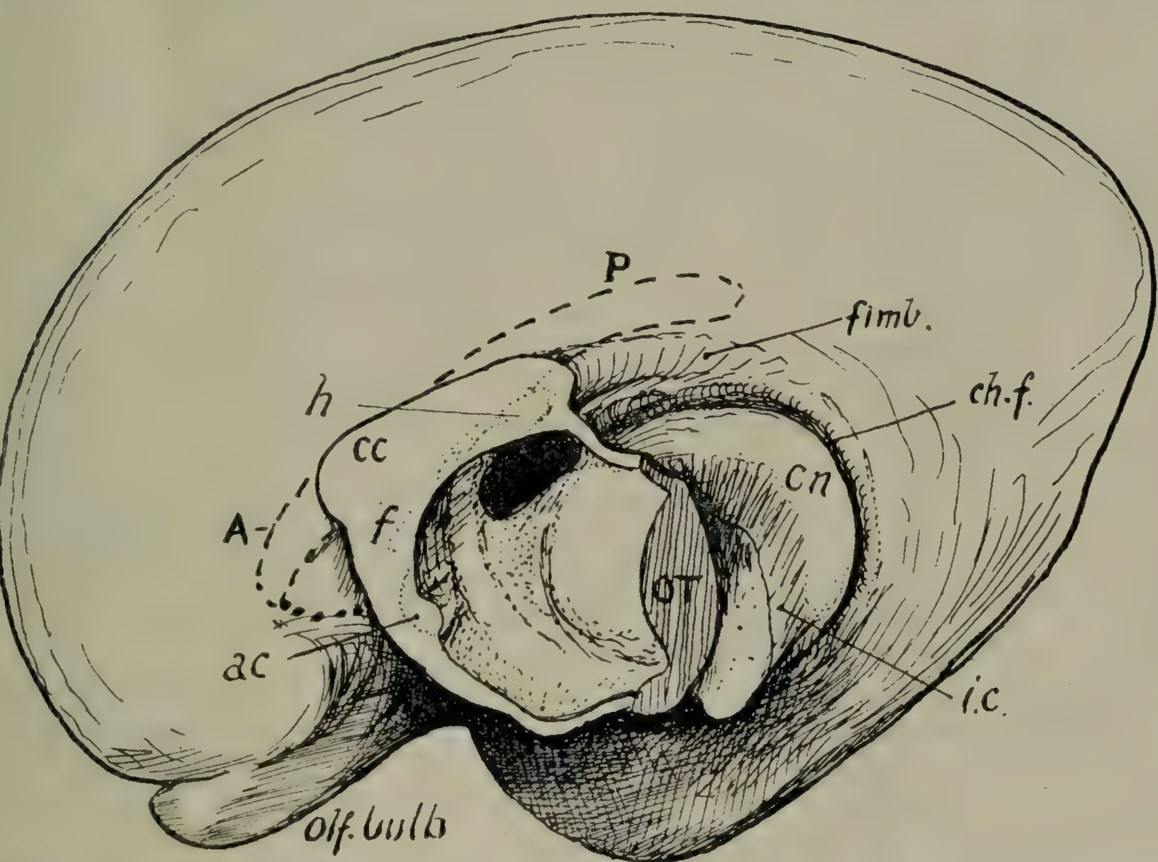


FIG. 984.—SCHEMATIC FIGURE TO SHOW THE GENERAL FORMATION OF THE MAIN COMMISSURES.

The thalamus (OT) is supposed to be cut away in part, exposing the region of the corpus striatum; this has grown up (producing the curved form of ventricle already described), and the choroidal fissure (*ch.f.*) is therefore a curved line. Fibres of the internal capsule (*i.c.*) also come through the mass of the corpus striatum in a curved line, and lie between the thalamus and lenticular part of corpus striatum. Hippocampal formations lie on the other side of the choroidal fissure, and association fibres here make the fimbria (*fimb.*) and fornix (*f*). Commissural fibres cross the middle line and are cut at *h* (hippocampal commissure) and *ac* (anterior commissure); these are in the lamina terminalis. As the neopallium grows, its commissure, the corpus callosum, begins to form; it is at first in the lamina terminalis (*cc.*), but with increasing growth it extends forwards (A) and backwards (P). The rostrum, shown by the dotted line, is subsequently formed by fusion of the walls of the two vesicles, the septum lucidum being that part of the wall between this and A. The backward extension carries with it the hippocampal commissure; these backward movements, involving also the hippocampus, are associated with great growth of the front part of the brain.

Fornix—Anterior Commissure.—These appear in the third month. In Fig. 984 is shown the inner aspect of a cerebral vesicle in which the **lamina terminalis** is visible. Thickenings begin in this from fibres crossing between the *olfactory and insular regions*; these make the *anterior commissure*. A little later fibres extend from each hippocampus to the sides of the lamina, where they turn into the side walls of the telencephalon, and reach much later the basal laminæ of the thalamencephalon, constituting the *anterior*

pillars of the fornix. The rest of the fornix is carried back with the growing vesicle.

Corpus Callosum.—Some time later, as the neopallium grows, its commissural fibres begin to become evident as the *corpus callosum.* These at first make use of the path already utilized by the earlier commissural fibres, and are found crossing at and above the upper part of the lamina terminalis as far back as the level of the interventricular foramen, as seen in the figure. As the neopallium grows, however, its commissural fibres become too numerous to be confined to this area, and their line of crossing extends backwards and forwards. The hinder extension necessarily lies with the fornix above the choroidal fissure, while the forward extension is between the two anterior expansions of the vesicles or hemispheres. These anterior fibres of the corpus callosum come from the frontal lobe above the anterior horn of the ventricle, hence that part of the wall of the hemisphere below these fibres is the medial wall of this horn. The hemispheres become approximated and fused below this small area of medial wall as the result of growth of neopallium round it, and commissural fibres now find their way through the line of fusion below the medial wall of the anterior horn. This makes the *rostrum,* and its continuity in front and above with the original forward extension of the corpus callosum cuts off the two areas of medial wall from the rest of this wall in the longitudinal fissure; they now form the two layers of the *septum lucidum,* and the cavity between them is only the corresponding part of the space of the fissure, similarly cut off. The fusion between the medial walls is not confined to the region just considered, but is found behind this in the neighbourhood of the callosal fibres and the fornix; this explains the posterior extension of the region of the septum lucidum.

The **hippocampal commissure** appears on the back part of the ventral aspect of the plate formed by the fused areas of the cerebral hemispheres, to which position it has been carried by the backgrowth of the corpus callosum. Its fibres pass across from one hippocampus to the other, and they correspond to the region known as the *lyra* or *psalterium.*

The **posterior commissure** is formed in connection with the back part of the roof of the diencephalon behind the pineal diverticulum.

The so-called **middle commissure** is not a commissure properly so called, but is formed by the fusion over a limited area of the grey matter of the medial surfaces of the thalami, and properly termed *connexus thalami.*

The **habenular commissure** is produced by the decussating fibres of the thalamic striæ, these fibres, as they decussate, forming the dorsal part of the pedicle of the pineal body.

Meninges of the Encephalon.—The walls of all the cerebral vesicles are invested by mesoderm, and this tissue becomes differentiated into the three meninges—namely, the dura mater, arachnoid, and pia mater.

Choroid Plexuses.—The choroid plexuses of the two lateral, third, and fourth ventricles are developed as infoldings of the ependymal walls of the ventricles. Vascular mesenchyme (mesoderm) dips in between the two layers of each infolding, and in this manner *plicæ chorioideæ* are formed. These choroidal folds give rise to the choroid plexuses, which as they project into the ventricles carry the ependymal walls, already infolded, before them.

Tela Chorioidea.—The vascular mesoderm (*pia mater*) investing the neural tube is converted into a double layer interposed between fore-brain and cerebral vesicles as a result of the backgrowth of the latter. It is clear that this *velum interpositum* extends to the interventricular foramen, where its two layers are continuous, and where vessels of the cerebral layer can join those of the earlier one. The dotted lines in Fig. 982 show the position of these two layers on section; it can be seen that the 'cerebral' layer reaches out to the thin medial wall of the vesicle, and its marginal vessels can invaginate this to form the choroid plexus of the lateral ventricle, while the deeper layer rests on the roof of the third ventricle, and makes its choroid plexus. The continuity of the two layers at the foramen explains why the lateral vein runs there to join the internal cerebral vein, which is in the lower layer.

Development of the Peripheral Nervous System.

The peripheral nerves are arranged in two groups—namely, **spinal,** which are derived from the spinal cord; and **cranial,** which arise from the brain.

The **spinal nerves** are composed of two kinds of fibres—efferent, centrifugal, or motor; and afferent, centripetal, or sensory.

A **motor spinal nerve-fibre** arises as the axon of a neuroblast or nerve-cell in the mantle layer of the neural tube (see Development of the Spinal Cord).

A **sensory spinal nerve-fibre** is developed from a cell of a spinal ganglion, and these ganglia are developed from the corresponding neural crest.

Neural Crests.—The neural or ganglionic crests, right and left, are ridges of ectodermic cells which lie on either side of the neural tube. They are derived from a single crest of ectoderm, which is formed by the fusion of the ectoderm over each neural fold, this single crest being situated medially on the dorsal aspect of the neural tube along the line of fusion of the neural folds to close the tube. Subsequently the medial crest divides into right and left halves, which cover the dorso-lateral aspects of the neural tube.

Each neural crest becomes broken up into a number of segments, or **ganglia**, there being four pairs for the head region, and thirty-one pairs for the region of the trunk.

Spinal Ganglia.—The spinal ganglia are arranged in thirty-one pairs, right and left.

Each cell of a ganglion acquires two poles—afferent or centripetal, and efferent or centrifugal—and at this stage it is consequently a *bipolar* cell.

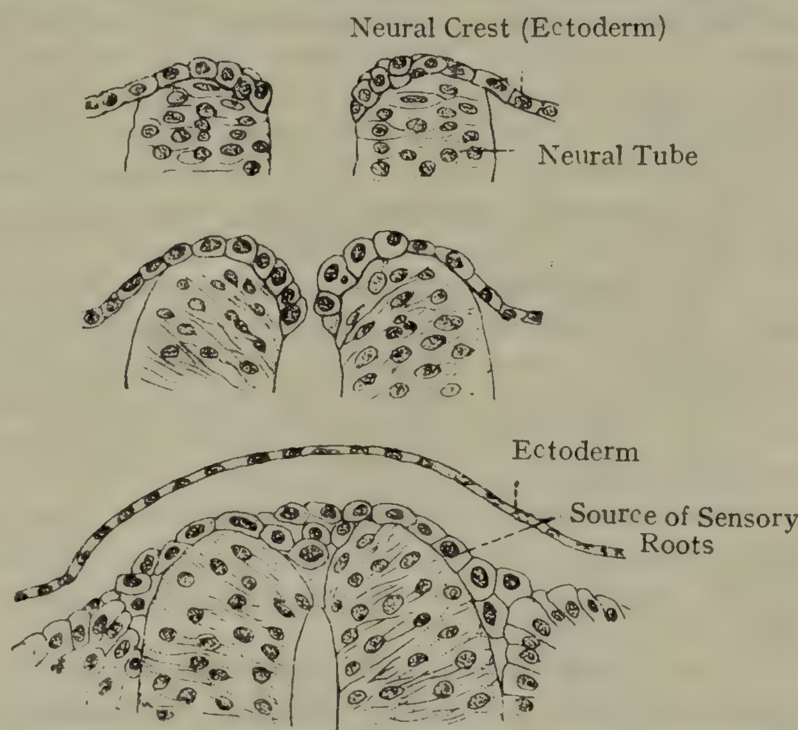


Fig. 985.—Development of the Neural or Ganglion Crest (Keibel and Mall) (after Von Lenhossek and Kollmann).

The *centripetal* or *proximal pole,* which is the axon of a ganglionic cell, *grows into* the dorsal part of the wall of the neural tube and forms part of the **dorsal** or **posterior root** of a spinal nerve. Within the marginal layer of the neural tube the centripetal pole or nerve-fibre divides into two branches, ascending and descending, which give off collaterals and terminate in arborizations. The *centrifugal* or *distal pole* joins the ventral or anterior nerve-root of the same segment of the spinal cord on the distal side of the ganglion to form a spinal nerve.

Though the cells of a spinal ganglion are originally *bipolar,* they become in the course of growth *unipolar,* the single pole having a **T**-shape. This is brought about by an excessive growth of one wall of the bipolar cell, which brings the two original poles into contact, when they fuse, and are now connected with the cell by one stalk or pole, which divides into a centripetal and a centrifugal process.

Whilst the fibres of the dorsal or posterior roots of the spinal nerves *grow into* the mantle layer of the neural tube from the cells of the spinal ganglia, the fibres of the **ventral** or **anterior roots** arise *within* the mantle layer as the axons of its neuroblasts or nerve-cells. The fibres of the anterior roots therefore *grow out* from the neural tube.

Cranial Nerves.—The development of the cranial nerves, with the exception of the *olfactory* and *optic nerves,* corresponds for the most part with the development of the spinal nerves. The **motor** cranial nerve-fibres arise as the axons of nerve-cells of the brain, and *grow into* the brain, whereas the **sensory** cranial nerve-fibres *grow into* the brain from the cells of the cephalic ganglia.

Cephalic Ganglia.—The cephalic ganglia, like the spinal ganglia, are developed from the neural crests, and they constitute four pairs of ganglionic groups—namely, trigeminal, acoustico-facial, glosso-pharyngeal, and vagal. They are all comparable to the spinal ganglia.

The **trigeminal ganglion** is connected with the sensory root of the fifth cranial nerve. The centripetal poles of its nerve-cells pass inwards *into* the brain, forming the large sensory root of the nerve, and the centrifugal poles of its cells pass peripherally, forming the ophthalmic, superior maxillary, and sensory part of the inferior maxillary nerves. The trigeminal ganglion is thus clearly comparable to a spinal ganglion. The small motor root of the fifth nerve is homologous to the motor or anterior root of a spinal nerve, inasmuch as its fibres arise as the axons of nerve-cells *within* the brain.

The **acoustico-facial ganglion** resolves itself into facial and acoustic parts.

The **facial ganglion,** known as the **geniculate ganglion,** is connected with the *genu* of the facial nerve in the aqueduct of Fallopius. The centripetal poles of the nerve-cells of this ganglion form the **sensory root** of the facial nerve—the *pars intermedia of Wrisberg*—which passes *inwards* to the fasciculus solitarius and upper part of the glosso-pharyngeal nucleus. Many of the centrifugal poles of the cells *issue from* the ganglion as the **chorda tympani nerve,** which passes to the anterior two-thirds of the tongue as a nerve of special sense.

The **acoustic ganglion** is represented by the vestibular and cochlear ganglia in connection with the auditory nerve.

The **vestibular ganglion** is connected with the vestibular division of the auditory nerve in the internal auditory meatus. As in the other ganglia, the centripetal poles of the cells of this ganglion form the centripetal fibres of the vestibular nerve, which pass *inwards* to the brain. The centrifugal poles of the cells leave the ganglion, and form the peripheral part of the nerve as regards its distribution.

The **cochlear ganglion,** known as the **ganglion spirale,** is connected with the cochlear division of the auditory nerve, and is situated in the spiral canal of the modiolus. Its nerve-cells are related to nerve-fibres, as in the case of the vestibular ganglion.

The **glosso-pharyngeal ganglion,** which is broken up into a **superior (jugular) ganglion** and an **inferior (petrous) ganglion,** is comparable to a spinal ganglion. The centripetal poles of the nerve-cells, which issue from the ganglion, represent the centripetal sensory fibres of the glosso-pharyngeal nerve, passing *into* the brain. The centrifugal poles of the nerve-cells, issuing from the ganglion, represent the peripheral sensory fibres of the nerve.

The **vagal ganglion,** which is broken up into the **upper ganglion (of the root)** and the **lower ganglion (of the trunk),** is disposed towards the sensory fibres of the vagus nerve, as in the case of the other ganglia.

MENINGES OF THE ENCEPHALON.

Dura Mater.

The dura mater is a strong fibrous membrane which surrounds the encephalon, and is composed of two layers—outer and inner. The **outer** or **endosteal layer** serves as the internal periosteum or endocranium of the cranial bones, and the **inner** or **sustentacular layer** supports the encephalon. It is more firmly adherent to the bones forming the base of the skull than to those over the cranial vault, and it is also firmly attached along the course of the sutures. At the various openings it is prolonged outwards, blending with the sheaths of the transmitted nerves, and also becoming continuous with the external periosteum or pericranium. At the sphenoidal fissure it passes into the orbit

to form the orbital periosteum. At the lower margin of the foramen magnum the two layers of which the dura mater is composed separate. The external layer blends with the periosteum of the occipital bone around the margin of the foramen magnum. The internal layer is prolonged into the spinal canal, and forms the theca of the spinal cord. The outer surface of the dura mater is rough and flocculent, owing to fibrous processes which connect it to the inner surfaces of the cranial bones. Its inner surface is smooth and covered by endothelium. Superiorly, on either side of the superior longitudinal sinus there are several small granular nodules, called **arachnoid granulations,** which are best marked in old age. They indent the parietal bone, and protrude into the superior longitudinal sinus, carrying with them prolongations from the endothelial lining of the sinus, which separate them from the blood.

The bodies are enlargements of the villi of the arachnoid membrane (see p. 1609).

Structure.—The dura mater consists of fibrous and elastic tissues arranged as parallel bundles.

The intracranial dura mater differs from the dura mater of the spinal cord in the following respects: (1) it consists of two layers—outer or periosteal, and inner or sustentacular—whereas the spinal dura mater has only one layer, representing the sustentacular layer; (2) it furnishes certain processes or septa, which project into the cranial cavity, and separate parts of the encephalon from each other, whereas the spinal dura mater sends no septa into the spinal cord; and (3) it contains venous sinuses, which are absent in the spinal dura mater, or are represented by the extradural venous plexuses (see p. 1434).

Subdural Space.—This is the interval between the dura mater and the arachnoid membrane. There is really no space, but simply sufficient interval to contain a minute quantity of serous fluid for lubricating purposes. The dura mater and the arachnoid are therefore practically in contact with each other.

Blood-supply.—The cranial dura mater is supplied by the **meningeal arteries,** which are extradural and supply the inner table of the cranial bones. These vessels are very numerous, and the chief are as follows on either side, from before backwards: (1) anterior meningeal, two in number, from the anterior and posterior ethmoidal arteries; (2) meningeal, from the cavernous part of the internal carotid artery; (3) small meningeal, from the middle meningeal, or from the first part of the maxillary artery; (4) middle meningeal, from the first part of the internal maxillary; (5) meningeal branches of the ascending pharyngeal artery; (6) posterior meningeal branch of the occipital artery; and (7) posterior meningeal, from the vertebral artery.

The **anterior meningeal branch of the anterior ethmoidal artery** arises from that vessel as it accompanies the nasal nerve on the cribriform plate of the ethmoid bone, and it takes part in the supply of the dura mater of the anterior fossa.

The **anterior meningeal branch of the posterior ethmoidal artery** arises from that vessel after it has entered the cranial cavity through a minute foramen between the cribriform plate of the ethmoid and the sphenoid. It has a limited distribution to the dura mater in this region.

The **meningeal branch of the internal carotid artery** arises from the cavernous part of that vessel, and enters the middle fossa to supply the dura mater.

The **small meningeal artery** is usually a branch of the middle meningeal, but it may arise from the first part of the maxillary artery. It enters the cranial cavity through the foramen ovale, and supplies the adjacent dura mater and the trigeminal ganglion.

The **middle meningeal artery,** as stated, is a branch of the first part of the maxillary artery. Its diameter is that of the foramen spinosum, through which it enters the cranial cavity. After passing into the cranium it divides into two branches, anterior and posterior. The *anterior branch* passes forwards, outwards, and upwards in a groove on the upper surface of the great wing of the sphenoid bone to the inner aspect of the antero-inferior angle of the parietal bone, where there is a groove, or sometimes a short canal. The position of the middle meningeal artery at this level is ascertained by taking a point on the exterior of the skull 1½ inches behind the zygomatic process of the frontal bone and 1½ inches above the zygomatic arch. From this point the artery ascends in a

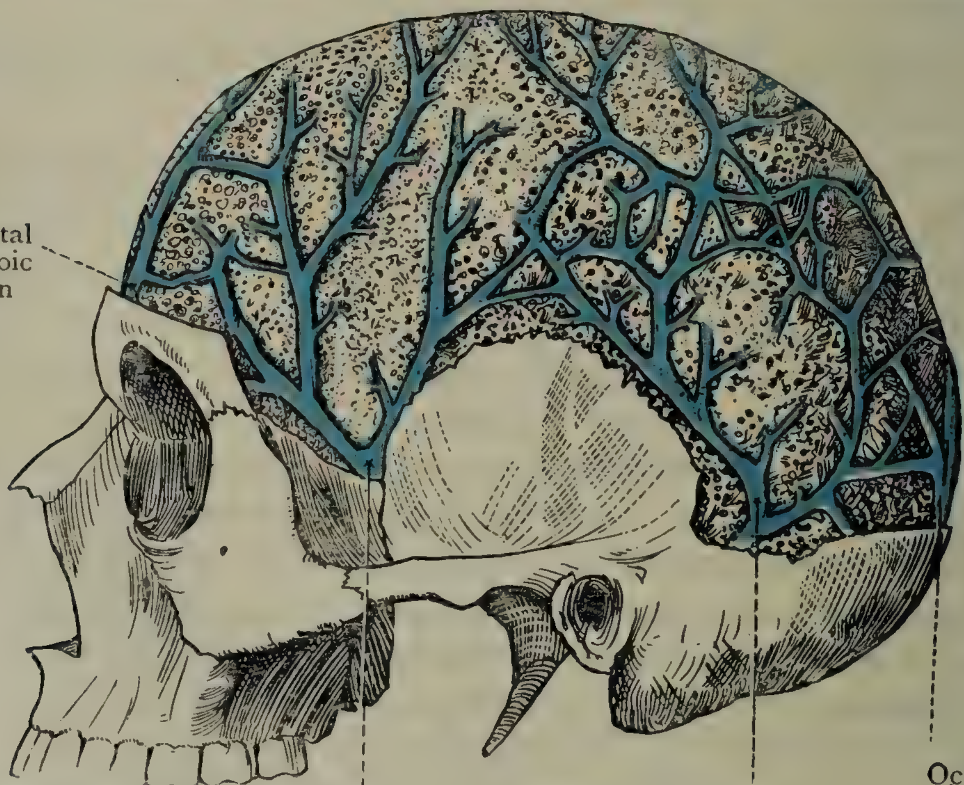


FIG. 986.—THE VEINS OF THE DIPLOË.

The outer tables of the cranial bones have been removed.

branching meningeal groove near the anterior border of the parietal bone as high as the superior longitudinal sinus. In this part of its course it furnishes numerous branches forwards and backwards.

The *posterior branch* passes backwards on the squamous part of the temporal bone, and then on to the inner aspect of the inferior border of the parietal bone, where there is a meningeal groove about the centre. From this point it ascends in a branching groove as high as the superior longitudinal sinus, giving off branches forwards and backwards.

The distribution of the middle meningeal artery extends as high as the superior longitudinal sinus forwards on to the frontal bone, and backwards on to the occipital bone. Besides supplying the dura mater and the inner table and diploë of the bones, the vessel furnishes the following branches: (1) *Ganglionic* to the trigeminal ganglion; (2) a *petrosal branch,* which passes through the hiatus (Fallopii) to supply the facial nerve in its canal, and anastomose with the stylo-mastoid branch of the posterior auricular artery; and (3) an *orbital branch,* which enters the orbit through the sphenoidal fissure, and anastomoses with the ophthalmic artery.

The **meningeal branches of the ascending pharyngeal artery,** which is a branch of the external carotid, are three in number: One passes through the foramen lacerum into the middle fossa; another passes through the jugular foramen into the posterior fossa; and the third passes through the anterior condylar foramen, likewise into the posterior fossa.

The **posterior meningeal branch of the occipital artery** passes through the jugular or mastoid foramen into the posterior fossa.

The **posterior meningeal branch of the vertebral artery** passes through the foramen magnum into the cerebellar fossa of the occipital bone.

As a rule, only one of these various posterior meningeal arteries is large enough to carry injection.

Meningeal Veins.—The sinuses or veins with the middle meningeal artery are two in number. They pass through the *foramen ovale,* and terminate in the pterygoid plexus of veins. The other meningeal veins are disposed in one of two ways. Some of them accompany the corresponding arteries and terminate in extracranial veins; whilst others end in the various intracranial venous sinuses, in part directly and in part by means of venous lacunæ.

Veins of the Diploë.—These vessels are situated in the cancellous tissue between the outer and inner plates of the cranial bones, and are exposed after removal of the outer plate. They are destitute of valves, and are arranged in the form of a network, from which the blood is returned by four diploic veins on either side—namely, frontal, anterior temporal, posterior temporal, and occipital. These terminate partly in extracranial veins, and partly in the intracranial venous sinuses and meningeal veins.

The **frontal diploic vein** passes downwards and escapes through an opening in the outer plate of the frontal bone at the supra-orbital notch, where it joins the communicating vein which passes between the supra-orbital and ophthalmic veins. It receives radicles from the frontal air-sinus of the same side.

The **anterior temporal diploic vein** is confined to the back part of the frontal and anterior part of the parietal regions, and descends to terminate in two ways. It partly joins one of the extracranial deep temporal veins by passing through an opening in the outer plate of the great wing of the sphenoid, and in part it ends in a meningeal vein, or in the spheno-parietal, or it may be the cavernous sinus.

The **posterior temporal diploic vein** is confined to the parietal region, and descends to the postero-inferior angle of the parietal bone, where it pierces the inner plate of that bone, and terminates in the transverse sinus.

The **occipital diploic vein** occupies the occipital region, and pierces the inner table of the occipital bone, to terminate in the transverse or sigmoid sinus.

Nerves of the Dura Mater.—The dura mater receives nerves from (1) the sympathetic plexuses which accompany the arteries; (2) the three divisions of the fifth cranial nerve; (3) the ganglion of the root of the vagus nerve; and (4) the hypoglossal nerve. Headache is said to be due to irritation of these nerves, especially to one of the branches of the fifth, known as the nervus tentorii.

Processes of the Dura Mater.—It has been already explained that the dura mater is composed of two layers—outer or periosteal, and inner or sustentacular. The processes are formed by the inner or sustentacular layer, and are four in number—the falx cerebri, tentorium cerebelli, falx cerebelli, and diaphragma sellæ.

The **falx cerebri** is an extensive sickle-shaped process, which occupies the great longitudinal fissure, where it lies between the two cerebral hemispheres. *Anteriorly* it is almost pointed, and is attached to the *crista galli* of the ethmoid bone. *Posteriorly* it is broad, and is attached to the upper surface of the tentorium cerebelli along the median line, the straight sinus being situated at the place of junction. The *superior border* is convex, and is attached in the median line to the frontal,

parietal, and occipital bones, extending upon the latter bone only as low as the internal occipital protuberance. The superior sagittal sinus is situated along this border. The *inferior border* is concave and free. It overhangs the upper surface of the corpus callosum, from which it is separated by a slight interval. The inferior sagittal sinus is situated within this border. The *lateral surfaces* face the medial surface of the cerebral hemispheres.

The **tentorium cerebelli** is an extensive crescentic sheet which covers the cerebellum. *Superiorly* it supports the posterior parts of the cerebral hemispheres, and is elevated along the median line, whence it slopes towards the attached borders. *Anteriorly* it presents a free,

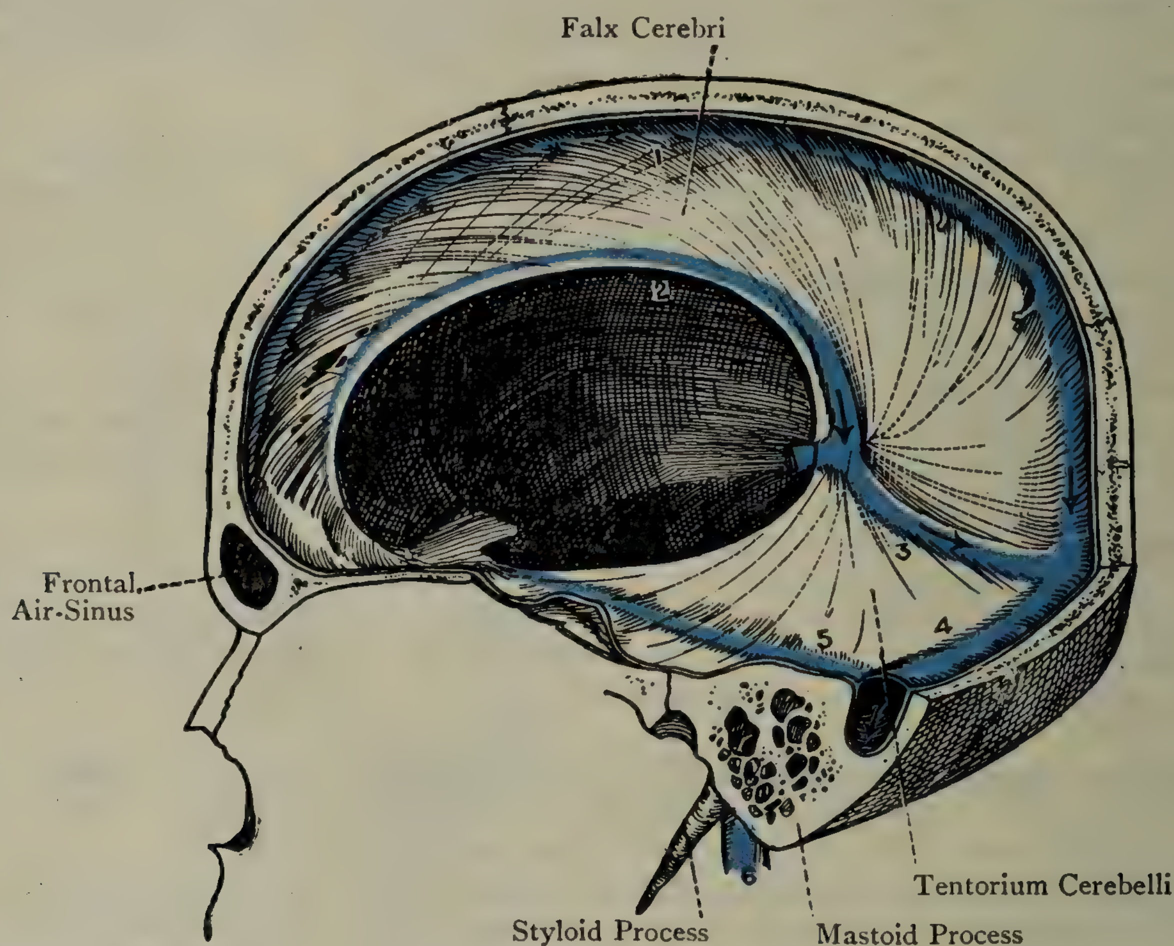


FIG. 987.—THE FALX CEREBRI, TENTORIUM CEREBELLI, AND VENOUS SINUSES OF THE DURA MATER (LEFT VIEW).

1. Superior Sagittal Sinus
2. Inferior Sagittal Sinus
3. Straight Sinus
4. Transverse Sinus
5. Superior Petrosal Sinus
6. Internal Jugular Vein

sharp, concave border, which forms, with the dorsum sellæ of the sphenoid bone anteriorly, an oval opening, called the *foramen ovale tentorii*, within which the mesencephalon is placed. *Posteriorly* and *laterally* the tentorium cerebelli is convex, and is attached as follows, from behind forwards: (1) to the horizontal ridge on the inner surface of the tabular part of the occipital bone, where the process contains the transverse sinus; (2) to the inner aspect of the postero-inferior angle of the parietal bone, where the process also contains this sinus; and (3) to the superior border of the petrous part of the temporal bone, where the process contains the superior petrosal sinus. Close to the apex of the *pars petrosa* the outer and anterior borders of the tentorium

cerebelli cross, the outer border passing inwards to be attached to the posterior clinoid process of the sphenoid bone, and the anterior border passing forwards to be attached to the anterior clinoid process of that bone.

In all the carnivora the tentorium is ossified.

The **falx cerebelli** extends forwards into the posterior cerebellar notch, where it lies between the two cerebellar hemispheres. It is falciform in outline. *Superiorly* it is attached to the posterior part of the inferior surface of the tentorium cerebelli in the median line. *Posteriorly* it is attached to the internal occipital crest, and this portion bifurcates inferiorly, the two divisions being connected to the lateral margins of the vermiform fossa. Along this posterior attachment it contains the occipital sinus and its two divisions. *Anteriorly* it ends in a free border.

In the ornithorhynchus and many cetacea the falx is ossified.

The **diaphragma sellæ** is a small circular fold horizontally placed, which forms a roof for the sella turcica or hypophysial fossa of the sphenoid bone, and almost entirely covers the hypophysis. At its centre there is a small opening for the passage of the infundibulum.

Venous Sinuses of the Dura Mater.—These are blood-channels or spaces situated between the two layers of the dura mater, and lined with endothelium. They are as follows:

Superior sagittal sinus.	Spheno-parietal sinuses (two).
Inferior sagittal sinus.	Circular sinus.
Straight sinus.	Superior petrosal sinuses (two).
Transverse sinuses (two).	Inferior petrosal sinuses (two).
Occipital sinus.	Basilar sinus.
Cavernous sinuses (two).	Petro-squamous sinuses (two).

The **superior sagittal sinus** is situated in the median line within the superior convex border of the falx cerebri. It extends from the *crista galli* of the ethmoid bone to the internal occipital protuberance, where as a rule it turns sharply to the right, and opens into the right transverse sinus. It sometimes, however, turns to the left, and opens into the left transverse sinus. Its posterior extremity is dilated, and forms the **confluens sinuum,** which usually occupies a depression on the right side of the internal occipital protuberance, and is connected with the dilatation at the posterior extremity of the straight sinus by a transverse vessel. It increases in size as it passes backwards, and its shape is triangular in section, the base being directed towards the cranial vault. The apex is directed downwards, and in this region the sinus is crossed by a number of delicate fibrous bands. Opening into the sinus on either side there are venous spaces, called **lacunæ laterales,** which are situated within the dura mater, and projecting into these lacunæ from below, or into the sinus itself, there are several arachnoid granulations, covered by the endothelial lining. The sinus receives the superior cerebral veins and some of the meningeal veins of the falx

cerebri. The former open into it from *behind forwards*, so far at least as the more posterior vessels are concerned, so that the blood-flow in these veins is opposed to the current of blood in the sinus, which is from before backwards.

The superior sagittal sinus sometimes communicates anteriorly with the veins of the roof of the nose through the *foramen cæcum*, and

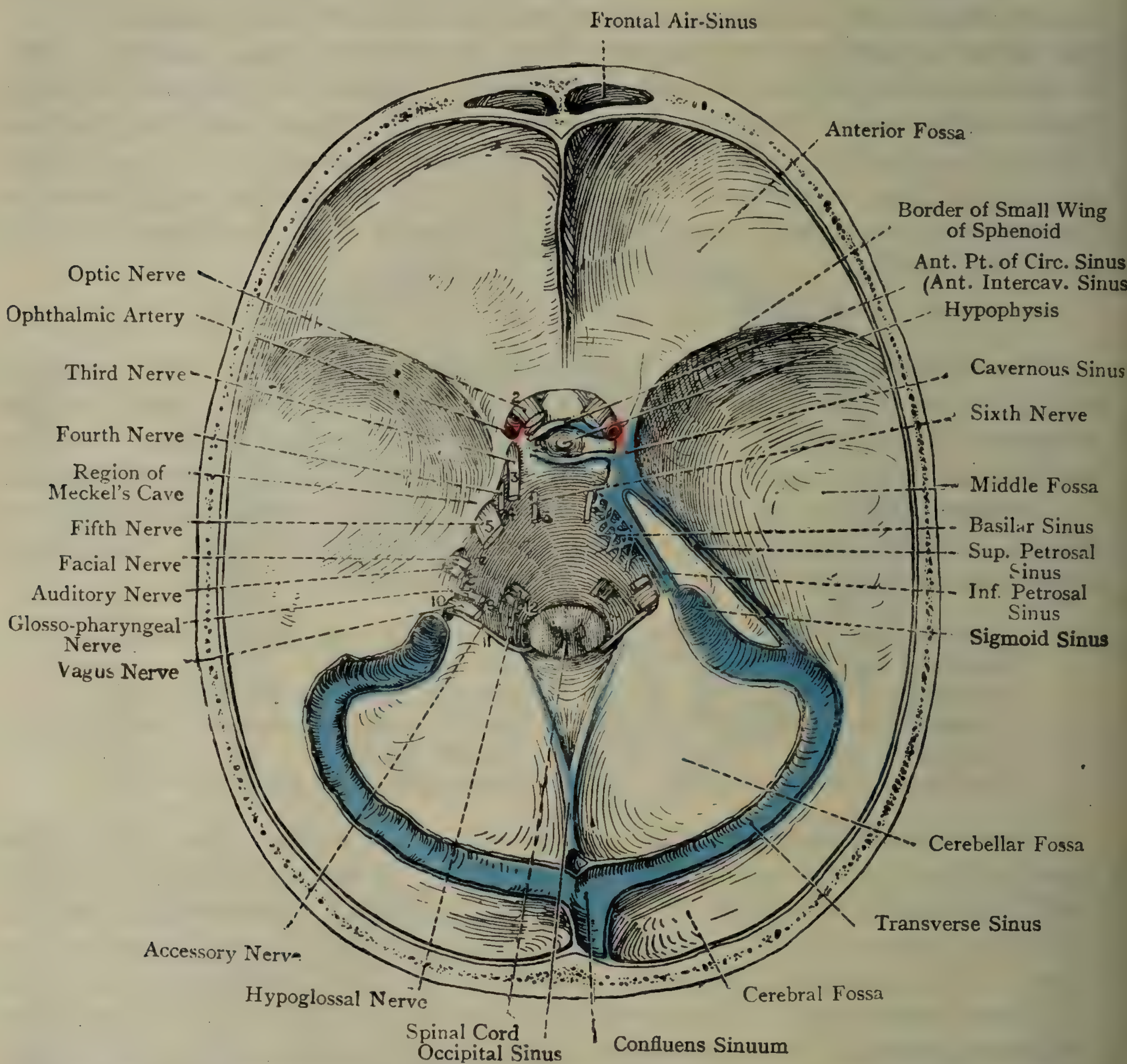


FIG. 988.—THE INTERNAL BASE OF THE SKULL, SHOWING THE CRANIAL NERVES AND VENOUS SINUSES.

it communicates with the veins of the scalp by means of an emissary vein, which passes through the parietal foramen of each side, when that is present.

The **inferior sagittal sinus** (vein) is of small size, and is situated in the lower free border of the falx cerebri over its posterior two-thirds. Its direction is backwards, and it opens into the front part of the straight sinus at the anterior margin of the tentorium cerebelli. It is circular, and increases in size as it passes backwards. Its tributaries are derived

from the lower part of the falx cerebri, and from the adjacent parts of the medial surfaces of the cerebral hemispheres.

The **straight sinus** is situated at the junction of the falx cerebri with the tentorium cerebelli, and is formed by the union between the inferior longitudinal sinus and the great (internal) cerebral vein at the anterior margin of the tentorium. It is triangular in section, and increases in size from before backwards. Its course is downwards and backwards in the median line to the left side, as a rule, of the internal occipital protuberance, where it becomes slightly dilated, and is continued into the left transverse sinus. Its terminal dilatation is connected with the confluens sinuum by a transverse vessel. In those cases where the superior longitudinal sinus passes into the left transverse sinus the straight sinus passes into the right transverse sinus. In addition to the inferior longitudinal sinus and the great cerebral vein, the straight sinus receives some of the superior cerebellar veins and tributaries from the falx cerebri and tentorium cerebelli.

The **transverse sinuses** extend on each side from the internal occipital protuberance to the postero-lateral compartment of the jugular foramen, through which it passes, to terminate in the bulb of the internal jugular vein. The sinus pursues a curved course. It passes outwards in the transverse groove on the inner surface of the tabular part of the occipital bone as far as the inner surface of the postero-inferior angle of the parietal bone. Here it ascends for a little in a groove, and, having described a sharp curve, it passes downwards and medially in the **sigmoid** groove on the inner surface of the mastoid portion of the temporal bone. Finally, it turns forwards in the groove on the upper surface of the jugular process of the occipital bone to the jugular foramen. As far as the postero-inferior angle of the parietal bone the transverse sinus is contained within the attached border of the tentorium cerebelli, and just before leaving this it receives the superior petrosal sinus. The right transverse sinus is, as a rule, formed by the superior longitudinal sinus, and in these circumstances is larger than the left, which is usually formed by the straight sinus. The reverse, however, may be the case. Before leaving the torcular the two sinuses communicate freely.

The transverse sinus of each side, in addition to the superior petrosal sinus, receives tributaries from the posterior part of the cerebrum and the superior and inferior surfaces of the cerebellum. It also receives the posterior temporal and occipital diploic veins, and the petro-squamous sinus, when that sinus is present. Near its termination it communicates with the marginal sinus of the same side. The sinus communicates with extracranial veins by means of two large emissary veins, posterior condylar and mastoid, which pass through the corresponding foramina. These foramina, however, being inconstant, the emissary veins are sometimes wanting.

The name ' transverse ' is strictly applicable only to that part of the sinus which is *contained within the attached border of the tentorium cerebelli*, and extends from the internal occipital protuberance to the

postero-inferior angle of the parietal bone. Beyond this latter point the sinus is known as the **sigmoid sinus.**

The **occipital sinus** is situated within the falx cerebelli along its attachment to the internal occipital crest. It is of small size, and is formed inferiorly by the union of the two *marginal sinuses* (inferior occipital) which lie on either side of the vermiform fossa and foramen magnum, where they communicate with the posterior intraspinal veins and the terminal part of each lateral sinus. Superiorly it opens into the confluens sinuum. In certain cases the marginal or inferior occipital sinuses remain separate, and then each opens into the corresponding transverse sinus. The occipital sinus receives tributaries from the falx cerebelli and the inferior surface of the cerebellum, and it establishes a communication between the beginning and end of the transverse sinuses.

The **cavernous sinuses** are so named because the interior of each is broken up by fibrous filaments, which impart to it a reticular appearance. Each sinus is situated on the side of the body of the sphenoid bone, and extends from the inner extremity of the sphenoidal fissure to the apex of the petrous part of the temporal bone. Anteriorly it receives the ophthalmic vein or veins from the orbit, and posteriorly it terminates by dividing into the superior and inferior petrosal sinuses. In addition to the ophthalmic vein or veins, the cavernous sinus receives the spheno-parietal sinus and some of the inferior cerebral veins. It communicates with the angular vein of the face through the superior ophthalmic vein; with its fellow of the opposite side through the circular sinus; with the transverse sinus by the superior petrosal sinus; with the internal jugular vein by the inferior petrosal sinus; with the pterygoid plexus through the inferior ophthalmic vein, and by an emissary vein which passes through the foramen ovale, or through the 'foramen Vesalii'; and with the pharyngeal plexus by an emissary vein which passes through the foramen lacerum medium. The internal carotid artery, with the cavernous sympathetic plexus, lies within the sinus, and the sixth cranial nerve (Fig. 989) is close to the outer side of the artery. In connection with the roof and outer wall of the sinus there are the third and fourth, as well as the ophthalmic and superior maxillary divisions of the fifth cranial nerves.

The **spheno-parietal sinus** is of small size, and is situated on the inferior surface of the lesser wing of the sphenoid bone. It generally begins in connection with the anterior temporal diploic vein, and ends in the anterior part of the cavernous sinus.

The **circular sinus** fills any small part of the hypophysial fossa which is not occupied by the gland; on each side it opens freely into the cavernous sinus.

The **superior petrosal sinus** is situated along the superior border of the petrous part of the temporal bone, and lies within the attached margin of the tentorium cerebelli. It begins at the back part of the cavernous sinus, and, having passed laterally and backwards, it opens into the transverse sinus as that is about to enter the sigmoid groove

of the *pars mastoidea*. It receives tributaries from the cerebellum and tympanum.

The **inferior petrosal sinus** occupies the groove at the junction of the basilar process of the occipital bone with the petrous part of the temporal bone. It begins at the back part of the cavernous sinus, and, passing backwards and slightly laterally, it leaves the cranial cavity through the antero-medial compartment of the jugular foramen, to terminate in the bulb of the internal jugular vein. It receives tributaries from the inferior surface of the cerebellum, and from the internal ear.

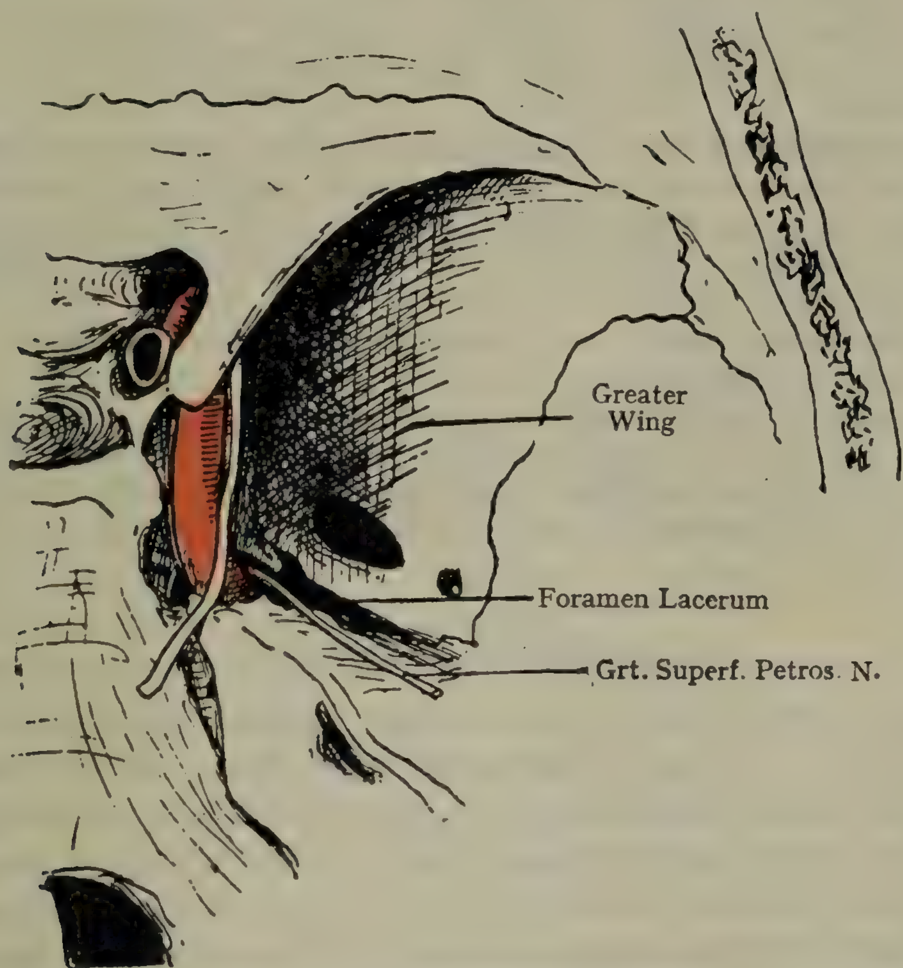


FIG. 989.—RIGHT INTERNAL CAROTID PUT IN POSITION ON BASE OF SKULL AND CROSSED BY SIXTH NERVE.

Greater superficial petrosal nerve is also seen entering foramen lacerum.

The **basilar sinus** is really a plexus of veins situated within the dura mater over the basilar process of the occipital bone, extending as low as the anterior margin of the foramen magnum, where it communicates with the anterior intraspinal veins. It connects the anterior ends of the inferior petrosal sinuses with each other.

The **petro-squamous sinus** is situated along the junction of the petrous and squamous parts of the temporal bone. Its direction is backwards, and it opens into the transverse sinus as that is entering the sigmoid fossa of the *pars mastoidea*.

Each petro-squamous sinus represents the continuation of the transverse sinus in early life, to terminate in the primitive jugular vein. Often there are no traces of the petro-squamous sinus.

Emissary Veins.—These are vessels which pass through foramina in the cranial wall, and establish communications between the intracranial venous sinuses and the extracranial veins. The principal emissary veins are mastoid, nasal, posterior condylar, parietal, and occipital. In addition to these there are emissary veins, which pass through (1) the foramen ovale, (2) the foramen Vesalii (when present), and (3) the foramen lacerum and the carotid canal.

The *transverse sinus* in many cases has two emissary veins, mastoid and posterior condylar.

The **mastoid emissary vein** is of large size. It passes through the mastoid foramen, and usually opens into the posterior auricular vein.

The **posterior condylar emissary vein** passes through the posterior condylar foramen, and opens into the suboccipital plexus, from which the blood is carried away by the vertebral and deep cervical veins.

The mastoid and posterior condylar veins are not constant.

The *superior sagittal sinus* may have three emissary veins—parietal and occipital and nasal.

The **parietal emissary vein** passes through the parietal foramen, and opens into the occipital plexus, or into radicles of the superficial temporal vein.

The **occipital emissary vein** passes from the confluens sinuum to the occipital plexus, being transmitted through a minute foramen which pierces the external occipital protuberance.

The **nasal emissary vein** passes through the foramen cæcum; like all other emissary veins it is often absent.

It has been seen already that the **cavernous sinus** communicates with (1) the angular vein of the face, (2) the pterygoid plexus, and (3) the pharyngeal plexus. The **marginal** or **inferior occipital sinus** communicates with the posterior intraspinal veins, and the **basilar sinus** communicates with the anterior intraspinal veins.

Arachnoid Membrane.

This is a very delicate membrane which loosely surrounds the encephalon, and is situated between the dura mater and pia mater. It does not dip into the fissures, except in the case of the great longitudinal fissure, its general course being over the gyri and other eminences and depressions of the encephalon. It is conspicuous at the base of the encephalon in the region of the interpeduncular space, pons, and medulla oblongata. Its outer surface is practically in close contact with the inner surface of the dura mater, the extremely slight interval containing a very little lubricating serous fluid, and being known as the **subdural space.** Between the arachnoid and the pia mater there is the interval known as the subarachnoid space. The membrane furnishes sheaths to the various cranial nerves.

Subarachnoid Space.—This space lies between the arachnoid and the pia mater. It is crossed by delicate trabeculæ of connective tissue, which pass between the two membranes in a reticular manner. The meshes of this reticulum contain the cerebro-spinal fluid.

The subarachnoid space communicates with the ventricles of the brain by one main opening, the *median aperture of the ventricle* or foramen of Magendie, which is situated in the median line of the roof of the ventricle a little above the lower angle.* In some situations—as, for example, over the gyri—the arachnoid and pia mater are in close

* The modern view is that there are also foramina at the lateral angles of the ventricle, *lateral apertures*.

contact, but in other localities the two membranes are more or less widely separated by intervals, called **cisternæ.** The most important of these are the cisterna magna, cisterna pontis, cisterna basalis, and cisterna venæ magnæ.

The **cisterna cerebello-medullaris** (or **magna**) lies between the posterior part of the inferior surface of the cerebellum and the medulla oblongata. It is of large size, the arachnoid, which here passes from cerebellum to medulla, being widely separated from the pia mater. It is continuous through the foramen magnum with the posterior part of the subarachnoid space of the spinal cord.

The **cisterna pontis** is situated on the ventral aspect of the pons. Inferiorly it is continuous with the anterior part of the subarachnoid space of the spinal cord, and in the region of the medulla oblongata it is continuous otherwise with the previous cisterna and interpeduncularis. It contains the basilar artery.

The **cisterna basalis** or **interpeduncularis** is situated in front of the pons, in which situation the arachnoid extends over the interpeduncular space from one temporal lobe to the other. It contains the arteries which form the circulus arteriosus. This cisterna is prolonged outwards on each side into the stem of the lateral fissure, each of these prolongations containing the middle cerebral artery. Anteriorly it extends in front of the optic commissure into the great longitudinal fissure over the upper surface of the corpus callosum, this prolongation containing the anterior cerebral arteries.

The **cisterna venæ magnæ** lies just behind the entrance of the great transverse fissure, between the splenium and the corpora quadrigemina, where the great cerebral vein comes out.

The **subarachnoid fluid** can be drained away in two directions. It can enter the lymph-spaces of the cranial nerves upon which the arachnoid is prolonged outwards in the form of sheaths; and it can enter the lacunæ laterales, and through the intervention of the Pacchionian bodies make its way into the superior longitudinal sinus.

Structure of the Arachnoid Membrane.—The arachnoid consists of fine fibrous tissue arranged in interlacing bundles, the intervals between these bundles being occupied by delicate cellular membranes. Several such layers, intimately blended together, form the membrane.

Beneath the arachnoid, and constituting a part of it, there is a *reticulum* of *subarachnoid trabeculæ.* These trabeculæ consist, as in the case of the arachnoid proper, of fine fibrous tissue, but the intertrabecular spaces, instead of being occupied by cellular membranes, contain cerebro-spinal (subarachnoid) fluid. The trabecular reticulum connects the arachnoid with the subjacent pia mater. The superficial surface of the arachnoid is covered with a delicate layer of endothelium.

Arachnoid Granulations.—These are small granular bodies which are situated along the course of the superior longitudinal sinus, into which some of them project. They are seldom met with in adults in other sinuses—*e.g.*, the lateral and straight sinuses. Each body is a villous projection of the arachnoid membrane, with which it is connected by a narrow pedicle. Some bodies project into the superior

longitudinal sinus; others project from below into the lacunæ laterales. In all cases the bodies pierce the dura mater and carry before them the lining of the sinus. Superficially the bodies give rise to the depressions on the internal surface of the parietal bone near the superior border. Each body contains a prolongation of the subarachnoid space and reticulum. This is surrounded by a prolongation of the arachnoid membrane, and external to this is the endothelial lining of the sinus or of the lacuna. The granulations probably are channels through which the subarachnoid fluid can be drained away from the subarachnoid space into the lacunæ laterales, and thence into the superior sagittal sinus, as well as into the other sinuses—*e.g.*, the transverse and straight sinuses. They are rarely met with in children under twelve, and then most commonly in the transverse sinus.

Pia Mater.

The pia mater is the most internal covering of the encephalon. It is a very vascular membrane, which invests and is closely adherent to the entire surface. From its internal surface delicate processes pass into the cerebral substance, which represent the minute bloodvessels, surrounded by pia-matral sheaths. The pia mater not only invests the external surface, but also dips into the sulci, and covers the opposed surfaces of the gyri. It also furnishes sheaths to the various cranial nerves, which blend with their perineurium. It gives rise to two web-like expansions—namely, the tela chorioidea inferior and tela chorioidea superior.

The **tela chorioidea inferior** is situated in the lower part of the roof of the fourth ventricle, and from it are derived the choroid plexuses of that ventricle. The **tela chorioidea superior** (or *velum interpositum*) is an invagination of the pia mater through the transverse fissure beneath the splenium of the corpus callosum. It lies underneath the body of the fornix, and its lower surface is covered by the ependymal lining of the third ventricle, the latter forming the roof of that cavity. The tela chorioidea superior furnishes the choroid plexuses of the two lateral and third ventricles.

The pia mater of the encephalon differs from the pia mater of the spinal cord in being thinner and less adherent to the nervous substance. The greater thinness is due to the fact that it is destitute of the outer layer which characterizes the spinal pia mater.

Structure.—The pia mater of the encephalon consists of a single layer of areolar tissue, which contains a great many small bloodvessels, these being derived from the larger vessels lying in the subarachnoid space.

The Cranial Nerves.

The cranial nerves are arranged in twelve pairs. They have received numerical names according to the order in which they leave the cranial cavity from before backwards, and they also have descrip-

tive names. The different pairs of nerves are as follows, in order from before backwards:

First, or **olfactory.**	**Seventh**, or **facial.**
Second, or **optic.**	**Eighth**, or **auditory.**
Third, or **oculo-motor.**	**Ninth**, or **glosso-pharyngeal.**
Fourth, or **trochlear** (**pathetic**).	**Tenth**, or **vagus.**
Fifth, or **trigeminal** (**trifacial**).	**Eleventh**, or **accessory.**
Sixth, or **abducent.**	**Twelfth**, or **hypoglossal.**

The cranial nerves are connected to certain parts of the encephalon, and these connections constitute their *superficial* or *apparent origins*. The fibres, however, can be traced to certain collections of grey matter, which are called **nuclei.** From the deep positions occupied by these nuclei they constitute the *deep origins* of the nerves.

First or olfactory nerve consists of the olfactory filaments or nerves, which are about twenty in number.

The **olfactory nerves** are non-medullated. They arise as the axons of the olfactory cells of the olfactory mucous membrane of the nasal fossa; and enter the cranial cavity through the foramina of one half of the cribriform plate of the ethmoid bone. Thereafter they enter the grey matter on the ventral or inferior aspect of the olfactory bulb, and terminate in arborizations which intermingle with the arborizations formed by the dendrites of the mitral cells situated in the granular layer of the bulb (see p. 1570).

Second or Optic Nerve.—This nerve arises from the brain by means of the optic tract, the deep connections of which have been already described (p. 1545). Each **optic tract** passes forwards and inwards to the **optic commissure** or **chiasma,** which is situated in front of the inter-peduncular space. The **optic nerve** of each side arises from the anterior part of the optic chiasma. It courses forwards and outwards to the optic foramen, through which it passes into the orbit, piercing the dura mater, and receiving a sheath from it, as well as from the arachnoid membrane. Having reached the back part of the eyeball, it pierces the sclerotic and choroid coats $\frac{1}{8}$ inch to the nasal or inner side of the axis of the eyeball, and terminates in an expansion which forms the most internal layer of the retina, called the nerve-fibre or optic layer.

Neither this nor the preceding is, strictly speaking, a nerve at all.

Third or Oculo-motor Nerve.—The fibres of this nerve arise from the *oculo-motor nucleus,* which is situated in the grey matter of the ventral aspect (floor) of the aqueduct on a level with the upper quad-rigeminal body, and extends superiorly for a short distance on to the lateral wall of the third ventricle. The nucleus is intimately related to the medial longitudinal bundle, by means of which it is connected with the trochlear and abducent nuclei. All three nuclei receive collaterals from the bundle; and in this manner a functional association between these nuclei is maintained, and harmonious action is insured on the part of the muscles which are supplied by the nerves arising from them. It consists of several groups of cells. As many as seven groups are ascribed to each oculo-motor nucleus by Perlia, which correspond

to the seven muscles supplied by the oculo-motor nerve, and are disposed symmetrically. In addition to these, there is a medially-placed group, the cells of which furnish fibres to both oculo-motor nerves. The fibres which arise from the individual groups of each nucleus are regarded as supplying particular orbital muscles. Certain of the oculo-motor fibres of one side arise from the nucleus of the opposite side, the fibres from either side decussating at the median line. Moreover, each oculo-motor nerve is said to receive fibres from the abducent

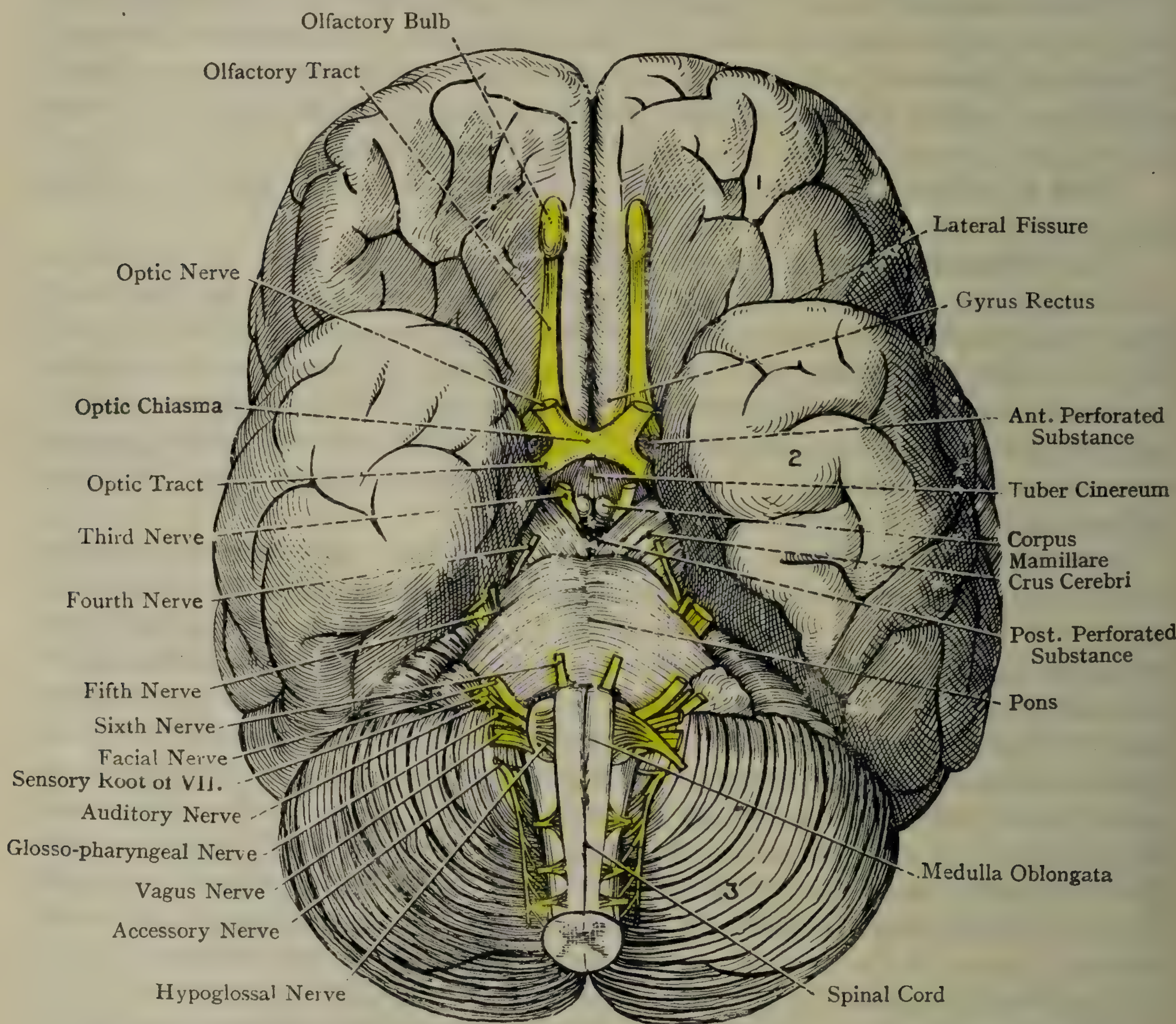


FIG. 990.—THE BASE OF THE ENCEPHALON, AND THE CRANIAL NERVES.
1, frontal lobe (orbital surface); 2, temporal lobe; 3, cerebellum.

nucleus of the opposite side, which ascend in the posterior longitudinal bundle and cross to the other side.

Two views are entertained in regard to the nerve-supply of the medial rectus muscle. According to one view, the muscle of one side is supplied by those fibres which have crossed from the oculo-motor nucleus of the opposite side. The other view is that the muscle of one side is supplied by those fibres which have crossed from the abducent nucleus of the opposite side. According to this latter view,

the nerve-fibres which supply the lateral rectus muscle of one side and those which supply the medial rectus muscle of the opposite side arise from the same nucleus—namely, the abducent nucleus—and *vice versa.*

Probably the whole of the oculo-motor nucleus is not in series with the medial somatic group to which the fourth, sixth, and twelfth nuclei belong, but that some of it corresponds to the more lateral group containing the seventh, ninth, and tenth nuclei. Fibres from this part probably go to the ciliary muscle and iris.

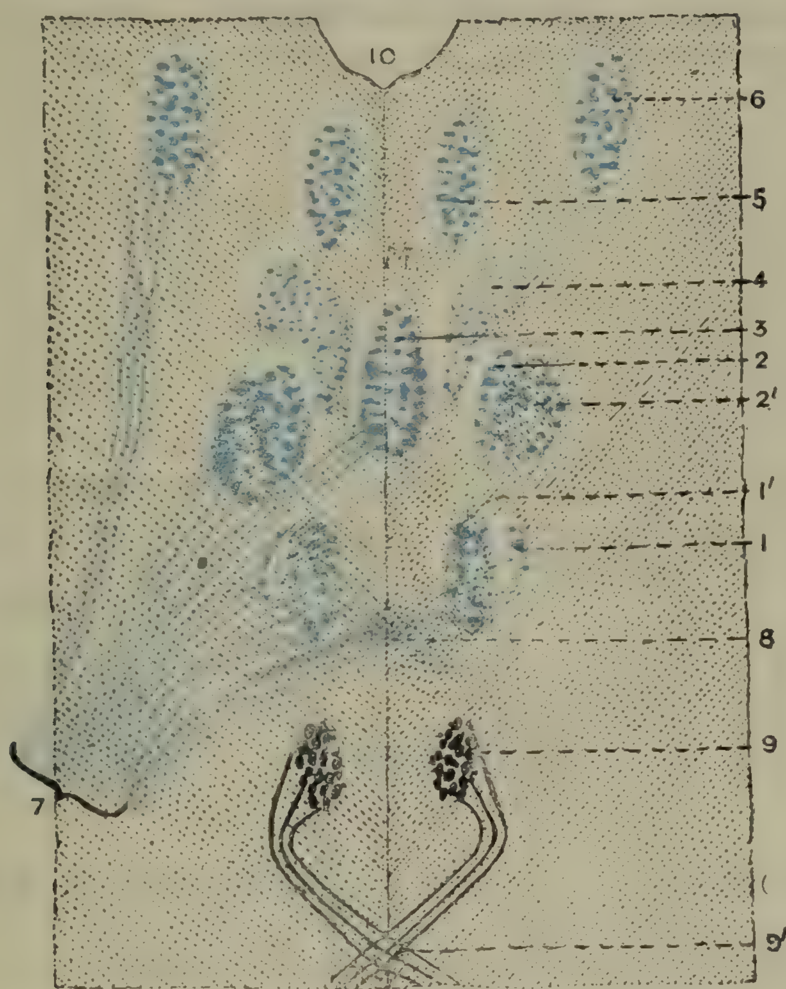


FIG. 991.—SCHEME SHOWING THE DIFFERENT CELL-GROUPS WHICH CONSTITUTE, ACCORDING TO PERLIA, THE NUCLEUS OF ORIGIN OF THE THIRD CRANIAL OR OCULO-MOTOR NERVE (FROM TESTUT, AFTER PERLIA).

1. Posterior Dorsal Nucleus
1'. Posterior Ventral Nucleus
2. Anterior Dorsal Nucleus
2'. Anterior Ventral Nucleus
3. Central Nucleus
4. Nucleus of Edinger and Westphal
5. Antero-medial Nucleus
6. Antero-lateral Nucleus
7. Trunk of Oculo-Motor Nerve
8. Crossed Fibres
9. Nucleus of Origin of Fourth Nerve
9'. Intercrossing of Fourth Cranial Nerves
10. Third Ventricle
M. Middle Line.

The old view, that the orbicularis oculi is supplied from this nucleus, by the medial longitudinal bundle and the facial trunk, is no longer held by anatomists.

Course of the Fibres of the Third Nerve.—The fibres pass forwards from their origin through the tegmentum, the red nucleus, and the medial portion of the substantia nigra, and afterwards make their superficial appearance at the oculo-motor sulcus on the medial aspect of the crus cerebri.

The third or oculo-motor nerve supplies the following seven muscles: the levator palpebræ superioris; the superior, inferior, and internal

recti; the inferior oblique; the sphincter pupillæ; and the ciliary muscle.

Fourth (Trochlear, or Pathetic) Nerve.—The fibres of this nerve arise from the *trochlear nucleus*, which is situated in the grey matter of the ventral aspect (floor) of the aqueduct on a level with the upper part of the lower quadrigeminal body. The nucleus is intimately related to the medial longitudinal bundle, by means of which it is connected with the oculo-motor nucleus.

The fibres are at first directed laterally and backwards, and then medially to the upper part of the superior medullary velum, which they enter. Here the nerve crosses to the opposite side, decussating

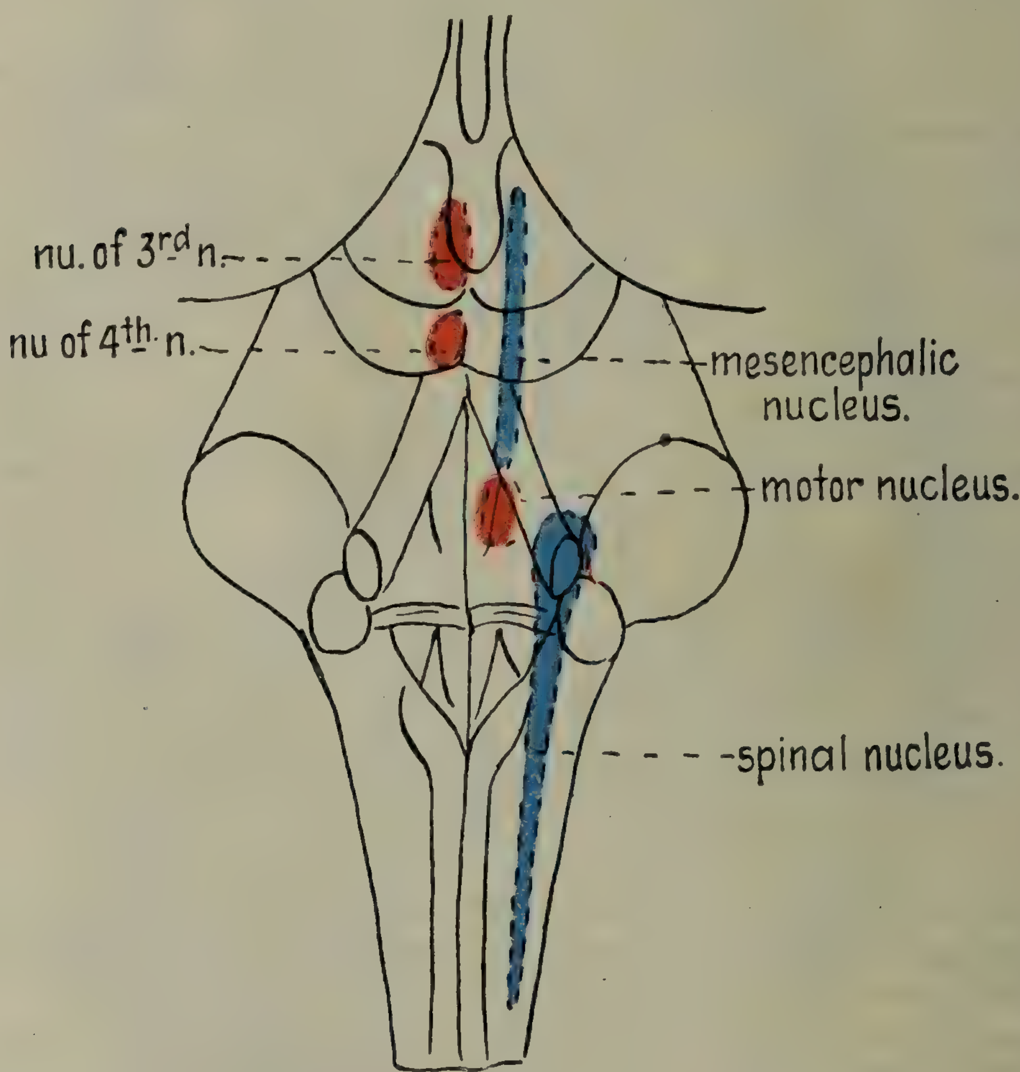


FIG. 992.—DEEP ORIGINS OF THIRD, FOURTH, AND FIFTH CRANIAL NERVES.

with its fellow, after which it emerges from the upper end of the superior medullary velum close below the lower quadrigeminal body, and by the side of the *frenulum veli*. After this the nerve turns over the superior peduncle of the cerebellum, and is then directed forwards, round the outer aspect of the crus cerebri, between which and the temporal lobe it makes its superficial appearance.

The fourth nerve supplies the superior oblique muscle of the eyeball.

Fifth Cranial, Trigeminal (or Trifacial) Nerve.—The fifth cranial nerve resembles a spinal nerve in having two roots—sensory and motor—the former being large, and having a ganglion, called the *trigeminal ganglion*.

Sensory Root.—The fibres of this root are derived from the central poles of the bipolar cells of the **trigeminal ganglion.** After entering the pons each fibre divides into two branches, ascending and descending, as in the case of the fibres of the dorsal or sensory root of a spinal nerve. The terminal nuclei of these ascending and descending sensory fibres are two in number—upper and lower.

The **upper sensory nucleus** is situated in the outer portion of the dorsal part of the pons, where it lies close to the lateral side of the pontine or principal motor nucleus of the nerve. The *ascending sensory fibres*, after a short course, enter this nucleus and terminate in arborizations around its cells.

The **lower sensory nucleus,** continuing the line of the upper sensory nucleus, is an upward prolongation of the substantia gelatinosa from the tubercle and funiculus gelatinosus in the medulla oblongata. The nucleus is traceable as low as the dorsal grey horn of the spinal cord on a level with the second cervical spinal nerve, where it is close to the substantia gelatinosa. The *descending sensory fibres*, which are numerous, and constitute the **spinal root** of the fifth nerve, pass downwards through the pons and medulla oblongata into the spinal cord as low as the level of the second cervical spinal nerve. They are accompanied by the **lower sensory nucleus,** and at different levels they enter this nucleus and terminate in arborizations around its cells.

The disposition of the fibres and cells within the spinal root is of a reversed order—that is, the ophthalmic nerve is associated with the lower part of the spinal root, above this the maxillary, with the mandibular at the upper end.

The ascending or **mesencephalic nucleus** of the fifth extends along the grey matter on the side of the aqueduct as far as the level of the lower part of the upper corpus quadrigeminum. Its lower limit is lateral to the substantia cœrulea in the upper part of the fourth ventricle. The mesencephalic root has only been recognized as sensory within the last few years, and there is reason to suppose that it receives proprioceptive impulses from certain muscles.

Motor Nucleus.—This nucleus is placed in the lateral part of the tegmental region of the pons, deep to the floor of the upper or pontine portion of the fourth ventricle, and immediately medial to the upper sensory nucleus of the nerve. Its fibres run ventro-laterally to emerge as the small *motor root* of the nerve.

Most of the axons of the cells of the terminal sensory nuclei pass inwards to the raphé and cross to the opposite side. They then become longitudinal and ascend in company with the medial lemniscus or chief sensory tract, their destination being the thalamus of the side to which they have crossed. They thus constitute a *trigemino-thalamic ascending tract.* From these fibres collaterals are furnished to (1) the facial nucleus, and (2) the ventral vago-glosso-pharyngeal nucleus, or nucleus am-

biguus, from the cells of which latter the efferent or motor fibres of the pneumogastric or vagus nerve arise.

A few of the axons, however, enter the pontine or chief motor nucleus, and also the mesencephalic sensory nucleus, of the nerve, and terminate in arborizations around its cells.

The large sensory and small motor roots appear close together on the lateral aspect of the ventral surface of the pons, the motor root lying above and slightly internal to the sensory root. The sensory root *enters* and the motor root *leaves* the pons.

Distribution.—The fifth cranial nerve has an extensive distribution by means of its three divisions—ophthalmic, superior maxillary, and inferior maxillary.

Ophthalmic Nerve (Sensory).—(1) The front part of the cranium; (2) the integument of (*a*) the upper eyelid, and (*b*) the root and tip of the nose; (3) the anterior part of the nasal mucous membrane, and the conjunctiva; (4) the eyeball; and (5) the lacrimal gland.

Maxillary Nerve (Sensory).—(1) The integument of the zygomatic and anterior part of the temporal regions; (2) the integument of (*a*) part of the lower eyelid, (*b*) the side of the nose, (*c*) the upper lip, and (*d*) that part of the face between the lower eyelid and the upper lip; (3) the upper teeth, and the mucous membrane of the upper gum; (4) a large part of the nasal mucous membrane; (5) the mucous membrane of the maxillary air-sinus (or antrum of Highmore); (6) the mucous membrane of (*a*) the naso-pharynx, and (*b*) the soft and hard palate and the tonsil.

Mandibular Nerve (Sensory and Motor).—The **sensory distribution** of this nerve is as follows: (1) the integument of (*a*) the temporal region, (*b*) the outer surface of the pinna, and (*c*) the external auditory meatus; (2) the integument of the lower lip, and that which covers the mandible; a recurrent branch runs along the petro-squamous suture, supplying the mucous membrane of the tympanum and of the mastoid antrum; (3) the temporo-mandibular joint; (4) the parotid salivary gland; (5) the mucous membrane lining the buccinator muscle, and the integument covering that muscle (by means of the *long* or *sensory buccal nerve*); (6) the mucous membrane (fungiform and conical papillæ) of the anterior two-thirds of the tongue (**common sensation**); (7) the submandibular and sublingual salivary glands; and (8) the pulps of the lower teeth, and the mucous membrane of the lower gum.

The **motor distribution** of the mandibular nerve is as follows: (1) The muscles of mastication—namely, (*a*) the masseter, (*b*) the temporal, and (*c*) the pterygoid muscles; (2) the mylo-hyoid muscle and *anterior belly* of the digastric; (3) the tensor tympani muscle by means of a branch from the otic ganglion; and (4) the tensor palati muscle through the otic ganglion.

Sixth or Abducent Nerve.—The fibres of this nerve arise from the *abducent nucleus*, which is situated in the dorsal part of the pons close to the median line. It lies above the striæ acusticæ on the floor of the

fourth ventricle subjacent to the eminentia teres. The fibres emerge from the inner part of the nucleus, and pass through the lower part of the pons in a forward and slightly downward and lateral direction to the lower border of the pons just lateral to the pyramid of the medulla oblongata, where the nerve makes its superficial appearance.

The abducent nucleus receives collaterals from the medial or posterior longitudinal bundle, and a functional connection is thereby established between that nucleus and the oculo-motor nucleus. The medial rectus muscle of one side and the lateral rectus of the other side are thus associated muscles.

The sixth nerve supplies the lateral rectus muscle of the eyeball.

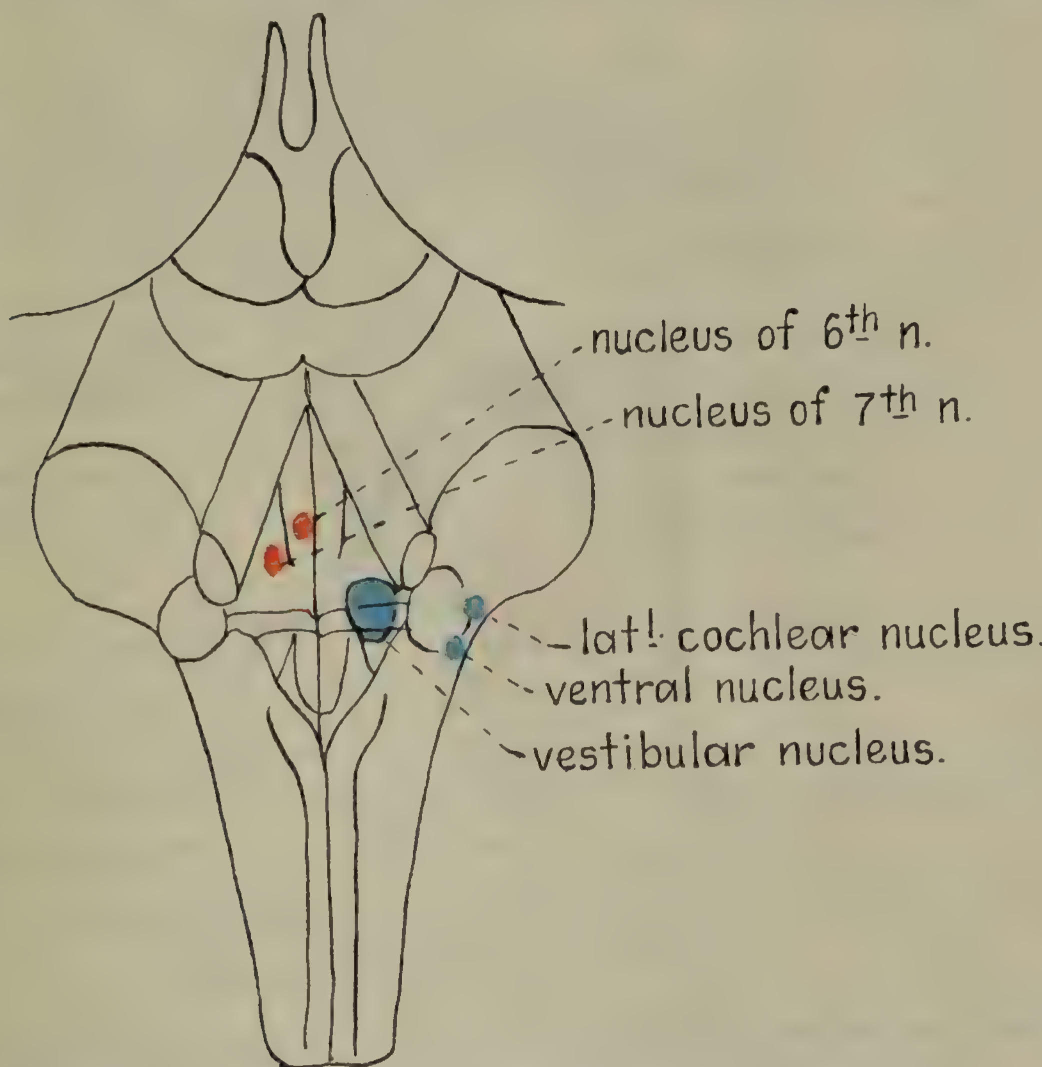


FIG. 993.—DEEP ORIGINS OF SIXTH, SEVENTH, AND EIGHTH CRANIAL NERVES.

Seventh or Facial Nerve.—The facial nerve is composed of two parts. One of these consists of efferent or *motor* fibres, and is known as the facial nerve proper. The other part, of small size, consists of afferent or *sensory* fibres. The **facial nerve proper** arises from the *facial nucleus*, which is situated deeply in the dorsal part of the lower portion of the pons. The fibres of the nerve pursue an intricate course before appearing superficially. They at first pass backwards and inwards to the floor of the fourth ventricle. Here they turn upwards, lying close to the median line in the form of a single bundle. The nerve then makes a sharp bend laterally, and passes forwards through the pons in a downward and outward direction to its place of emergence.

In its course within the pons the nerve is intimately related to the dorsal aspect of the abducent nucleus.

The *intrapontine part* of the facial nerve proper is intimately related to the following structures:

1. The abducent nucleus.
2. The superior olive.
3. The corpus trapezoides.
4. The spinal root of the fifth nerve.
5. The medial or posterior longitudinal bundle.

The motor facial nucleus receives fibres from the following sources: (1) The corpus trapezoides, being thereby brought into connection with the cochlear division of the auditory nerve; (2) the spinal root of the

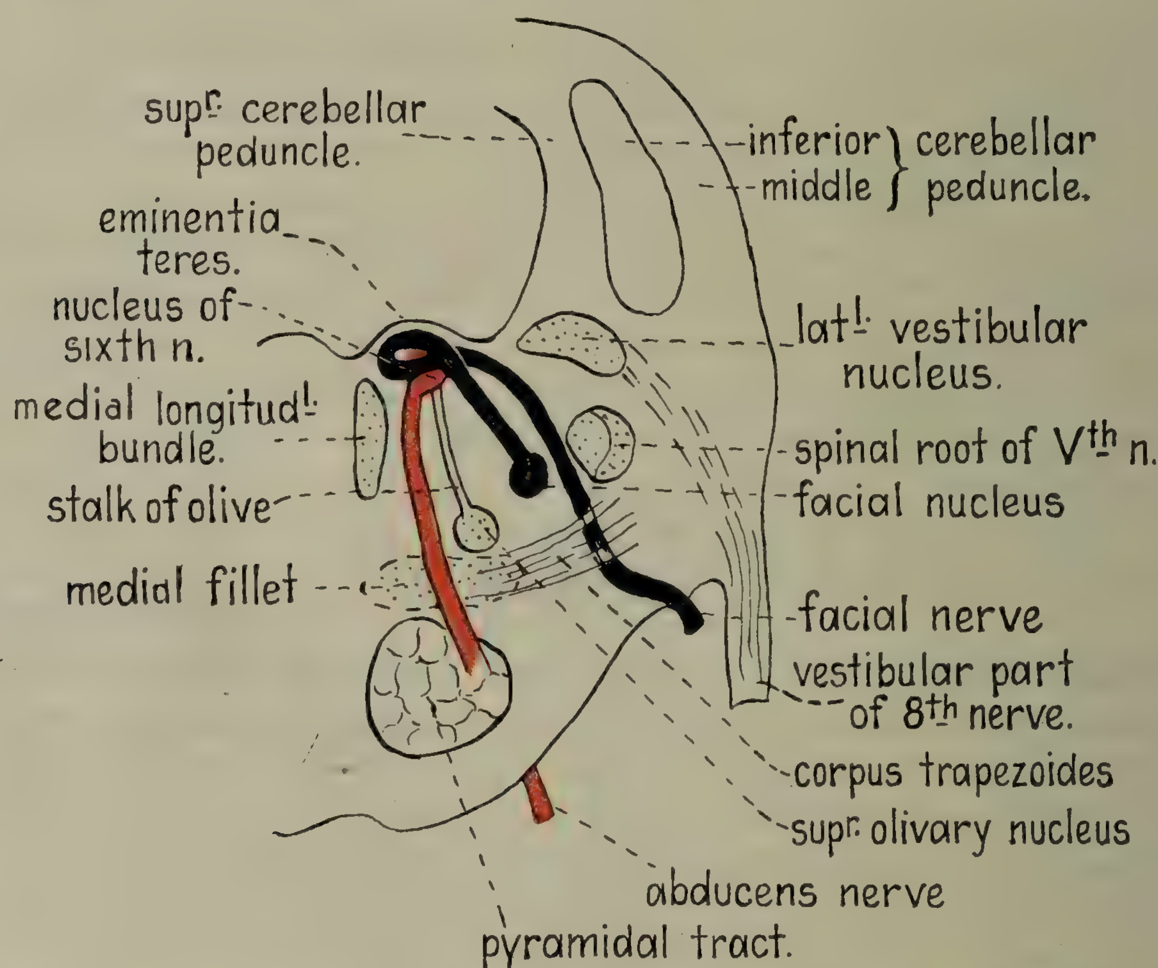


FIG. 994.—DIAGRAMMATIC SECTION THROUGH THE PONS, TO SHOW DEEP ORIGINS OF SIXTH (RED) AND SEVENTH (BLACK) CRANIAL NERVES.

fifth cranial or trigeminal nerve, which is the sensory nerve of the face; and (3) the pyramidal tract of the opposite side, being thereby brought into connection with the precentral motor area of the cerebral cortex.

All the foregoing fibres terminate within the nucleus in arborizations around its component cells.

The **sensory portion of the facial nerve** arises from the central poles of the bipolar cells of the *geniculate ganglion* on the facial nerve in the facial canal. This ganglion resembles the ganglion of the fifth nerve and the spinal ganglia, and most of the peripheral poles of its bipolar cells give rise to the **chorda tympani nerve.** The *pars intermedia* passes from the facial canal into the internal auditory meatus, after leaving which it runs to the lower border of the pons, where it lies between the

facial nerve proper and the auditory nerve. The nerve then *enters* the medulla oblongata, and passes downwards to the upper part of the **nucleus of the fasciculus solitarius** (see Glosso-pharyngeal Nerve), and its fibres terminate in arborizations around the cells of the *upper part* of that nucleus. In this situation it is closely associated with the terminal afferent or sensory fibres of the glosso-pharyngeal nerve.

The **facial nerve proper** *emerges from* the brain at the lower border of the pons in front of, and internal to, the auditory nerve; and the **sensory part** *enters* between the facial nerve proper and the auditory nerve.

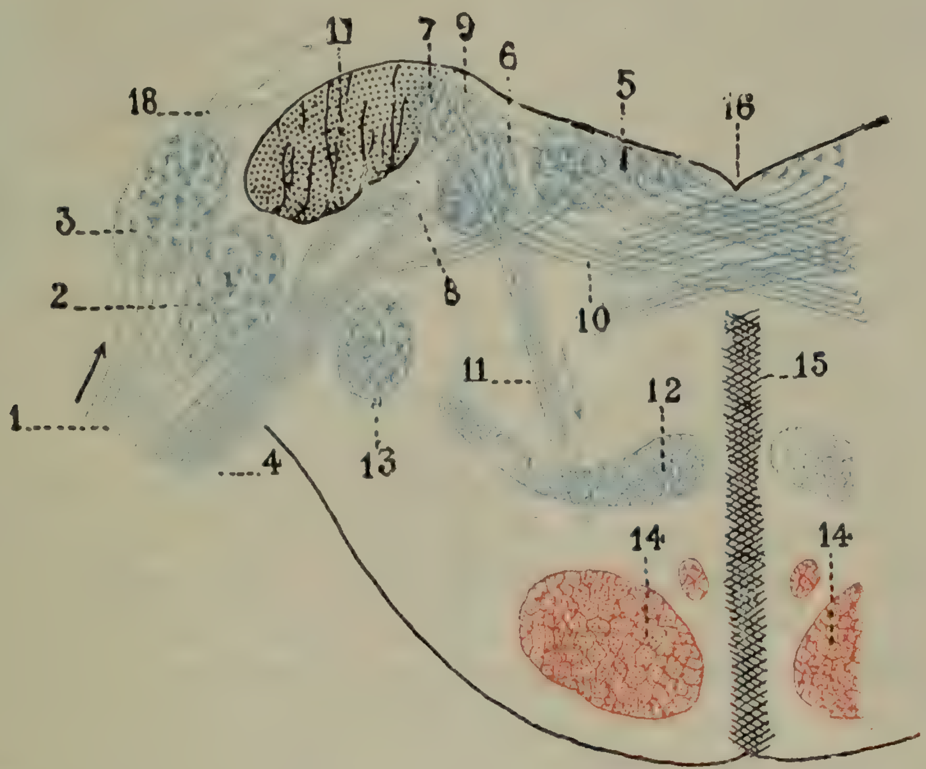


FIG. 995.—TERMINAL NUCLEI OF THE VESTIBULAR NERVE, WITH THEIR SUPERIOR CONNECTIONS (SCHEMATIC) (L. TESTUT'S 'ANATOMIE HUMAINE').

1. Cochlear Root, with its Two Nuclei
2. Accessory Nucleus
3. Lateral Nucleus (or Tuberculum Acusticum)
4. Vestibular Root
5. Medial Nucleus
6. Lateral Vestibular Nucleus (or Nucleus of Deiters)
7. Superior Nucleus (of Bechterew)
8. Inferior Root or Nucleus of Auditory Nerve
9. Ascending Cerebellar Fibres
10. Fibres passing to Raphé
11. Oblique Fibres
12. Lemniscus
13. Inferior Sensory Root of Fifth Cranial Nerve
14. Pyramidal Fibres
15. Raphé
16. Fourth Ventricle
17. Inferior Peduncle of Cerebellum (Restiform Body)
18. Origin of Auditory Striæ

Distribution—Motor Part (Facial Nerve Proper).—(1) The muscles of the face, *including the buccinator*; (2) the occipito-frontalis; (3) the muscles of the auricle; (4) the posterior belly of the digastric and the stylo-hyoid; (5) the platysma myoides; and (6) the stapedius muscle within the tympanic cavity.

Sensory Part (Sensory Root and Chorda Tympani).—The anterior two-thirds of the tongue (sense of **taste**).

The **chorda tympani nerve** conveys secretory and vaso-dilator fibres from the facial nerve proper to the submandibular and sublingual salivary glands.

The **large superficial petrosal nerve** from the *geniculate ganglion* of the facial nerve is concerned in the supply of the mucous membrane

of the palate, the path being as follows: (1) Large superficial petrosal nerve (facial fibres); (2) the nerve of pterygoid canal; (3) spheno-palatine ganglion; and (4) the descending palatine nerves.

Eighth, Auditory, or Acoustic Nerve.—The auditory nerve is the nerve of **hearing** and of **equilibrium.** It is an afferent or centripetal nerve which conducts impressions from the membranous labyrinth (cochlea and vestibule) to the medulla oblongata and pons, and thence to the cerebrum and cerebellum. It consists of two divisions—namely, the cochlear nerve or root, and the vestibular nerve or root.

The fibres of the *cochlear* nerve arise from the bipolar cells of the spiral ganglion in the spiral canal of the modiolus, the modiolus being the central pillar of the osseous cochlea. The fibres of the *vestibular* nerve arise from the bipolar cells of the **vestibular ganglion** (or ganglion of Scarpa) at the deep end of the internal auditory meatus.

The two nerves or roots reach the brain at the lower border of the pons lateral to the facial nerve and ventral to the restiform body. They have different central connections, and consequently take different courses. The cochlear nerve passes round the outer side of the restiform body, whilst the vestibular nerve passes backwards medial to that body, and each root has special terminal nuclei.

Cochlear Nerve.—The **terminal nuclei** of the cochlear nerve, which is the nerve of hearing, are two in number—ventral and lateral.

The **ventral** or **accessory nucleus** lies on the ventral aspect of the inferior peduncle between the cochlear and vestibular nerves. The **lateral** or **dorsal nucleus,** or *tuberculum acusticum,* is situated on the lateral and dorsal aspects of the peduncle. The fibres of the cochlear nerve or root enter these two nuclei, and terminate in arborizations around their component cells.

Central Connections of the Ventral and Lateral Cochlear Nuclei.—The ventral and lateral nuclei constitute cell-stations in the path of the fibres of the cochlear nerve, and from these cell-stations two fresh nerve-tracts arise, one being ventral, which constitutes the corpus trapezoides, and the other dorsal, which forms the auditory striæ.

Ventral Cochlear Tract.—The relays, or fresh supplies, of nerve-fibres for this tract are furnished by the cells of the *ventral nucleus.* The axons of these cells give rise to the **trapezium,** or **corpus trapezoides,** which is reinforced by the axons of the cells of the nucleus trapezoides, and fibres from the superior olive of the same side. The trapezoidal fibres cross the median plane, and thereafter constitute the **lateral lemniscus,** being further reinforced by fibres from the superior olive of the side to which they have crossed, and from the nucleus of the lateral lemniscus. The fibres of this fillet terminate in the lower quadrigeminal body and internal geniculate body, both of the same side.

Dorsal Cochlear Tract.—The relays of fibres for this tract are furnished by the cells of the *lateral nucleus.* The axons of its cells form the **auditory striæ,** which cross the dorsal aspect of the restiform body and the floor of the fourth ventricle. At the median line they pass

forwards, and then cross to the opposite side. Thereafter they join the lateral or acoustic lemniscus of the side to which they have crossed.

The **lateral** or **acoustic lemniscus** (see p. 1557) derives its fibres from the following sources: (1) The corpus trapezoides; (2) the auditory striæ; (3) the superior olive of both sides; and (4) the nucleus of the

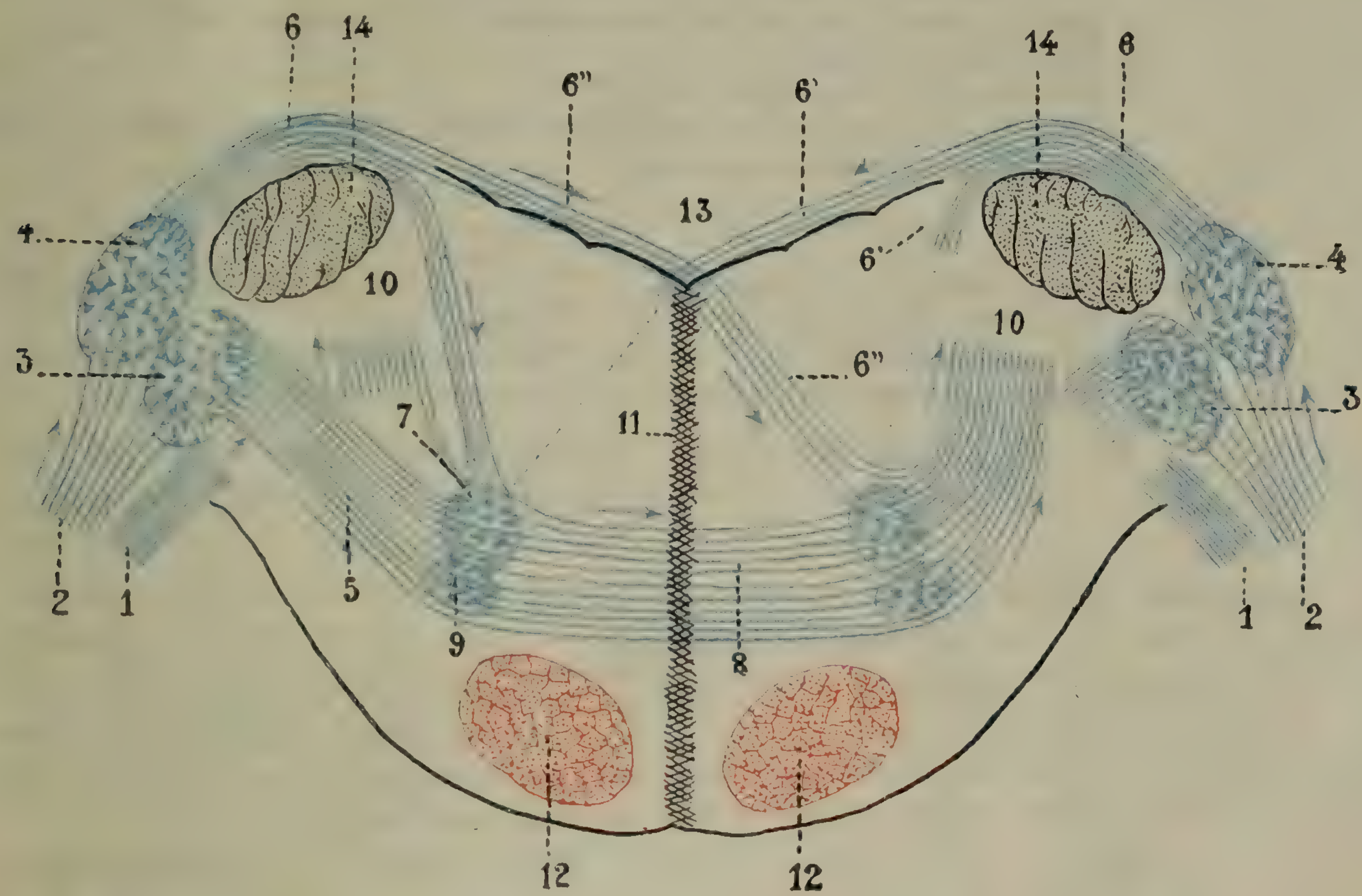


FIG. 996.—TERMINAL NUCLEI OF THE COCHLEAR NERVE, WITH THEIR SUPERIOR CONNECTIONS (SCHEMATIC) (L. TESTUT'S 'ANATOMIE HUMAINE').

The vestibular root and its terminal nuclei, with the efferent fibres of these latter, have been suppressed. In order not to obscure the trapezoid body, the efferent fibres of the terminal nuclei of the right side have been in a great part of their extent resected. The trapezoid body is consequently composed of only half of its fibres—namely, those which come from the left.

1. Vestibular Root of Auditory Nerve
2. Cochlear Root
3. Ventral Nucleus of Auditory Nerve
4. Lateral Nucleus (or Tuberculum Acusticum)
5. Efferent Fibres of Ventral Nucleus
6. Efferent Fibres of Lateral Nucleus, forming the Auditory Striæ

6'. Direct Fibres of the Striæ going to the Superior Olivary Body of the same side

6". Crossed Fibres of the Striæ going to the Superior Olivary Body of the opposite side.

7. Superior Olivary Body
8. Corpus Trapezoides
9. Trapezoid Nucleus
10. Lateral Lemniscus
11. Raphé
12. Pyramidal Tract
13. Fourth Ventricle
14. Inferior Peduncle of Cerebellum (Restiform Body)

lateral lemniscus. It serves as a path of connection between the ventral and lateral cochlear nuclei of one side, and the **lower quadrigeminal body** and **medial geniculate body** of the opposite side.

It is to be noted that the ventral and lateral cochlear nuclei are slightly connected with the lower quadrigeminal body of the same side, but not with the corresponding medial geniculate body.

The axons of the cells of the medial geniculate body form a *corti-*

cipetal tract, which passes to the cortex of the first or superior temporal gyrus of the temporal lobe of the brain.

The complex nervous chain associated with the cochlear nerve may be tabulated as follows:

1. **The bipolar cells of the spiral ganglion.**
2. **The fibres of the cochlear nerve.**
3. **The ventral and lateral cochlear nuclei.**
4. **The fibres of the corpus trapezoides, reinforced as stated.**
5. **The auditory striæ.**
6. **The medial geniculate body.**
7. **The corticipetal tract from the medial geniculate body to the superior temporal gyrus.**

The **cell-stations** connected with this nervous chain are as follows:

1. **The ventral cochlear nucleus.**
2. **The lateral cochlear nucleus.**
3. **The nucleus trapezoides.**
4. **The superior olive of each side.**
5. **The nucleus of the lateral lemniscus.**
6. **The lower quadrigeminal body.**
7. **The medial geniculate body.**

Some of the fibres of the chain terminate in these cell-stations, and others are derived from the axons of the cells which compose the stations.

Vestibular Nerve.—The **terminal nuclei** of the vestibular nerve, which is the nerve of **equilibrium,** are three in number—namely, (1) the dorsal or principal nucleus, (2) the descending nucleus, and (3) the nucleus of Deiters, associated with which there is the nucleus of Bechterew.

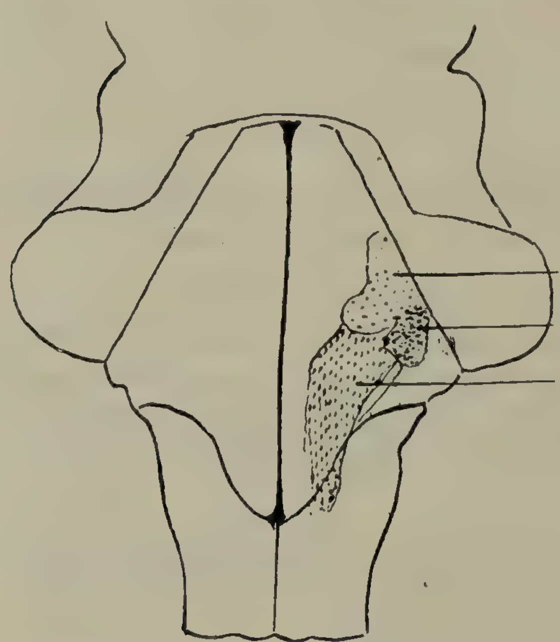


Fig. 997.—The Position of the Vestibular Nuclei in Relation to Floor of Fourth Ventricle (Semi-schematic).

The **medial** or **principal nucleus** is situated in the floor of the fourth ventricle underneath the *area acustica* and *striæ* (see Fig. 995, 5). The **inferior nucleus** is continuous with the lower end of the dorsal nucleus, and it accompanies the descending fibres of the vestibular nerve into the medulla oblongata. The **lateral nucleus** (**nucleus of Deiters**) is situated lateral to the dorsal and descending nuclei, and the **superior nucleus** (**nucleus of Bechterew**) represents the upper and outer part of the nucleus of Deiters.

As the vestibular nerve passes backwards medial to the inferior peduncle, some of its fibres, to be presently described, turn downwards. The majority, however, pass to the principal nucleus, the lateral nucleus, and the superior nucleus, and terminate in arborizations around the cells of these nuclei. A few of the vestibular fibres are regarded as passing directly to the cerebellum (superior vermis).

Central Connections of the Nuclei of the Vestibular Nerve.—The fibres of the vestibular nerve terminate in the nuclei just stated. The medial or principal nucleus and the other vestibular nuclei are intimately related to the superior vermis of the cerebellum, and especially to the roof-nucleus, by means of cerebellar fibres. This communication represents the *direct sensory cerebellar tract of Edinger*, and it is contained within the inferior peduncle of the cerebellum. The axons of many of the cells of the lateral nucleus and superior nucleus pass into the **medial** or **posterior longitudinal bundle,** within which they divide into ascending and descending branches. In this manner the medial longitudinal bundle is brought into communication with the vestibular nerve. By means of the medial longitudinal bundle, which represents the ground-bundles in the spinal cord, the nucleus of Deiters is brought into communication with the anterior or motor horns of the spinal cord. By means of this bundle the nucleus is also brought into communication with the nuclei which control the ocular muscles—namely, the oculo-motor, trochlear, and abducent nuclei.

The complex nervous chains associated with the vestibular nerve may be tabulated as follows:

Cerebellar Chain.

1. **The bipolar cells of the vestibular ganglion.**
2. **The fibres of the vestibular nerve.**
3. **The medial vestibular nucleus, lateral nucleus, and superior nucleus.**
4. **The secondary cerebellar vestibular tract or the direct sensory cerebellar tract of Edinger, leading to the superior vermis and roof-nucleus of the cerebellum.**

Spinal and Oculo-motor Chains.

1. **The bipolar cells of the vestibular ganglion.**
2. **The fibres of the vestibular nerve.**
3. **The lateral and superior vestibular nuclei.**
4. **The secondary vestibular tract from the nuclei to the posterior longitudinal bundle, and thence to the motor horns of the spinal cord and the motor nuclei of the ocular muscles.**

The lateral nucleus thus has important connections as follows:

1. The membranous vestibule.
2. The cerebellum.
3. The motor horns of the spinal cord.
4. The motor nuclei of the ocular muscles.

Descending Fibres of the Vestibular Nerve.—As the vestibular nerve passes backwards on the medial side of the inferior peduncle, some of its fibres, as stated, take a downward course. These **descending fibres** constitute the so-called *descending root of the vestibular nerve.* They descend through the lower part of the pons into the medulla oblongata as low as the level of the cuneate tubercle. They are accompanied throughout by the descending nucleus, and they are usually regarded as terminating in arborizations around the cells of

that nucleus. *Superiorly* they are related to the lateral vestibular nucleus, and some authorities have regarded them as fibres passing between the nucleus and the cuneate nucleus.

The cochlear and vestibular nuclei originally form one **acoustic** or **auditory nucleus,** which is developed from the **rhombic lip.**

Ninth or Glosso-pharyngeal Nerve.—This nerve consists chiefly of afferent or sensory fibres, which grow into the medulla oblongata, but it also contains a few efferent or motor fibres, which arise within the medulla oblongata.

Afferent or Sensory Fibres.—These fibres arise from the central poles of the bipolar cells of the ganglia which are situated on the

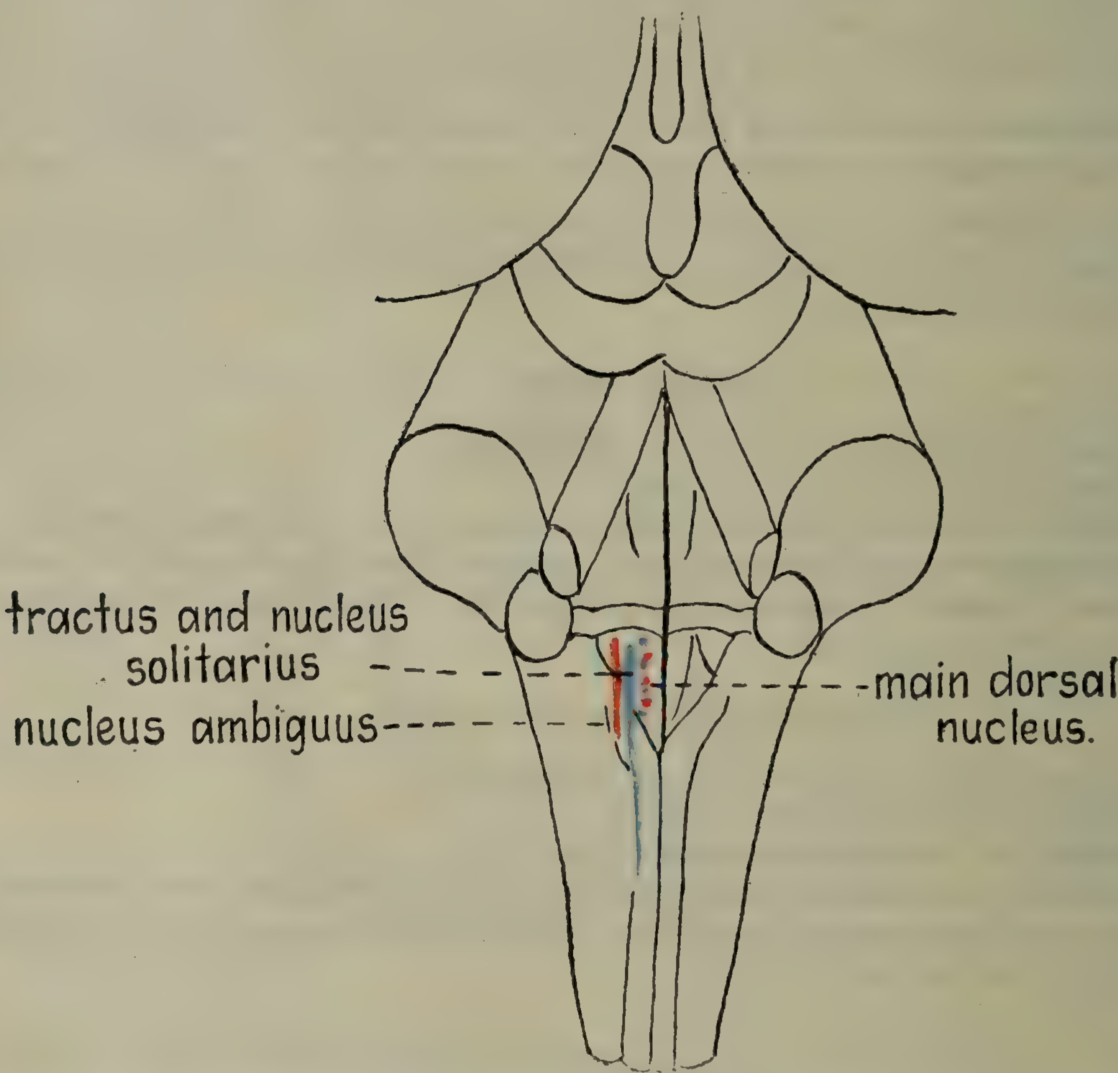


FIG. 998.—DEEP ORIGINS OF NINTH AND TENTH CRANIAL NERVES.

glosso-pharyngeal nerve as it passes through the jugular foramen. These ganglia resemble the ganglion of the fifth nerve and the spinal ganglia. Having entered the medulla oblongata, the afferent fibres end in two terminal sensory nuclei—namely, the dorsal vago-pharyngeal nucleus, and the nucleus of the fasciculus solitarius.

The **dorsal vago-pharyngeal nucleus** consists of two parts—upper and lower. The *upper part* is situated in the grey matter of the floor of the lower or bulbar part of the fourth ventricle, underneath the superficial area known as the *trigonum vagi*, and immediately *external* to the hypoglossal nucleus. The *lower part* is situated in the lower or closed part of the bulb, and lies in the grey matter which forms the lateral

wall of the central canal of the bulb, being here situated *behind* the hypoglossal nucleus.

The *highest part* of the dorsal vago-glosso-pharyngeal nucleus represents the portion associated with the glosso-pharyngeal nerve, and the remaining and greater part belongs to the vagus nerve.

The **nucleus of the fasciculus solitarius** is a column of grey matter and nerve-cells which accompanies the fasciculus solitarius, to be presently described, throughout the whole length of the medulla oblongata (Figs. 889 and 998).

A *few* of the afferent fibres of the glosso-pharyngeal nerve enter the *highest part* of the dorsal vago-glosso-pharyngeal nucleus, and terminate in arborizations around its cells. *Most* of the afferent fibres, however, descend along with a few of the afferent fibres of the vagus nerve, the two sets of descending fibres constituting a strand, called the **fasciculus solitarius** (**tractus solitarius**). This strand descends throughout the whole length of the medulla oblongata. It lies lateral to the dorsal vago-glosso-pharyngeal nucleus, inclining towards the ventral aspect of the upper part of that nucleus, and towards the dorsal aspect of its lower part. It is accompanied throughout by the nucleus of the fasciculus solitarius, and the glosso-pharyngeal afferent fibres of the fasciculus solitarius terminate at different levels in arborizations around its cells. The fasciculus solitarius is formed chiefly, not entirely, by glosso-pharyngeal fibres: fibres from facial enter its upper end.

Efferent or Motor Fibres.—These fibres arise within the medulla oblongata as the axons of some of the cells of the **ventral vago-glosso-pharyngeal nucleus** or **nucleus ambiguus.** This nucleus is situated in the formatio reticularis grisea of the medulla oblongata, and is in line with the facial motor nucleus, which is placed in the dorsal part of the lower portion of the pons. The nucleus ambiguus is ventral in position to the dorsal vago-glosso-pharyngeal nucleus, and the axons of its cells, some of which form the glosso-pharyngeal efferent or motor fibres, pass dorsalwards towards the last named. They then alter their course, and, passing forwards and laterally, associate themselves with the afferent or sensory glosso-pharyngeal fibres.

The funiculi of the glosso-pharyngeal nerve appear in the dorso-lateral sulcus of the medulla oblongata, between the olivary and resti-form bodies, and immediately below the facial nerve.

Distribution.—The glosso-pharyngeal nerve is distributed to (1) the mucous membrane of the posterior third of the tongue, of which part it is the nerve of taste, as well as of common sensation; (2) the mucous membrane of the pharynx, tonsil, and fauces; (3) the mucous membrane of the tympanum; and (4) the stylo-pharyngeus muscle. It also furnishes secretory and vaso-dilator fibres to the parotid gland by means of (1) its tympanic branch (Jacobson's nerve), (2) the tympanic plexus, (3) the small superficial petrosal nerve, (4) the otic ganglion, and (5) the auriculo-temporal nerve.

Tenth or Vagus Nerve.—This nerve consists of afferent or sensory

fibres, which grow into the medulla oblongata; and efferent or motor fibres, which arise within the medulla oblongata.

Afferent or Sensory Fibres.—These fibres arise from the central poles of the bipolar cells of the *ganglion of the root* and the *ganglion of the trunk* of the nerve, which resemble the glosso-pharyngeal ganglia, the ganglion of the fifth nerve, and the spinal ganglia. Having entered the medulla oblongata, the afferent fibres pass to the same two terminal sensory nuclei as do the afferent fibres of the glosso-pharyngeal nerve—namely, the **dorsal vago-glosso-pharyngeal nucleus** and the **nucleus of the fasciculus solitarius**—which have just been described in connection with the glosso-pharyngeal nerve. *Most* of the afferent fibres of the vagus nerve pass to the *vagal portion* of the dorsal vago-glosso-pharyngeal nucleus, which represents its greater and lower part, the highest part of the nucleus receiving, as stated, *a few* of the afferent fibres of the glosso-pharyngeal nerve. Within the vagal part of the nucleus the afferent fibres of the vagus terminate in arborizations around its cells. *A few* of the afferent fibres, however, descend along with *most* of the afferent fibres of the glosso-pharyngeal nerve, the two sets of descending fibres constituting the strand called the **fasciculus solitarius,** already described in connection with the glosso-pharyngeal nerve. These descending afferent vagal fibres terminate, like the corresponding glosso-pharyngeal fibres, in the **nucleus of the fasciculus solitarius,** which has been described in connection with the glosso-pharyngeal nerve.

The dorsal vago-glosso-pharyngeal sensory nucleus, and the nucleus of the fasciculus solitarius, also sensory, are therefore shared in common by the afferent or sensory fibres of the glosso-pharyngeal and vagus nerves, but in unequal proportions. Only a few glosso-pharyngeal afferent fibres go to the dorsal vago-glosso-pharyngeal nucleus, whereas most of the vagal afferent fibres pass to that nucleus. In the case of the nucleus of the fasciculus solitarius it is the reverse.

Efferent or Motor Fibres.—These fibres arise within the medulla oblongata as the axons of most of the cells of the **ventral vago-glosso-pharyngeal nucleus** or **nucleus ambiguus,** which has been described in connection with the glosso-pharyngeal nerve. The fibres pass dorsalwards to the more superficially placed dorsal vago-glosso-pharyngeal nucleus. They then alter their course, and, passing forwards and outwards, associate themselves with the afferent or sensory vagal fibres.

The ventral vago-glosso-pharyngeal nucleus or nucleus ambiguus, which is a *motor nucleus*, is shared in common by the efferent or motor fibres of the glosso-pharyngeal and spinal accessory nerves, especially the latter. The fibres from this nucleus join the vagus, and leave it as the pharyngeal and laryngeal branches.

The funiculi of the vagus nerve appear in the dorso-lateral sulcus of the medulla oblongata, between the olivary and restiform bodies, and immediately below the funiculi of the glosso-pharyngeal nerve.

Distribution.—The vagus nerve has a very extensive distribution on either side, of which the following is a summary:

Motor Distribution.—(1) The muscles of the soft palate (except the *tensor palati*); (2) the constrictor muscles of the pharynx; (3) the intrinsic muscles of the larynx; (4) the muscular tissue of the œsophagus and stomach; and (5) the muscular tissue of (*a*) the trachea, (*b*) the bronchi, and (*c*) the bronchial tubes.

Sensory Distribution.—(1) The pharynx, œsophagus, and stomach; (2) the larynx, trachea, and bronchial tubes to their terminal ramifications; and (3) the skin on the cranial aspect of the pinna, as well as of the lower and back part of the external auditory meatus.

Cardiac Fibres.—The cardiac fibres of the nerve are *inhibitory* (efferent) and *depressor* (afferent).

The most important connection of the vagus nerve is that which is established with the *bulbar* or *accessory portion* of the **accessory nerve.**

Glosso-pharyngeal and Vagal Nuclei.—These two nerves, as stated, consist of afferent or sensory and efferent or motor fibres. The afferent fibres of both nerves share in common two *terminal nuclei*—namely, the **dorsal vago-glosso-pharyngeal nucleus** and the **nucleus of the fasciculus solitarius.** Most of the glosso-pharyngeal afferent fibres terminate in the nucleus of the fasciculus solitarius, and most of the vagal afferent fibres terminate in the dorsal vago-glosso-pharyngeal nucleus. According to the description which has been given of the **dorsal vago-glosso-pharyngeal nucleus,** it is a *nucleus of termination,* or *sensory nucleus.* According to certain authorities, however, it is a *mixed nucleus*—that is to say, it is both a nucleus of termination, or sensory nucleus, and a nucleus of origin, or motor nucleus. In accordance with this view, the nucleus contains two sets of cells—*sensory* and *motor*—some of the afferent glosso-pharyngeal and most of the afferent vagal fibres terminating in arborizations around the sensory cells, and some of the efferent fibres of each nerve arising as the axons of the motor cells.

The **nucleus of the fasciculus solitarius** is a *nucleus of termination,* or sensory nucleus.

The fibres of the **sensory portion of the facial nerve** terminate in the *upper part* of the nucleus of the fasciculus solitarius.

The efferent or motor fibres of the glosso-pharyngeal and vagus nerves arise as the axons of the motor cells of the **ventral vago-glosso-pharyngeal nucleus,** or **nucleus ambiguus,** which is a *nucleus of origin,* or *motor nucleus.* According to the description which has been given of this nucleus, it gives origin to *all* the motor fibres of the two nerves. If, however, the dorsal vago-glosso-pharyngeal nucleus is a *mixed nucleus,* then some of the efferent or motor fibres of the two nerves arise as the axons of its motor cells.

The axons of the cells of the terminal sensory nuclei are disposed like those of the cells of the terminal sensory nuclei of the fifth nerve. They cross to the opposite side, become longitudinal, and ascend in company with the medial lemniscus or chief sensory tract to the thalamus of the side to which they have crossed. They constitute the *vago-glosso-pharyngeal ascending thalamic tract.*

Eleventh or Accessory (Spinal Accessory) Nerve.—This is a motor nerve, which is partly a continuation of the vagus. Its spinal fibres arise from the **accessory nucleus**, which is situated to a small extent within the medulla oblongata or bulb, and mostly within the cervical part of the spinal cord. This nucleus consists of a column of large cells which is continuous with the dorsal vago-glosso-pharyngeal nucleus at the medullary level. The column extends from the level of the lower part of the olivary body to the level of the sixth cervical nerve. The *bulbar* termination of the nucleus is situated on the dorso-lateral aspect of the hypoglossal nucleus. The *spinal portion* is situated in the lateral part of the anterior grey horn of the cervical spinal cord, and its cells lie directly behind the motor cells which give origin to the anterior roots of the upper five cervical nerves.

The fibres which emerge superficially from the bulb constitute the **bulbar part** of the accessory nerve, and are *accessory* to the vagus nerve. The fibres which arise from the spinal cord constitute the **spinal part** of the accessory nerve, and are really distinct from the bulbar fibres.

Bulbar Part.—The fibres of this part arise as the axons of the cells of the **nucleus ambiguus.** They are directed at first dorsalwards, and then outwards through the lateral part of the medulla oblongata or bulb, from which they emerge, behind the olive, in the form of about five funiculi, placed below, and in line with the funiculi of the vagus nerve. They then pass outwards, lying within the cranial cavity, and join the spinal part of the accessory nerve (which has entered the cranial cavity through the foramen magnum). The **accessory nerve** afterwards leaves the cranial cavity through the jugular foramen.

Spinal Part.—The fibres of this part arise as the axons of the cells of the **accessory nucleus** in the cervical cord. They are directed at first backwards, and then outwards through the lateral column of the spinal cord, from which they emerge as a series of funiculi which succeed to the funiculi of the bulbar part, the lowest spinal funiculus being on a level with the fifth cervical nerve. The funiculi of the spinal part *ascend*, lying in the subdural space between the ligamentum denticulatum and the posterior roots of the upper five cervical nerves. They enter the cranial cavity through the foramen magnum, and join the bundles of the bulbar part, to form the **accessory nerve.**

Distribution of Accessory Nerve.—After leaving the jugular foramen, the accessory nerve divides into two branches—internal and external—the *internal branch* containing the fibres of the **bulbar part,** whilst the *external branch* contains the fibres of the **spinal part.**

Spinal Distribution.—The *external* or *spinal branch* supplies the sterno-cleido-mastoid and trapezius muscles.

Bulbar Distribution.—The *internal* or *bulbar branch* passes over, and in close contact with, the **ganglion** of the trunk of the vagus nerve. Its fibres are continued into (1) the pharyngeal and superior laryngeal branches of the ganglion of the trunk of the vagus, and (2) the trunk of the vagus *beyond* the ganglion.

The **bulbar fibres,** through their connection with the vagus nerve, are probably distributed to (1) the muscles of the soft palate, excluding the tensor palati; (2) the constrictor muscles of the pharynx; and (3) the intrinsic muscles of the larynx. The bulbar fibres may also furnish (*a*) the *inhibitory fibres* to the heart, (*b*) the motor fibres to the œsophagus, and (*c*) the motor fibres to the stomach.

The bulbar fibres of the accessory nerve are regarded by some authorities as arising from the column of cells which constitutes the ventral vago-glosso-pharyngeal nucleus, or nucleus ambiguus.

Twelfth or Hypoglossal Nerve.—The fibres of the hypoglossal nerve arise from the axons of the cells of the **hypoglossal nucleus,** which is situated within the medulla oblongata. This nucleus represents a column of large multipolar motor-cells, which extends from the level of the auditory striæ *superiorly* to the level of the upper part of the decussation of the pyramids *inferiorly*. The lower part of the nucleus is situated within the lower or closed part of the medulla oblongata, and its upper part lies within the upper, open, or ventricular part. The *lower part* lies in the grey matter which forms the ventro-lateral aspect of the central canal of the medulla oblongata. The *upper part* lies in the grey matter which covers the bulbar part of the floor of the fourth ventricle, and is underneath the area known as the *trigonum hypoglossi*.

The nerve-fibres issue from the ventral aspect of the nucleus, and the nerve-funiculi pass through the medulla oblongata in a dorso-ventral direction, lying between its anterior and lateral areas, and between the formatio reticularis alba and formatio reticularis grisea. Having reached the bottom of the ventro-lateral sulcus between the pyramid and the olive, they emerge from the medulla oblongata in line with the sixth cranial nerve *superiorly*.

The two hypoglossal nuclei, right and left, are connected with each other by commissural dendrons; and each nucleus receives collaterals from the pyramidal tract of the opposite side, being thereby brought into connection with the precentral motor area of the opposite cerebral hemisphere.

Distribution.—The hypoglossal nerve is the **motor nerve of the tongue,** and supplies (1) the stylo-glossus, (2) the hyo-glossus, (3) the genio-hyo-glossus, and (4) the *intrinsic muscles* of the tongue.

Cranio-cerebral Topography (see Figs. 999 and 1000).

The **auricular point** is the centre of the orifice of the meatus auditorius externus.

The **pre-auricular point** is situated in the depression between the tragus of the auricle and the condyle of the mandible.

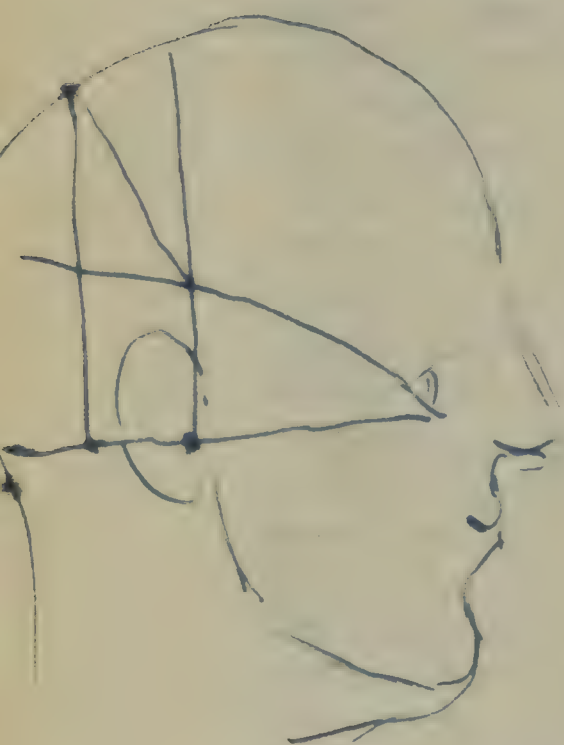
The **bregma,** or point of junction of the sagittal and coronal sutures, corresponds to the centre of a line connecting the two auricular points (the centre of the orifice of the meatus auditorius externus).

The **lambda,** or meeting of the sagittal and lamboidal sutures, is

situated about $2\frac{3}{4}$ inches or four fingers' breadth above the inion, or external occipital protuberance.

The **pterion,** or region of the spheno-parietal suture, is situated about $1\frac{1}{2}$ inches behind the external angular process of the frontal bone, and about $1\frac{3}{4}$ inches above the zygomatic arch. Two fingers' breadth above the middle of the zygoma forms quite a useful indication to it.

The **asterion,** or point where the parieto-mastoid, occipito-mastoid, and lambdoid sutures meet, is situated about 2 inches behind the



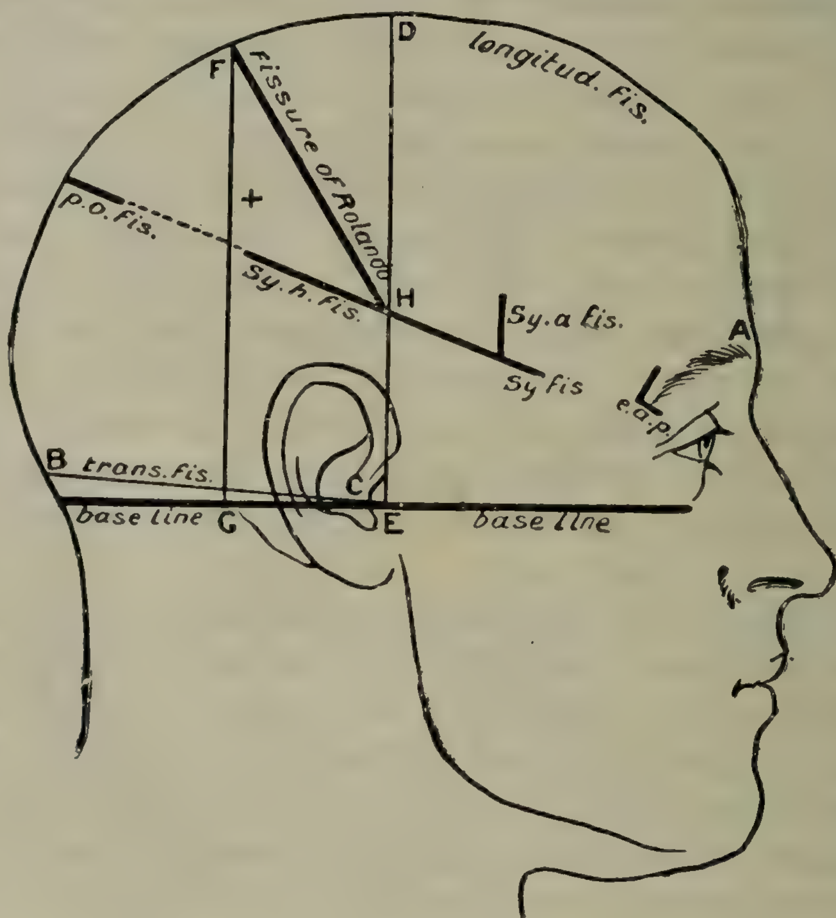


FIG. 999.—DIAGRAM SHOWING THE RELATIONS OF THE CHIEF CEREBRAL FISSURES TO THE EXTERIOR OF THE HEAD (REID).

A. Glabella B. Inion C. Auricular Point
E. Pre-auricular Point
F. Superior Rolandic Point
G. Posterior Border of Root of Mastoid Process
H. Inferior Rolandic Point
B.C. Transverse Fissure

D.E., F.G. Reid's Perpendicular Lines
Sy.Fis. Lateral Fissure
Sy.a.Fis. Anterior Limb of Fissure
Sy.h.Fis. Posterior Horizontal Limb of Fissure
p.o.Fis. External Parieto-occipital Fissure
\+ Parietal Eminence

auricular point very nearly in line with the upper border of the zygomatic arch.

The **sagittal line** represents the line which connects the nasion, or meeting of the two fronto-nasal sutures, with the inion.

The **sagittal suture** corresponds to that part of the sagittal line which extends from the lambda to the bregma.

The **coronal suture** is indicated on either side by a line extending from the bregma to the pterion.

The **lambdoid suture** (occipito-parietal) corresponds to a line extending from the lambda to the asterion.

The **squamo-parietal suture,** and its continuation backwards as the parieto-mastoid suture, are indicated by a curved line, with the con-

vexity upwards, extending from the pterion to the asterion, the highest part of the curve being about 2 inches above the zygomatic arch.

The **superior sagittal sinus** corresponds to a line drawn from the glabella to the inion, or external occipital protuberance. For the most part it occupies the median line, but as it grooves the upper portion of the tabular part of the occipital bone it deviates to one side, most commonly the right side.

The **confluens sinuum** (or **torcular Herophili**) is usually situated on the right side of the inion.

The **occipital sinus** corresponds to a line drawn downwards from the inion.

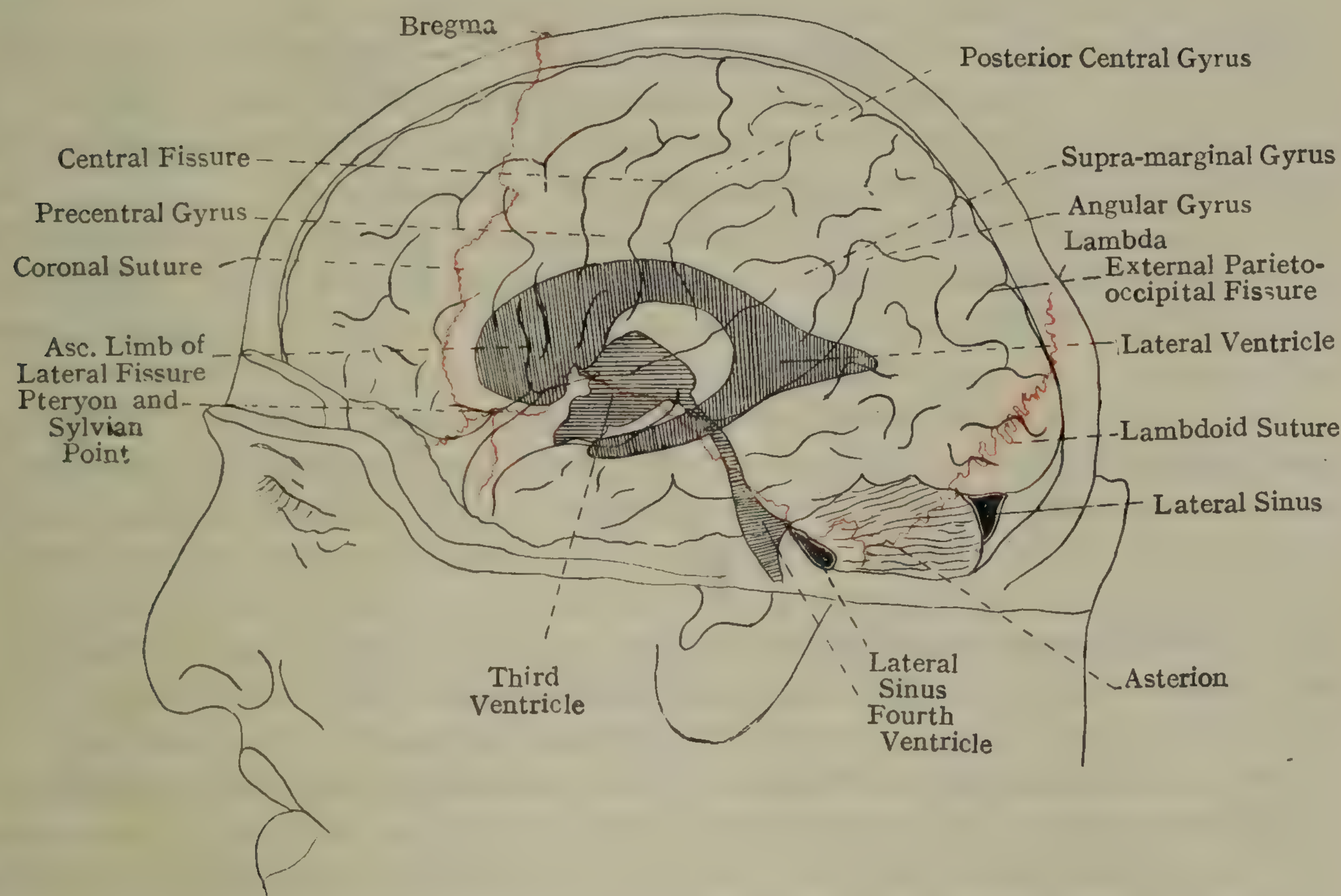


FIG. 1000.—THE RELATIONS OF THE BRAIN TO THE SURFACE (MODIFIED FROM HERMANN).

The **transverse sinus** on either side is indicated by a line drawn outwards from a point immediately above, and external to, the inion to a point immediately above the asterion. This line is slightly curved, the convexity being upwards. The sinus grooves the inner surface of one-half of the tabular portion of the occipital bone, along the line of attachment of the *tentorium cerebelli*; and in the region of the asterion, where the sinus, in altering its course, *describes a curve*, it grooves the inner aspect of the parietal bone, close to the postero-inferior angle, for a very short distance.

Inasmuch as the superior sagittal sinus usually opens into the right transverse sinus, the *right sinus* is usually larger than that of the left side.

The *sigmoid part* of the transverse sinus grooves the inner surface of the mastoid portion of the temporal bone, and the superior surface

of the jugular process of the occipital bone. The following line indicates approximately the course of the sinus: (1) Draw a line horizontally forwards from the asterion for fully $\frac{3}{4}$ inch to a point on the root of the mastoid process in line with the upper part of the meatus auditorius externus; (2) the line now *curves* and passes downwards and forwards on the front part of the mastoid process towards its tip for $\frac{3}{4}$ inch, lying close to the groove between the back of the pinna and the mastoid process (the level to which this line descends is $\frac{1}{4}$ inch below the lower margin of the orifice of the meatus auditorius externus); and (3) the line finally passes forwards for $\frac{1}{2}$ inch to meet the jugular foramen, through which the sigmoid part of the transverse sinus leaves the cranial cavity to become the internal jugular vein.

The sigmoid sinus lies directly *behind* the mastoid or tympanic antrum, being separated from it only by a very thin plate of bone. In pyogenic affections of the tympanum and antrum the sinus is consequently liable to become affected with thrombosis.

The convexity of the *genu* of the sigmoid sinus is on a level with the temporo-mandibular joint, and lies from $\frac{1}{8}$ to $\frac{1}{4}$ inch behind the base of the suprameatal triangle or $\frac{3}{4}$ inch behind the pre-auricular point.

The right sigmoid sinus is usually larger than the left. In many cases the genu is scarcely perceptible, and the horizontal and vertical limbs under these circumstances are practically almost in direct continuity with each other. The genu lies at a depth from the surface varying from $\frac{1}{4}$ to $\frac{1}{2}$ inch.

The **middle meningeal artery** corresponds to the centre of the zygomatic arch. At a point from $\frac{1}{2}$ to $\frac{3}{4}$ inch above the centre of the arch it divides into its two terminal branches—anterior and posterior.

The large **anterior division of the middle meningeal artery,** as it lies in the groove, or, it may be, short canal, on the internal aspect of the antero-inferior angle of the parietal bone, is indicated by taking a point $1\frac{1}{2}$ inches behind the external angular process of the frontal bone, and $1\frac{1}{2}$ inches above the zygomatic arch. From this point it ascends almost vertically towards the sagittal suture, lying about $\frac{1}{2}$ inch behind the coronal suture.

The **Sylvian point** coincides with the **pterion,** and is situated about $1\frac{1}{2}$ inches behind the external angular process of the frontal bone, and about 2 inches above the zygomatic arch. It indicates the division of the stem of the lateral fissure into its three limbs—anterior, ascending, and posterior. The anterior limb of the fissure passes horizontally forwards for about 1 inch, and the ascending limb upwards and slightly forwards for a variable distance, from the pterion.

The posterior limb of the fissure is long, and is directed for the most part horizontally backwards for fully 2 inches, after which it turns upwards into the parietal lobe for a short distance. The line which indicates the course of the posterior limb is called the *Sylvian* or *lateral line.* It extends from the pterion backwards and slightly upwards towards the lambda for about 2 inches until it lies below the parietal

eminence, when it turns directly upwards for ½ inch. The parietal lobe and a small portion of the frontal lobe lie above the Sylvian line, and the temporal lobe lies below it.

The **superior Rolandic point** is situated ½ inch behind the centre of the sagittal line, which connects the nasion and the inion. This point approximately represents the upper extremity of the central fissure.

The **inferior Rolandic point** is situated on the Sylvian line about 1 inch behind the Sylvian point, and 2 inches above the pre-auricular point. It indicates the point where the central fissure, if sufficiently prolonged, would meet the posterior limb of the stem of the lateral fissure.

The **line of the central fissure** is represented by a line connecting the superior and inferior Rolandic points.

The **Rolandic angle** is the angle which this line forms with the sagittal line. It ranges from 65 to 70 degrees. The line, if sufficiently prolonged, would cross the zygomatic arch at its centre. It indicates in a general way the course of the central fissure, but this fissure usually ceases at a point ½ inch above the Sylvian line. The cerebral convolutions directly in front of, and behind, the central line are (1) the precentral, or ascending frontal, convolution (motor area) in front; and (2) the postcentral, or ascending parietal, convolution (sensory area) behind. The line represents the boundary-line between the frontal and parietal lobes of the cerebral hemisphere.

The **base-line of Reid** is represented by a line drawn backwards from the centre of the infra-orbital margin through the pre-auricular and auricular points to the inion. The central fissure may be determined from Reid's base-line in the following manner: Two lines are drawn upwards to the sagittal line perpendicular to the base-line, one from the pre-auricular point and the other from the posterior border of the mastoid process close to its root. These two lines, together with the sagittal and Sylvian lines, enclose a quadrilateral area, and the diagonal connecting the postero-superior and antero-inferior angles represents the fissure except at its superior and inferior limits.

The **parietal eminence** may usually be felt, if it cannot be seen, as the point of maximal convexity in the parietal region. If it cannot be felt, its position may be estimated by localizing the four angles of the parietal bone, bregma, lambda, pterion, and asterion, and taking the point where the diagonals joining them meet. It indicates the position of the supramarginal gyrus of the parietal lobe of the cerebral hemisphere.

The **frontal eminence** corresponds to the middle frontal convolution.

The **foramen magnum,** through which the medulla oblongata is continuous with the spinal cord, lies midway between the mastoid processes. Its posterior margin is 2 inches from the inion in a downward and forward direction.

The **tentorium cerebelli** and **superior surface of the cerebellum**

practically coincide with the level of the transverse sinus, as indicated by a line slightly curved upwards connecting the inion and asterion.

The **lower level of the cerebral hemisphere** may be indicated by the following line: Commencing at a point $\frac{1}{2}$ inch external to the nasion, the line passes laterally in an arched manner, with the convexity upwards, lying about $\frac{1}{3}$ inch above the centre of the supra-orbital arch. It then inclines downwards and crosses the temporal ridge of the frontal bone about $\frac{1}{2}$ inch above the fronto-malar suture, which is easily felt. After this the line passes backwards and slightly downwards to the pterion, and thence to the upper border of the posterior part of the zygomatic arch. From this point the line passes backwards, lying about $\frac{1}{4}$ inch above the upper margin of the orifice of the meatus auditorius externus. It then crosses the supramastoid crest (posterior root of the zygoma), and passes to the asterion. From this it nearly follows the line of the transverse sinus from the asterion to a point a little above and external to the inion. In other words, speaking generally, the cerebral hemisphere extends as low as the superior nuchal line of the occipital bone *posteriorly*, the upper border of the zygomatic arch *laterally*, and the upper part of the eyebrow *anteriorly*. The **frontal lobe** of the cerebral hemisphere is to a large extent in contact with the frontal portion of the frontal bone, but it is also related to the anterior part of the parietal bone as far back as the central fissural line.

The **parietal lobe** is related to the part of the parietal bone which lies behind the central line. The lobe extends as far back as the **parieto-occipital fissure,** which is usually situated opposite the lambda.

The **occipital lobe** occupies the cerebral fossa of the tabular part of the occipital bone, its limits being the level of the lambda *superiorly* and the level of the inion *inferiorly*.

The **temporal lobe** is under cover of the squamous portion of the temporal bone and the postero-inferior part of the parietal bone. The parallel sulcus, which separates the first and second temporal convolutions, is indicated by a line drawn from the lambda to the *marginal tubercle* on the posterior border of the malar bone about $\frac{1}{2}$ inch below the fronto-malar suture.

Below it is the middle temporal gyrus, the centre of which corresponds to the inferior horn of the lateral ventricle. A perforation $\frac{1}{2}$ inch below the line just mentioned and $1\frac{1}{4}$ inches behind the middle of the external auditory meatus would strike it with certainty if it were distended.

Autonomic System.

The **autonomic nervous system,** mentioned at the beginning of this chapter, was then stated to be composed of two differentiated groups of fibres which were termed sympathetic and parasympathetic, the former known by that name to generations of anatomists, but the latter including within its limits a more modern conception of certain fibres

and functions which were not grouped in any way with the sympathetic by the older observers.

The **sympathetic system** comprises all that chain of nerve cords and ganglia which lies on each side and front of the vertebral column, with its connections and distributions. The detailed descriptions of the system in the different regions of the body have been given in previous chapters of this book, where they can be perused. It is not necessary, therefore, to enter on these details again, but something can be said about the system in its general aspect.

The **ganglia** which, with the connecting cords, make up the 'sympathetic chain' are probably modified in number from an original set which corresponded with the number of spinal nerves. This original number of ganglia has been lessened, however, by fusion of neighbouring masses, and sometimes by actual loss; for example, in the cervical region, the four uppermost ganglia have been fused into the single superior cervical ganglion, and the lower two have joined in the inferior ganglion—which itself shows signs of joining with the first thoracic—while the 'middle cervical ganglion' is frequently, if not usually, absent or very small. In the thoracic region the number is decreased frequently by fusion, and in the lumbar and sacral portions of the chain is very variable.

Both afferent and efferent (secretory and motor) impulses pass through the sympathetic system. The *afferent* fibres run through it without interruption, arising from the cells in the posterior root ganglia. *Efferent* fibres arise from the lateral grey matter of the spinal cord, and leave the cord through the anterior nerve roots of the **thoracic and upper two or three lumbar nerves.** They pass from these to the sympathetic chain by fine branches (white rami communicantes), and run in this chain to the particular ganglia with which they are concerned.

Rami communicantes are of two sorts, white (medullated) and grey (non-medullated). *White rami* bring the medullated fibres to the sympathetic chain from the nerves within which they emerged from the spinal cord, and are therefore confined to the thoracic and upper lumbar regions. *Grey rami* are fibres of sympathetic origin, arising from cells in the ganglia in which the white fibres have been interrupted, and passing for convenience of distribution to any and all of the spinal nerves; in this way they reach their objectives, and are found connecting the sympathetic chain with all the spinal nerves—not limited to particular regions like the white rami.

> The rami are thus of two sorts, and both sorts are present in the thoracic and upper lumbar region, but it must not be imagined that a ramus of either sort to a nerve is always a single branch; it may be doubled or even trebled, and may reach a ganglion or the interganglionic trunk, but there are only two *kinds* of fibres represented at the most, and the white fibres, wherever they join the sympatheitc trunk, run in it until they reach the appropriate ganglia—which may be near, or far away.

Afferent fibres from visceral structures pass from these through the sympathetic system, and through white rami to the spinal nerve and spinal ganglion concerned; some are said to go through grey rami. Those from the body-wall and limbs, and from the head and neck, run their courses within the spinal nerves themselves.

Efferent fibres are always interrupted once in their course, so that there are two relays of the efferent impulse. The first is represented anatomically by the course of the issuing white fibre from the cord to its appropriate ganglion, the second by the course of the non-myelinated fibre arising in this ganglion and passing to its objective.

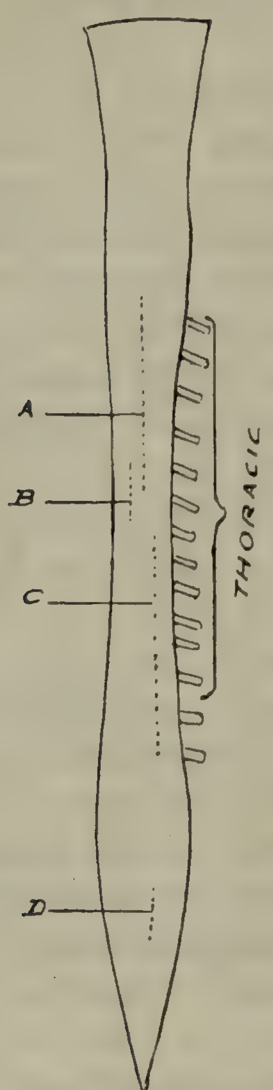


FIG. 1001.—APPROXIMATE LEVELS IN CORD OF CENTRES OF ORIGIN OF SWEAT-FIBRES (PRE-GANGLIONIC) SUPPLYING (A) HEAD, NECK, AND UPPER PART OF THORAX; B, UPPER LIMB; C, LOWER LIMB; D, EXTERNAL GENITALS AND ANAL REGION.

The ganglionic cell which interrupts the efferent impulse, and relays it secondarily, may be one of those in the sympathetic chain ganglia, or may lie at some distance from the chain, in one of the great plexuses (cardiac, cœliac, hypogastric), or even in some more remote and minute collection of nerve-cells in the wall of a viscus or on a bloodvessel. Wherever this ganglionic cell may be, the first relay of the impulse is carried by a fibre which is not interrupted before reaching it; this fibre is termed *preganglionic.* The second relay is carried by a *postganglionic* fibre, which is the axon of this ganglion cell, and is non-medullated.

From what has been said it can be understood that the efferent fibres, in white rami communicantes, may run even to the extreme end of the sympathetic chain, or to a distant plexus, before losing their preganglionic status, so that they will pass through any intervening ganglia without interruption. Afferent fibres always pass through such ganglia without interruption, to reach the posterior root ganglia. Thus the level of exit of an efferent preganglionic fibre has little to do with the level or position of its terminal ganglion, and the postganglionic fibres in a grey ramus may have come from a sympathetic ganglion some distance away.

Course of Sympathetic Efferent Impulses.

Central Origin.—The cells of the intermedio-lateral region of the cord, approximately corresponding with the nerve-levels which give passage to the fibres issuing from the cord, and considered generally to

be those from which these fibres take origin. There are probably higher centres in the nervous axis which exercise some controlling influence over these thoraco-lumbar cells; such centres are presumed to lie in the hypothalamus, their scattered fibres passing down in the tegmentum and formatio reticularis of the pons and medulla. Other control centres in the floor of the fourth ventricle are more doubtful.

Dilatation of Pupil.—*Preganglionic fibres* emerge through upper (? three) thoracic nerves and run up the gangliated cord. *Cell-station,* superior cervical ganglion. *Postganglionic fibres* pass through ciliary ganglion without interruption and enter short ciliary nerves. Their course to the ganglion is curious. They pass up in the plexus on the internal carotid, leave this by the carotico-tympanic filaments, and

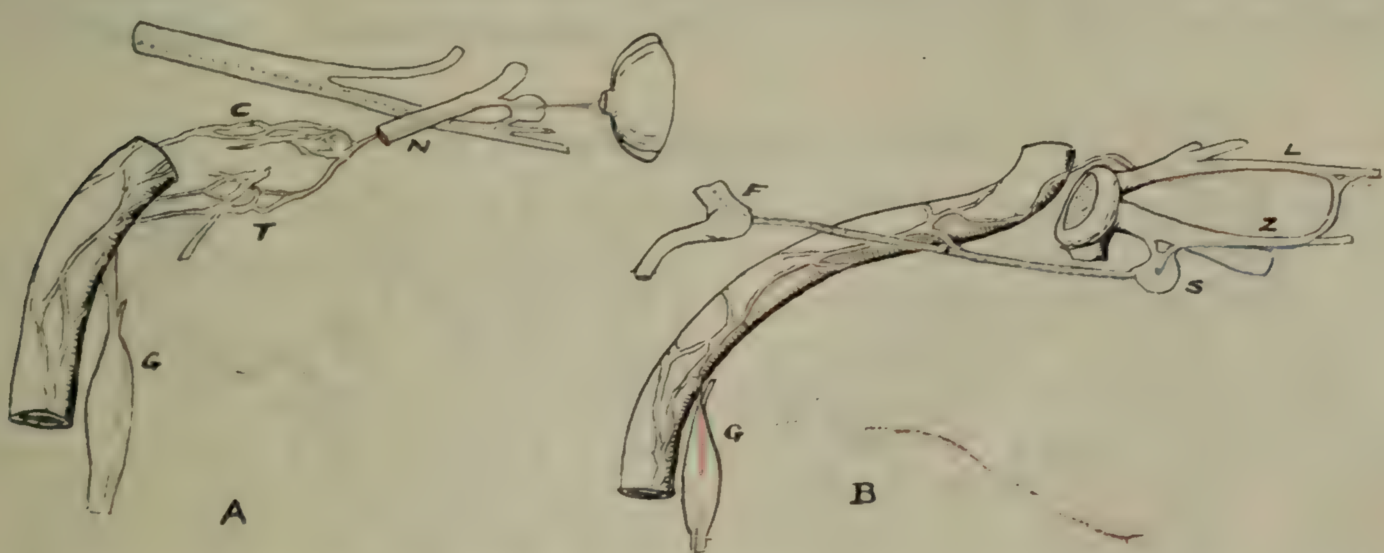


FIG. 1002.—TO SHOW COURSE OF SYMPATHETIC (RED) AND PARASYMPATHETIC (BLUE) FIBRES CONCERNED IN CERTAIN INFRA-ORBITAL ACTIONS (PREGANGLIONIC FIBRES, DOTTED; POSTGANGLIONIC, SOLID LINES).

A, the routes followed in the case of the pupil; B, those in the case of lacrimal secretion; G, superior cervical ganglion; T, C, tympanic and cavernous plexuses; N, naso-ciliary nerve; S, spheno-palatine ganglion; Z, zygomatico-malar nerve; L, lacrimal nerve; F, facial ganglion.

enter the middle ear. From this they pass up through the foramen lacerum and join the cavernous plexus, from which they find their way into the orbit with some of the branches of the fifth nerve, or on the ophthalmic artery (Fig. 1002).

Lacrimal Gland.—*Preganglionic* to superior cervical ganglion. *Postganglionic* along internal carotid, and probably through ophthalmic nerve and its lacrimal branch.

Salivary Glands (Fig. 1003).—**Submandibular.**—*Preganglionic* from upper thoracic nerves. *Cell-station,* superior cervical ganglion. *Postganglionic* along external carotid and facial, fibres passing unchanged through submandibular ganglion.

Parotid.—*Preganglionic* and cell-station as last.

Postganglionic along external carotid and maxillary arteries, through otic ganglion unchanged, into auriculo-temporal nerve.

Sweating.—The *preganglionic* fibres leave the spinal cord at varying levels according (Fig. 1001) to their final destinations. The *cell-stations* are in the sympathetic ganglia appropriate to the levels to be supplied. The *postganglionic* fibres, arising in these ganglia, are distributed through the cutaneous nerves; they reach these usually through grey rami communicantes and the nerves concerned, but in the case of the head and face they reach the cutaneous nerves by passing first through the arterial plexuses.

The **mammary gland,** being a modified sweat-gland, is supplied in a similar way, the *postganglionic* fibres reaching the gland along the fourth, fifth, and sixth intercostal nerves.

The **cardiac sympathetic** *preganglionic* fibres leave the cord by the upper four or five thoracic nerves, and end in the corresponding thoracic ganglia; these are therefore the *cell-stations*. *Postganglionic*

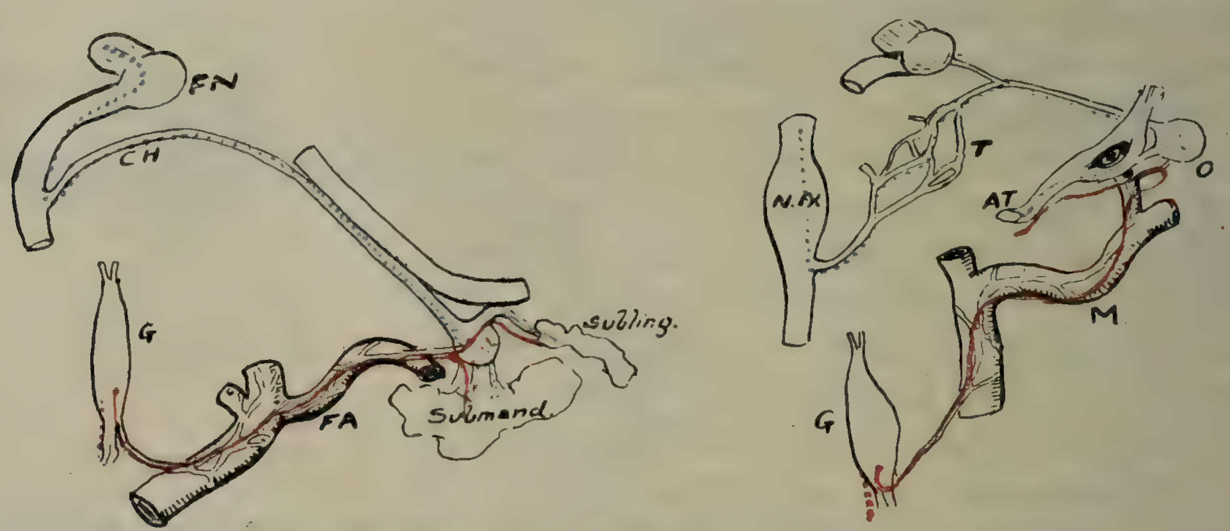


FIG. 1003.—TO SHOW THE PATHS OF SYMPATHETIC AND PARASYMPATHETIC FIBRES TO SALIVARY GLANDS (COLOUR PLANS AS LAST FIGURE).

FA, M, facial and maxillary arteries; CH, chorda tympani; AT, auriculo-temporal; O, otic ganglion; G, superior cervical ganglion; T, tympanic plexus.

fibres arise from the cells in these ganglia, pass upwards through the cervical chain to come off as cervical cardiac branches, or run more directly from the thoracic ganglia to the deep cardiac plexus. All these fibres pass through the plexus without interruption to reach the heart.

It may be added, although it does not come under this heading, that afferent fibres from the heart probably run in all these cardiac sympathetic nerves except the superior cervical branch.

It follows from this description of the course of the sympathetic cardiac fibres that the cell-collections which form the scattered cardiac ganglia are cell-stations for the parasympathetic only (see later).

The **splanchnic nerves,** which arise from the lower six ganglia of the thoracic gangliated cord, carry mainly medullated *preganglionic* fibres which have left the spinal cord through the lower seven or eight thoracic nerves. Their *cell-stations* are in the cœliac ganglion.

The *postganglionic* fibres arise here, and are distributed in the branches of the cœliac plexus.

Many afferent fibres run up through the plexus into the splanchnic nerves.

The **bladder** is supplied by sympathetic fibres which arise in the upper lumbar segments. Some of the *preganglionic* fibres appear to end in lumbar ganglia, but most of them go into the aortic plexus or lie lateral to this, cross the bifurcation of the aorta and the common iliac vessels, pass through their own side of the hypogastric plexus (presacral nerve), where some of them terminate, while others pass on into the vesical part of the pelvic plexus. The *cell-stations* are therefore in the lumbar ganglia, in the hypogastric plexus, and in the vesical plexus, and from these cells the *postganglionic* fibres run, in the course indicated, to the bladder wall.

The Parasympathetic System.

This system, connected in distribution and in some structural points with the sympathetic, is distinguished from it by separate origin from the central axis, and by different and largely opposed function. The fibres come from the central axis at its extremities, while the sympathetic has a limited output in its middle part; in both cases the fibres emerge among the ordinary fibres of an efferent nerve, but whereas they leave this almost at once (white rami) in the case of the sympathetic, they run to their distribution (for a considerable distance usually) in the parasympathetic in the nerve within which they emerge.

The **cranial parasympathetic** is comprised in an outflow of special fibres running in the *third, seventh, ninth,* and *tenth* nerves.

The third or **oculo-motor** nerve has fibres which run to the ciliary muscle and pupillary sphincter, being concerned in contraction of the pupil and accommodation. The *preganglionic* fibres, arising in the mid-brain, probably from the Edinger-Westphal nucleus, pass out in the third nerve into its inferior division, to reach their terminations in the ciliary ganglion; this is therefore the *cell-station. Postganglionic* fibres arise in the ganglion and pass forward in the short ciliary nerves.

The seventh or **facial** nerve contains parasympathetic fibres which reach the lacrimal, submandibular, and sublingual glands (Figs. 1002 and 1003).

Those to the **lacrimal gland** arise from nuclear material (? upper salivatory nucleus) in the reticular formation of the pons, run in the issuing nerve, and leave it by the greater superficial petrosal branch; they pass in this to the pterygoid canal, and so to the spheno-palatine ganglion; this is therefore the *cell-station. Postganglionic* fibres, arising here, pass into the maxillary nerve, enter its zygomatico-temporal offset, and run through the junction between this nerve and the lacrimal into this last-named nerve.

Those to the **submandibular and sublingual glands** come as *pre-*

ganglionic fibres from the upper salivatory nucleus, pass into the facial nerve, and leave it in the chorda tympani. The *cell-station* comprises the submandibular ganglion (for sublingual) and ganglion cells embedded in the submandibular gland (for this gland). The *postganglionic* fibres are short, arising from these ganglia.

The ninth or **glosso-pharyngeal** carries *preganglionic* fibres (which have arisen from the lower salivatory nucleus) to end in the otic ganglion; they reach this ganglion by passing through the tympanic branch and tympanic plexus, then through the lesser superficial petrosal nerve. The *cell-station* is in the otic ganglion. *Postganglionic* fibres run in the auriculo-temporal nerve.

The tenth or **vagus nerve** has a large number of visceral branches which belong to the parasympathetic system. The *preganglionic* fibres arise mainly (apparently) from the dorsal nucleus of the vagus, run in the nerve, and leave it by various visceral branches. They *end* in (*a*) microscopic ganglia in the viscera, or (*b*) more apparent but scattered ganglia, as in the cardiac plexus.

The **sacral parasympathetic** outflow takes place in the second and third sacral nerves; the fourth nerve apparently contributes sometimes to the outflow. Visceral *preganglionic* fibres issue with these nerves as the pelvic splanchnic nerves, and pass through the pelvic plexuses. The *cell-stations* are generally in the visceral walls of the pelvic viscera, but may lie in minute ganglia in the plexuses. *Postganglionic* fibres are short, arising from these cells.

Development of the Sympathetic Nervous System.

The **sympathetic ganglia** may be regarded as being developed from the ventral aspects of the neural crests and spinal ganglia, and they are therefore of *ectodermic origin*, according to this view. Certain cells become detached from the neural crests and spinal ganglia, and migrate ventralwards towards the

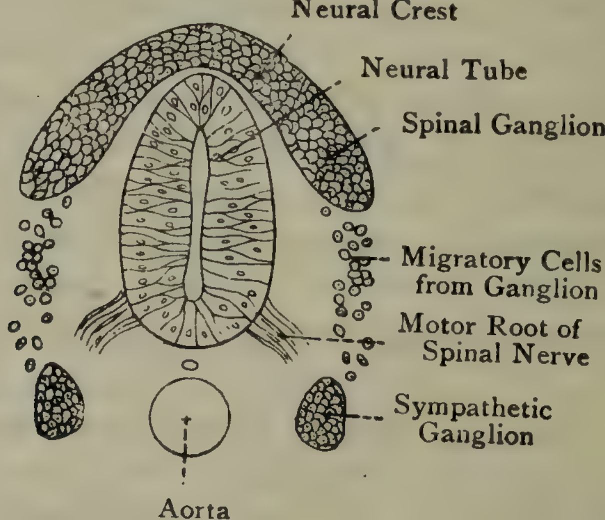


Fig. 1004.—Development of Sympathetic Ganglia (Schematic).

region of the aorta, where they form the ganglionic sympathetic chain. The ganglionic cells proliferate, and are furnished with processes which become fibrillar. These fibrillar processes give rise to the chain which connects the ganglia, and also to the *grey rami communicantes* and the various visceral branches.

CHAPTER XVI

THE EYE

THE eyeball is almost spherical. It consists of the segments of two spheres—namely, a large posterior or sclerotic segment, which is opaque, and a small anterior or corneal segment, which is transparent. The sclerotic segment forms five-sixths of the eyeball, and the corneal segment one-sixth. The centre of the corneal segment is called the **anterior pole,** and the centre of the sclerotic segment is known as the **posterior pole.** The sagittal (antero-posterior) axis, or **axis of vision,** of the eyeball is represented by a line connecting the anterior and posterior poles. The **equator** is represented by a line encircling the centre of the eyeball in a coronal plane, the diameter of the circle being about 1 inch. The plane of this circle would therefore divide the eyeball into two halves—an anterior half, consisting of the corneal and the front part of the sclerotic segment, and a posterior half, consisting of the back part of the sclerotic segment. The **meridian** is represented by a line encircling the eyeball horizontally at right angles to the equator, and passing through the anterior and posterior poles.

Posteriorly the eyeball receives the optic nerve, which pierces the sclerotic coat at a point about $\frac{1}{8}$ inch to the inner side of and about $\frac{1}{24}$ inch below the posterior pole.

The eyeball is composed of three coats concentrically arranged: (1) an *external coat,* consisting of an opaque part, called the **sclera,** and a transparent part, called the **cornea;** (2) a *middle coat,* which is vascular, pigmented, and muscular, and consists of (*a*) a posterior part, called the **choroid coat,** (*b*) an anterior part, the **iris,** and (*c*) an intermediate part, representing the **ciliary body;** and (3) an *internal coat,* called the **retina.**

These three coats enclose the following *refracting media*: (1) a fluid, called the **aqueous humour,** which lies between the cornea and the crystalline lens, where it occupies the *anterior* and *posterior chambers,* into which this region is divided by the iris; (2) a solid body, called the **crystalline lens,** which lies behind the aqueous humour; and (3) a soft gelatinous body, called the **vitreous body,** which occupies the large space behind the crystalline lens.

Coats of the Eyeball.

External = sclera and cornea.
Middle = choroid, ciliary body, and iris.
Internal = retina.

Refracting Media.

Aqueous humour.
Crystalline lens.
Vitreous body.

External Coat.

Sclera (or Sclerotic Coat).—The sclera (white of the eye) is a strong white fibrous coat of great density, which surrounds the posterior five-sixths of the eyeball, and maintains the shape of the organ. Anteriorly it unites, and becomes continuous with the cornea, which it slightly overlaps. The junction of the two is indicated by a slight groove, called the *sulcus scleræ,* and the union is known as the *corneo-scleral junction.* Posteriorly, as has been shown above, the sclera is pierced by the optic nerve a little below and to the inner side of the centre. The part of the sclera corresponding to the optic entrance

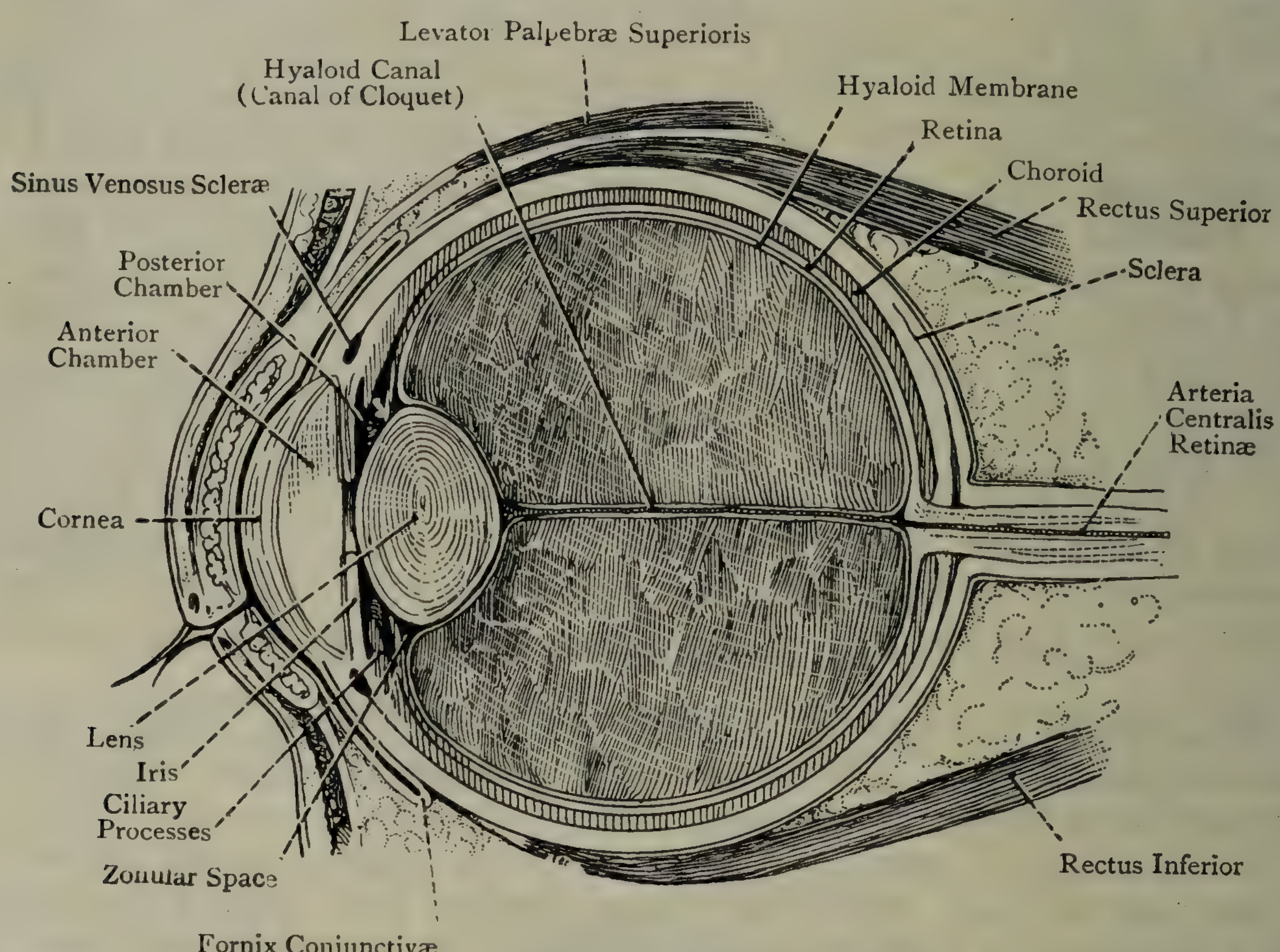


FIG. 1005.—VERTICAL SAGITTAL SECTION OF THE EYE AND ITS APPENDAGES (HIRSCHFELD AND LEVEILLÉ).

is pierced by a number of openings for the passage of the fasciculi of the optic nerve, and hence is called the *lamina cribrosa.*

Around the optic entrance there are numerous minute openings for the ciliary vessels and nerves, and here the dura matral sheath of the optic nerve blends with the sclerotic coat. About midway between the optic entrance and the corneo-scleral junction the sclera is pierced by four openings for the passage of the *venæ vorticosæ* of the choroid.

The sclera is thickest posteriorly around the optic entrance. It is also thick near the sclero-corneal junction, where it receives the insertions of the recti muscles.

The *outer surface* of the sclera is covered by a membranous investment, called the **fascial sheath of the eyeball (fascia bulbi** or **capsule of Tenon)**, and between the two there is the **episcleral lymph-space** (or

Tenon's space), which is broken up into a reticulum by processes of connective tissue which pass between the sheath and the sclera. This space communicates with the subdural and subarachnoid spaces. The *inner surface* of the sclerotic coat is dark brown, and has grooves for the ciliary vessels and nerves. It is lined with connective tissue containing pigment-cells, forming the **lamina fusca.** Processes from this layer pass to the choroid coat, and these, together with vessels and nerves, traverse an interval, which represents the **perichoroidal lymph-space.** This space communicates with the episcleral lymph-space through the vascular openings in the sclera. *Anteriorly* the sclera blends with the cornea at the sclero-corneal junction, the sclera slightly overlapping the cornea. *Posteriorly* around the optic entrance the sclera blends with the dura matral sheath of the optic nerve.

Structure.—The sclera is composed of fibrous tissue mixed with elastic fibres, and contains many connective-tissue corpuscles. The fibres are arranged in bundles, which are disposed longitudinally and transversely, and interlace with one another. The connective-tissue corpuscles occupy spaces between the fibres, which may be regarded as lymph-spaces.

Arteries.—These are the short ciliary group of posterior ciliary arteries, and the anterior ciliary arteries, which are branches of the ophthalmic. The vessels belonging to the former group are disposed in the form of capillary networks; whilst the vessels derived from the latter form a ring near the sclero-corneal junction beneath the conjunctiva, to which ring they converge in the substance of the sclerotic coat.

The sclerotic **veins** open into the anterior ciliary veins, and into the *venæ vorticosæ* of the choroid. There is also a slight drainage into the *sinus venosus scleræ*, a minute channel running deeply at the sclero-corneal junction.

Nerve-supply.—The ciliary nerves.

Cornea.—The cornea is the transparent part of the external coat of the eyeball, of which it forms the anterior sixth, and serves to transmit light. It is almost circular, its transverse measurement being slightly greater than the vertical. At its circumference it is continuous with the sclera, by which it is slightly overlapped. The *anterior surface* is convex. The *posterior surface* is concave, and forms the anterior boundary of the anterior chamber of the eye.

Structure.—The cornea consists of the following five layers, from before backwards:

1. The conjunctival epithelium.
2. The anterior elastic lamina.
3. The substantia propria.
4. The posterior elastic lamina.
5. A layer of endothelium.

The **conjunctival epithelium** is stratified, there being not less than five strata of cells, and is continuous with the epithelium, which covers

the free surface of the conjunctiva. The cells of the deepest stratum are columnar; succeeding these there are layers of polygonal cells; and these in turn are overlaid by layers of squamous cells.

The **anterior elastic lamina** (Bowman) is probably of the same nature as the fibrous portion of the substantia propria. It is closely connected with the substantia propria, is thin, and contains no corpuscles.

The **substantia propria** is composed of modified connective tissue arranged in bundles which form superimposed laminæ. These laminæ amount in number to about sixty. The fibres of alternate laminæ cross each other at right angles, and at the circumference of the cornea they are continuous with the fibres of the sclerotic. The successive laminæ are connected by cement substance, and within this substance are branched spaces, called the **corneal spaces** or **lacunæ,** which communicate with each other by very delicate canaliculi. Each of these spaces contains a nucleated connective-tissue corpuscle, called the **corneal corpuscle.** These corpuscles, like the spaces which they occupy, are branched, and the offsets of adjacent corpuscles communicate with one another. As seen in vertical sections of the cornea, the corpuscles are spindle-shaped, but in horizontal sections they appear flattened out, and give off their branches.

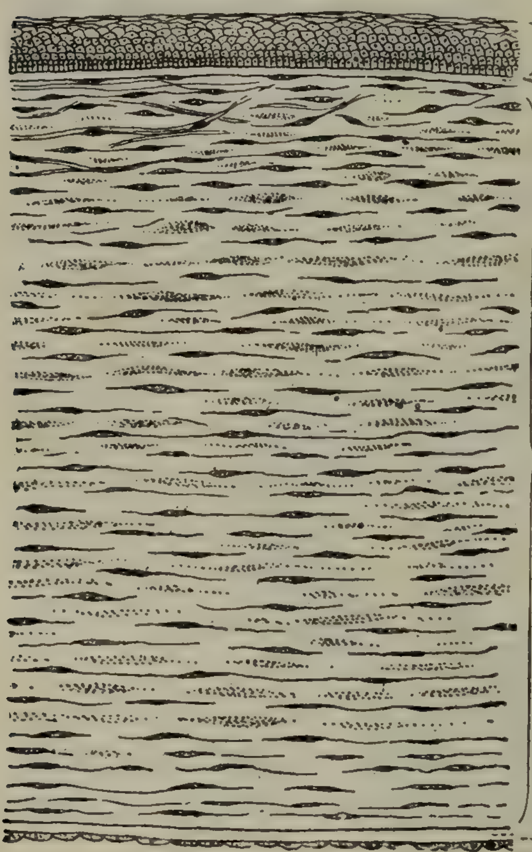


FIG. 1006.—VERTICAL SECTION OF THE CORNEA (MAGNIFIED).

The **posterior elastic lamina** (or **membrane of Descemet**) covers the posterior surface of the substantia propria. It is thicker than the anterior elastic lamina, and is composed of an elastic homogeneous membrane, which is very brittle. When stripped from the substantia propria it comes away in shreds, and these curl up at their ends in such a manner that the anterior or attached surface of each shred is turned inwards. At the circumference of the cornea the posterior elastic lamina becomes broken up into fibres. The most posterior of these fibres pass in a radiating manner into the iris, and they form the *ligamentum pectinatum iridis*, the intervals between the fibres of which represent the *spaces of the irido-corneal angle.*

The **layer of endothelium** lines the posterior surface of the posterior

elastic lamina, and consists of one stratum of cells. It is continued over the front of the iris, and into the spaces of the angle.

The cornea in the adult is non-vascular, except at the circumference, in which situation there are the conjunctival and sclerotic capillaries, which terminate in loops. Being destitute of blood-vessels, the nourishment of the cornea is maintained by the flow of lymph through its surface. It is about 1 mm. thick, slightly more peripherally.

Nerve-supply.—The nerves are derived from the ciliary nerves, and are very numerous. They enter the deep surface of the anterior part of the sclera, and form a plexus round the corneo-scleral junction. Offsets from this plexus enter the cornea, and form what is known as the *plexus annularis*. From this plexus delicate offsets are given off, which traverse the substance of the cornea and pass through the anterior elastic lamina. They then give rise to a fine plexus upon the surface of that lamina, called the *subepithelial plexus*. From this plexus, in turn, minute fibrils are given off, which pass amongst the cells of the conjunctival epithelium, and almost reach the surface, forming an **intra-epithelial plexus.**

Pectinate Ligament of Iris.—It has been seen that the posterior elastic lamina at its circumference breaks up into fibres. The most posterior of these pass in a radiating manner into the iris, constitute the ligamentum pectinatum iridis, and are covered by a prolongation of the endothelial layer of the cornea.

Spaces of Irido-corneal Angle (or Spaces of Fontana).—These spaces represent the irregular intervals which lie between the radiating fibres of the pectinate ligament. They are lined by a prolongation of the endothelial layer of the cornea, and they communicate *internally* with the anterior chamber and the lymph-spaces within the iris, and *externally* with the sinus venosus scleræ.

Sinus Venosus Scleræ.—This canal (formerly known as the *canal of Schlemm*) is situated deeply in the sclerotic, close to the corneo-scleral junction. It communicates *internally* with the anterior chamber through the spaces of the irido-corneal angle, and *externally* with anterior ciliary veins of the sclera. It encircles the outer margin of the cornea, and has a little projecting rim of sclerotic on its deep surface, called the 'scleral spur,' from which the ciliary muscle takes origin.

Middle Coat.

1. **Choroid Coat.**—This is a very vascular, deeply pigmented tunic of a dark brown colour, which lies between the sclera and the retina. It extends over the posterior five-sixths of the eyeball, and reaches as far forwards as the ora serrata of the retina. Anteriorly it is connected with the circumference of the iris, and posteriorly it is pierced by the optic nerve. Its *outer surface* is connected to the inner surface of the sclera by means of the lamina fusca and its processes, as well as by vessels and nerves which cross the 'perichoroidal lymph-space.' Its *inner surface* is in contact with the pigmentary layer of the retina.

Structure.—The choroid coat consists of connective tissue, bloodvessels, and branched pigment-cells. It is composed of three layers, which are as follows, from without inwards: (1) the lamina suprachoroidea; (2) the choroid proper; and (3) the lamina basalis, or membrane of Bruch.

The **suprachoroid lamina** is composed of delicate, non-vascular lamellæ, each of which is made up of elastic fibres arranged in a reticular manner, and of branched pigment-cells.

The **choroid proper** consists principally of bloodvessels and pigment-cells supported by connective tissue. The bloodvessels are arranged partly as arteries and veins, and partly as capillaries. The choroid proper is therefore composed of two layers—external or lamina vasculosa, and internal or lamina chorio-capillaris.

The **lamina vasculosa** (arterio-venous layer) is composed of (1) branches of the short ciliary group of the posterior ciliary arteries, which pass forwards before they turn inwards to end in capillaries;

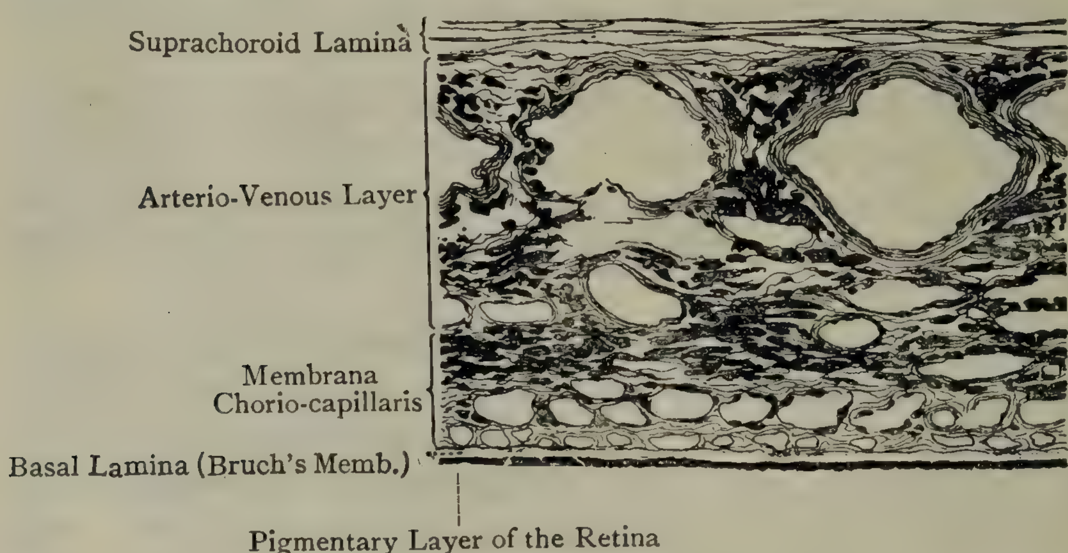


FIG. 1007.—VERTICAL SECTION OF THE CHOROID COAT.
The pigmentary layer of the retina is also shown.

and (2) veins, which form the chief part of the lamina vasculosa, and are called the **venæ vorticosæ.** These veins are very closely set, and are arranged in a whorled manner. They ultimately converge and form four or five vessels, which pierce the sclerotic nearly midway between the optic entrance and the corneo-scleral junction at points equally distant from each other. Scattered throughout the lamina vasculosa are branched pigment-cells.

The **lamina chorio-capillaris** is composed of a plexus of capillary bloodvessels, the arteries leading to it being derived from the short ciliary arteries.

The lamina vasculosa and lamina chorio-capillaris are connected by fine elastic fibres, which form what is known as the *stratum intermedium.*

The **lamina basalis,** or **membrane of Bruch,** is situated on the inner surface of the lamina chorio-capillaris, which it separates from the pigmentary layer of the retina. It is a very delicate membrane without any very definite structure.

Tapetum.—This is present in certain animals. It lies between the lamina vasculosa and the lamina chorio-capillaris in the stratum intermedium, and it gives rise to an iridescent or rainbow-like appearance. In some animals it is fibrous in structure, and in others cellular.

2. **Ciliary Body.**—The ciliary body connects the anterior part of the choroid to the circumference of the iris. It is composed of (1) the orbicularis ciliaris, (2) the ciliary processes, and (3) the ciliary muscle.

The **orbicularis ciliaris,** or **ciliary ring,** is a narrow zone which lies immediately in front of the anterior part of the choroid, with which it is continuous. In it are folds which are radially disposed, and it separates the ciliary processes from the ora serrata of the retina.

The **ciliary processes,** about seventy in number, are infoldings (Fig. 1005) of the anterior part of the choroid, and consist of the choroid proper and the basal membrane (of Bruch). They constitute a series

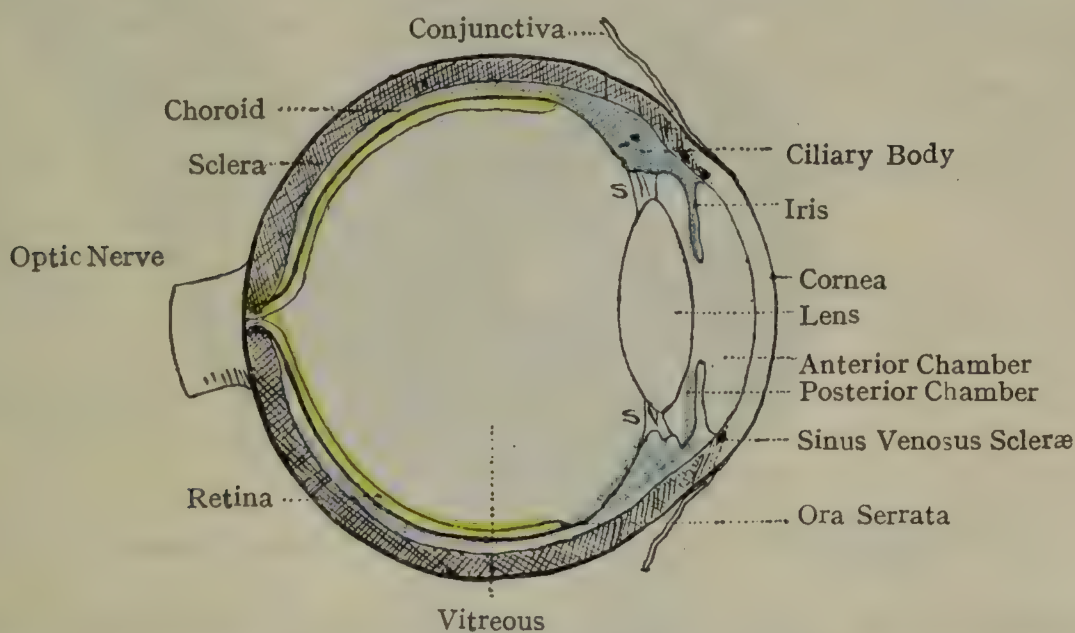


Fig. 1008.—Diagram of Section through the Eyeball to show the Main Layers mentioned in the Description.
S, S, suspensory ligament of lens.

of rays arranged in a circular manner, and converge as they pass inwards and forwards to the periphery of the crystalline lens on its anterior aspect. They are somewhat conical in outline. Their bases or free extremities, which are round and prominent, lie behind the circumference of the iris upon the anterior aspect of the periphery of the crystalline lens. Their apices are connected with the orbicularis ciliaris. Anteriorly they are related to the posterior chamber of the eyeball at its circumference. Posteriorly they are related to and connected with the suspensory ligament of the lens.

Structure.—The ciliary processes are similar in structure to the choroid, but the pigment-cells are not so numerous. On their deep or posterior surfaces the processes are covered by the **ciliary part of the retina,** which is prolonged from the pigmentary layer of the retina, and is continuous with the pars iridica retinæ (uvea) on the posterior surface of the iris.

The arteries of the ciliary processes are derived from those of the anterior part of the choroid, and from the anterior ciliary arteries. The veins pass to those of the choroid.

Ciliary Muscle.—This muscle is composed of unstriped fibres. It forms a greyish-white ring, about $\frac{1}{10}$ inch broad, which is situated at the anterior part of the choroid opposite the ciliary processes. The fibres are arranged in two sets—radial and circular. The *radial fibres* arise from the calcar scleræ close to the corneo-scleral junction and behind the sinus venosus of the sclera. From this origin they pass backwards in a radiating manner, and are inserted into the orbicularis ciliaris and the attached ends of the ciliary processes. The *circular fibres* form a ring around the circumference of the iris internal to the radial fibres.

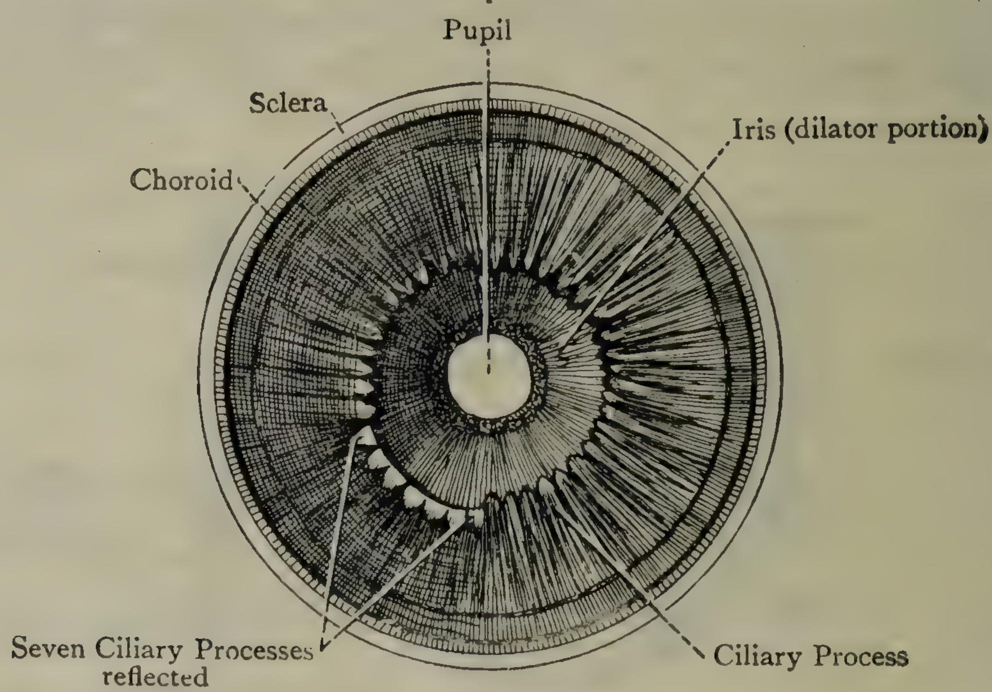


FIG. 1009.—THE IRIS AND CILIARY PROCESSES (POSTERIOR VIEW) (HIRSCHFELD AND LEVEILLÉ).

The ciliary muscle is supplied by the short ciliary nerves, which are branches of the ciliary ganglion, and derive their fibres from the motor oculi nerve.

Action.—The ciliary muscle is the muscle of *accommodation*, and adjusts the eye to the vision of near objects. When it contracts it draws forwards the choroid and the ciliary processes; the suspensory ligament of the crystalline lens is thereby relaxed, and, as a consequence, the anterior surface of the lens is rendered convex.

The circular fibres of the ciliary muscle are well developed in cases of hypermetropia, but are deficient in cases of myopia.

3. **Iris.**—The iris forms the anterior part of the middle coat of the eyeball. It is a coloured contractile diaphragm, which is suspended in the aqueous humour between the cornea and the crystalline lens. It is perforated by an almost circular aperture, called the **pupil,** which is situated slightly to the nasal or inner side of its centre, and serves for the transmission of light. The margin which surrounds the pupil is known as the *pupillary margin*. Its circumference is continuous

with the ciliary body, and is connected with the posterior elastic lamina of the cornea by means of the ligamentum pectinatum iridis

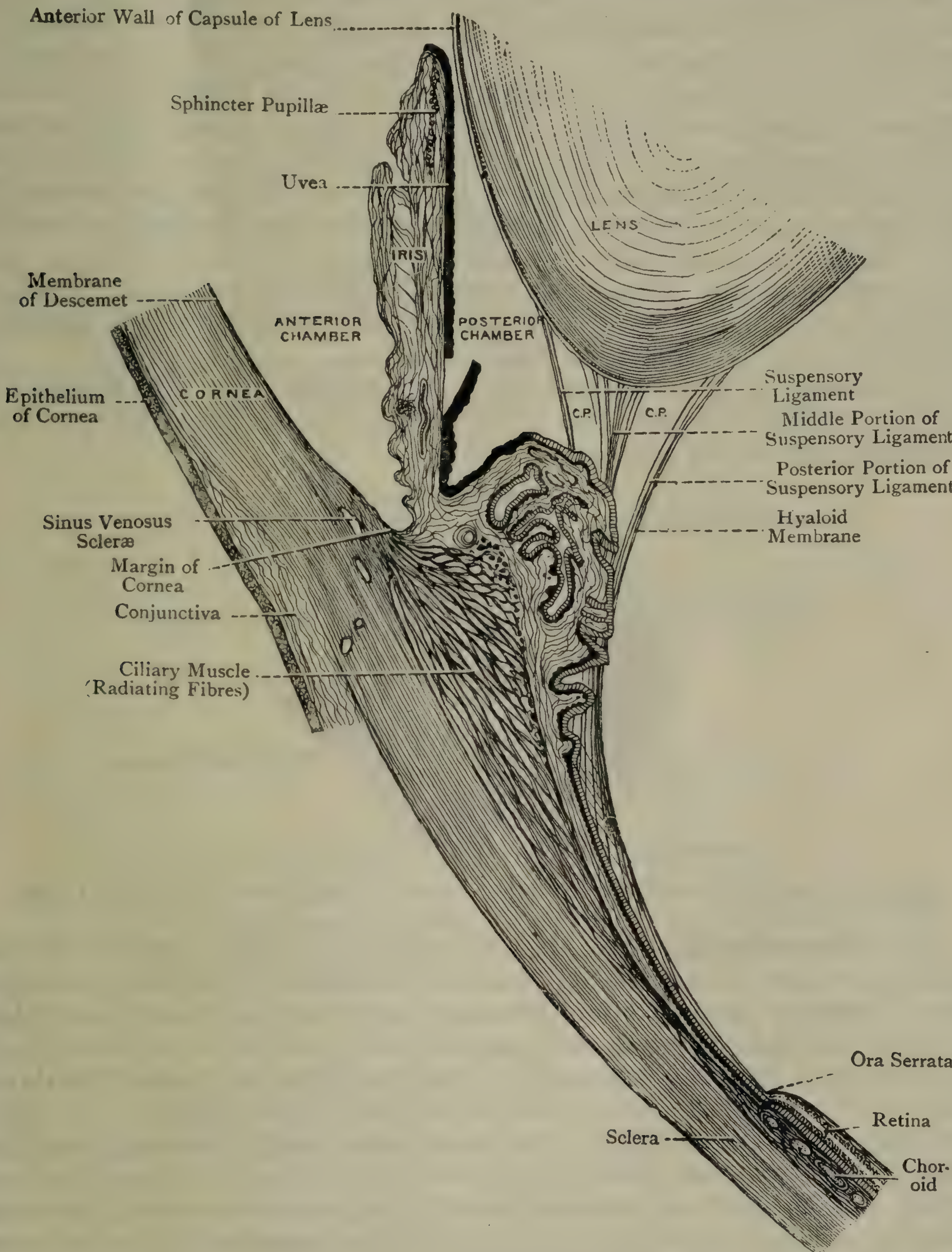


FIG. 1010.—MERIDIONAL SECTION THROUGH THE ANTERIOR PORTION OF THE EYE (MAGNIFIED 16×1) (FUCHS).

C.P., C.P., zonular spaces.

at the iridial angle. The circumference is known as the *ciliary margin.* The surfaces of the iris are anterior and posterior. The *anterior*

surface is directed towards the cornea. Its colour varies in different individuals, and it presents a striated appearance, the striæ converging towards the margin of the pupil, and being produced by the underlying vessels. The *posterior surface* is directed towards the crystalline lens and ciliary processes. It has a purple colour, and is covered by two layers of columnar epithelium, the cells of which contain dark pigment. These two layers of pigmented cells constitute the **pars iridica retinæ** (**uvea**), which is continuous with the pars ciliaris retinæ. The iris divides the space between the cornea and the crystalline lens into two compartments, the anterior chamber and posterior chamber, both of which contain the aqueous humour.

Structure.—The component parts of the iris are (1) a layer of endothelium; (2) a connective-tissue stroma, with branched pigment-cells; (3) muscular tissue; and (4) pigment.

The **layer of endothelium** covers the anterior surface of the iris, and is continuous with the endothelium which lines the posterior elastic lamina of the cornea.

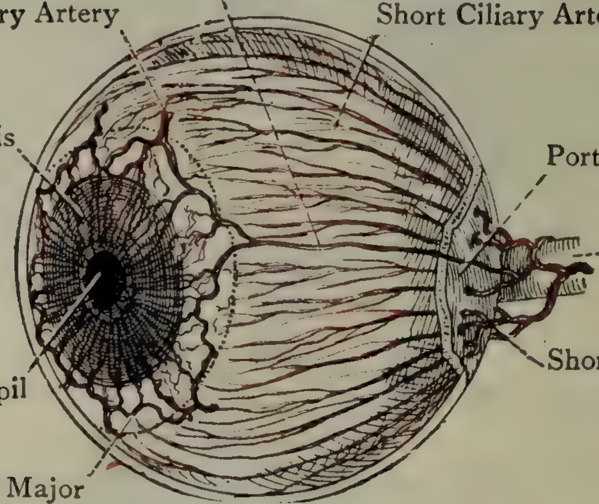


FIG. 1011.—THE ARTERIES OF THE CHOROID AND IRIS (LATERAL VIEW).

The **connective-tissue stroma** is composed of fibres which for the most part pass in a radiating manner towards the pupillary margin. Some, however, are disposed circularly at the ciliary margin. They support the bloodvessels and nerves, and scattered between their bundles there are branched cells. These cells contain pigment in dark-coloured eyes, but in blue eyes there is little pigment here.

The muscular tissue is of the unstriped variety, and its fibres are arranged in two sets, circular and radiating. The *circular fibres* form a ring round the pupil, and are nearer the posterior surface than the anterior. They are known as the **sphincter pupillæ.** The *radiating fibres* converge from the ciliary margin of the iris towards the pupillary margin, where they blend with the circular fibres. The radiating fibres constitute the **dilator pupillæ.** Some authorities regard the radiating fibres as elastic, and not muscular.

The **pigment** of the iris is variously situated, according to the colour of the eye. In the eyes of albinos there is no pigment. In other eyes pigment is contained in the cells of the two layers of columnar

epithelium which line the posterior surface of the iris, and form the pars iridica retinæ (uvea). In blue eyes the pigment is largely confined to this region, but in other coloured eyes it is also present in the branched cells of the connective-tissue stroma.

Blood-supply—Arteries.—The arteries of the iris are derived from (1) the long ciliary, and (2) the anterior ciliary vessels.

The **long ciliary arteries** are two in number, and belong to the posterior ciliary group of branches from the ophthalmic artery. They pierce the back part of the sclera, one on each side of the optic nerve, and pass forwards between the sclera and the choroid towards the ciliary margin of the iris. Here each vessel divides into two branches, upper and lower, which anastomose with those of the opposite side to form an arterial ring round the ciliary margin of the iris, called the *circulus arteriosus major.* This ring is joined by some of the anterior ciliary arteries, and it gives offsets to the ciliary muscle

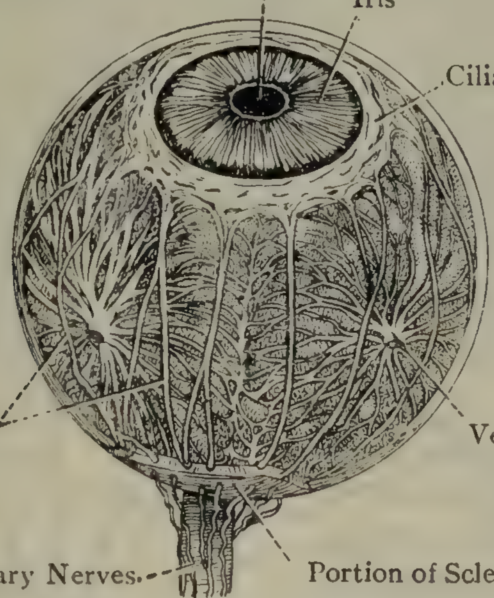


FIG. 1012.—THE CHOROID AND IRIS, SHOWING THE VENÆ VORTICOSÆ AND CILIARY NERVES (AFTER HIRSCHFELD AND LEVEILLÉ).
The sclera and cornea have been removed.

and iris. The branches which enter the iris are supported by the connective-tissue stroma, and converge towards the pupillary margin, near which they form by their anastomoses another arterial ring, called the *circulus minor.*

The **anterior ciliary arteries** are about six in number, and are derived from the muscular and lacrimal branches of the ophthalmic artery. They are of small size, and pierce the anterior part of the sclera close to the corneo-scleral junction. Some of them supply the ciliary processes, and others join the circulus major (see Fig. 1011).

The **veins** of the iris accompany the arteries, and are in communication with the sinus venosus scleræ.

Nerves of the Choroid Coat and Iris.—These are derived from the ciliary nerves, short and long, the former coming from the ciliary ganglion, and the latter from the naso-ciliary branch of the ophthalmic or first division of the fifth cranial nerve. They are about sixteen

in number, and pierce the back part of the sclera around the optic nerve. They then pass forwards between the sclerotic and choroid, giving branches to the latter coat, which become disposed in a plexiform manner amongst the bloodvessels. Having reached the corneo-scleral junction, the nerves enter the ciliary muscle, in which they form a plexus. From this plexus branches enter the iris at the ciliary margin. These branches accompany the vessels, and by their subdivisions and communications they form a copious plexus of non-medullated fibres in the connective-tissue stroma of the iris. The **sphincter pupillæ** is supplied by fibres which are derived from the oculomotor or third cranial nerve by means of the motor root of the ciliary ganglion. The **dilator pupillæ** is supplied by fibres which may be traced to the second thoracic ganglion through the sympathetic root of the ciliary ganglion (see p. 1637).

Membrana Pupillaris.—During intra-uterine life the pupil is closed by a delicate membrane, called the **membrana pupillaris.** This disappears shortly before birth, but remnants of it are sometimes found.

Internal Coat.

Retina.—The retina is the internal or nervous tunic of the eyeball. It is soft in consistence, translucent, and of a pinkish colour. Its internal surface is in contact with the hyaloid membrane, which

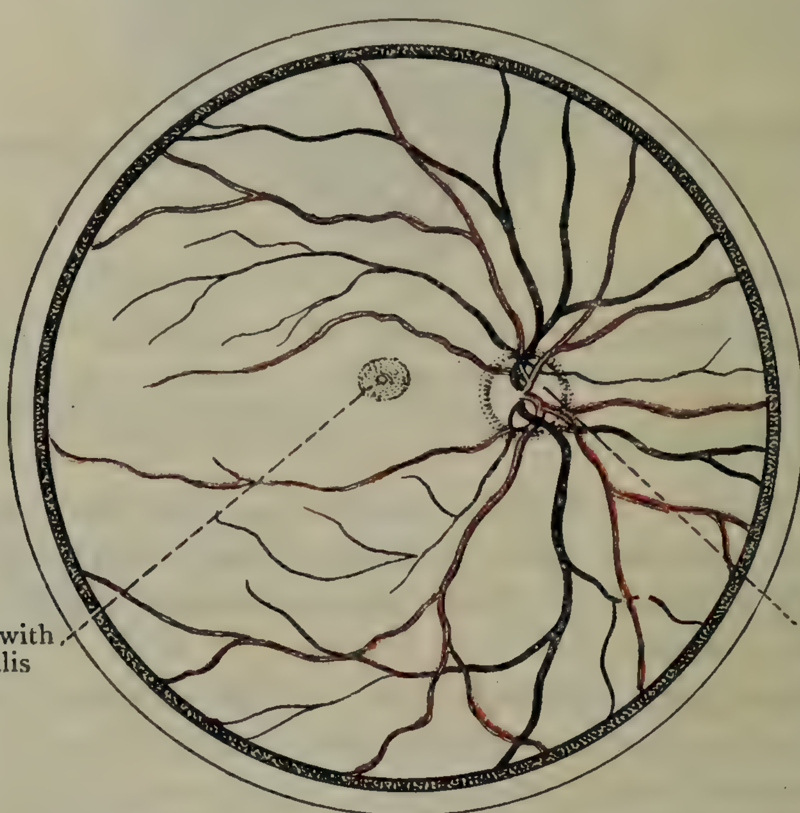


FIG. 1013.—THE POSTERIOR PORTION OF THE RIGHT RETINA (ANTERIOR VIEW).

encloses the vitreous body, and its external surface is in contact with the choroid coat. Posteriorly it receives the fibres of the optic nerve. Anteriorly it extends almost to the ciliary body, where there is a notched border, called the **ora serrata.** Here its nervous elements cease, but its pigmentary layer is continued over the deep or posterior

surfaces of the ciliary processes on to the posterior surface of the iris, forming, with the addition of a layer of columnar epithelial cells, the pars ciliaris retinæ and pars iridica retinæ (uvea) respectively. The retina diminishes in thickness from behind forwards.

The *external surface* is formed by a stratum of hexagonal pigment-cells, which send processes into the adjacent layer. When the choroid is separated from the retina these processes are torn, and the stratum of pigment-cells remains attached to the choroid, being apparently a part of it. The pigmentary layer, however, really belongs to the retina.

The *internal surface* shows, in the line of the visual axis of the eyeball, the **macula lutea** or **yellow spot,** where vision is most distinct. This spot is transversely oval, and measures about $\frac{1}{12}$ inch from side

FIG. 1014.—LONGITUDINAL SECTION THROUGH THE HEAD OF THE OPTIC NERVE (14×1) (FUCHS).

r. Retina
b. Centre of Porus Opticus
ch. Choroid
s. Sclera
so. Outer Part of Sclera
si. Inner part of Sclera
ci. Ciliary Artery (in longitudinal section)
sd. Subdural Space
sa. Subarachnoid Space
n. Bundles of Nerve-fibres
se. Septa between the Nerve-bundles
a. Arteria Centralis Retinæ
v. Vena Centralis Retinæ
p. Sheath formed by Pia Mater
ar. Sheath formed by Arachnoid
du. Sheath formed by Dura Mater

nasal, Medial Side

temporal, Lateral Side

to side. At its centre is a slight depression, called the **fovea centralis.** In this situation the retina is thinnest, and the dark colour of the hexagonal pigment-cells is visible through it, giving it the appearance of a foramen. About $\frac{1}{8}$ inch to the inner side of the posterior pole of the eyeball, and about $\frac{1}{24}$ inch below its level, is the **porus opticus,** or **optic disc.** This is circular in outline, and its circumference is slightly elevated. It is the point of entrance of the fibres of the optic nerve, and the centre of the disc is pierced by the arteria centralis retinæ, which immediately divides into two branches—upper and lower. The optic disc consists entirely of nerve-fibres, and is known as the 'blind spot,' vision being absent in this situation.

Structure of the Retina.—The retina consists of eight superimposed layers, seven of which are nervous and one pigmentary.

In addition to these, there are sustentacular fibres. The eight layers are as follows, from within outwards:

1. Stratum opticum, or layer of nerve-fibres.
2. Ganglionic layer, or layer of nerve-cells.
3. Inner plexiform (inner molecular) layer.
4. Inner nuclear or granular layer.
5. Outer plexiform (outer molecular) layer.
6. Outer nuclear or granular layer.
7. Layer of rods and cones.
8. Pigmentary layer.

In addition to the foregoing layers, there are two very delicate membranes, which really belong to the sustentacular fibres of the retina, but are known as the membrana limitans interna and externa. The **membrana limitans interna** covers the retina on its internal surface, and the **membrana limitans externa** intervenes between the outer nuclear layer and that of the rods and cones. The layers of the retina are supported by fibres called the **sustentacular fibres.**

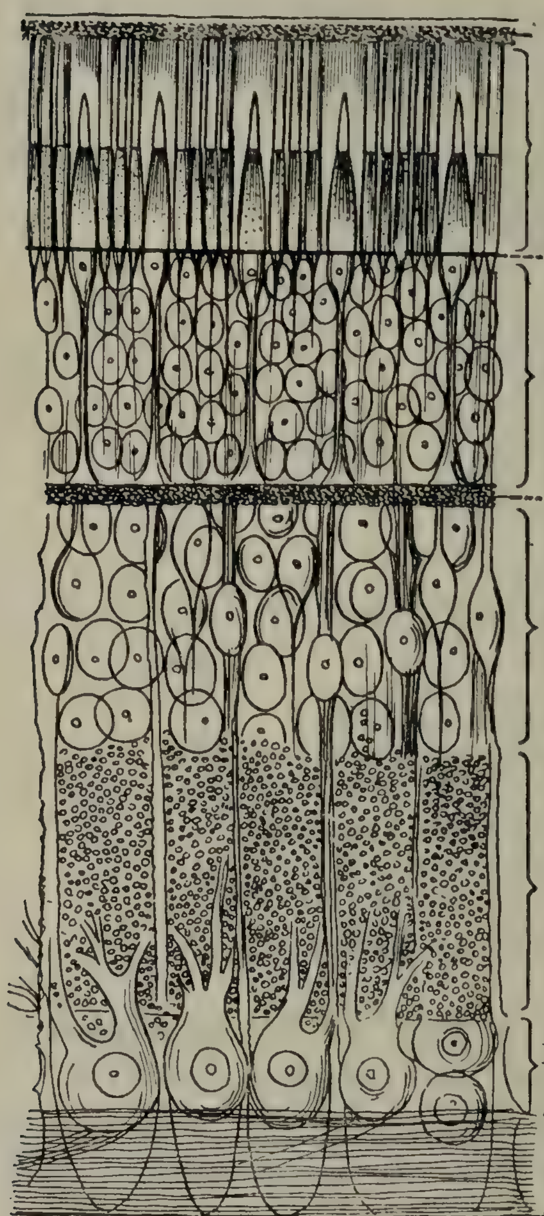


FIG. 1015.—DIAGRAMMATIC SECTION OF THE HUMAN RETINA (SCHULTZE) (COPIED FROM QUAIN'S 'ANATOMY').

1. **Stratum Opticum.**—This layer consists of the fibres of the optic nerve, and it extends from the optic disc to the ora serrata. The fibres are non-medullated, and are chiefly centripetal, but some are centrifugal. The centripetal fibres arise mainly as the axons of the cells of the ganglionic layer. The centrifugal fibres pass towards the inner plexiform and inner nuclear layers.

2. **Ganglionic Layer.**—This consists of large, somewhat flask-shaped, multipolar ganglion-cells, which for the most part form a single layer. In the macula lutea, however, they form several layers.

The round ends of the cells rest upon the stratum opticum, and from each of these ends an axon is given off, which enters the stratum opticum obliquely, and forms one of its component fibres. The tapering end of each cell sends off several dendrites, which enter the inner plexiform layer, within which they arborize.

3. **Inner Plexiform (Inner Molecular) Layer** contains the arborizations of the dendrites of (1) the cells of the ganglionic layer, and (2) the bipolar cells of the inner nuclear layer. The intercommunications between these two sets of dendrites give rise to five strata, according to Ramon y Cajal. Besides these, there are the arborizations of the processes of the spongioblasts of the inner nuclear layer, which are likewise arranged in strata.

4. **Inner Nuclear or Granular Layer.**—This layer consists of cells which are arranged in three groups: (1) bipolar cells, (2) horizontal cells, and (3) spongioblasts, or amacrine cells. The **bipolar cells** are the most numerous, and are nucleated. Each cell gives off two processes—internal and external. The *internal processes* of the cells enter the inner plexiform layer, and end at different levels in arborizations. The *external processes* pass into the outer plexiform layer, and form arborizations in its outermost part, which are closely related to the terminal parts of the rods and cones of the bacillary layer. According to Cajal, the bipolar cells are of two kinds—rod-bipolars and cone-bipolars. The external processes of the **rod-bipolars** ramify round the terminal parts of the rod-fibres, and the internal processes arborize round the cells of the ganglionic layer. The external processes of the **cone-bipolars** form horizontal arborizations round the ends of the cone-fibres, and the internal processes terminate in arborizations in the inner plexiform layer at different levels.

The **horizontal cells** occupy the outer part of the inner nuclear layer. Their dendrites enter the outer plexiform layer, and come into relation with the terminal parts of the cone-fibres, whilst their axons run in a horizontal direction.

The **spongioblasts** are situated in the innermost part of the inner nuclear layer. They are destitute of axons, and have been called *amacrine cells*, because each cell is ‘ without a long fibre or process.’ Their dendrites enter the inner plexiform layer, and end in arborizations, which are arranged in strata.

5. **Outer Plexiform (Outer Molecular) Layer.**—This layer is composed of the following structures: (1) the external processes of the rod-bipolars and cone-bipolars of the inner nuclear layer; (2) the dendrites of the horizontal cells of the inner nuclear layer; and (3) the terminal parts of the rod-fibres, and filaments from the foot-plates of the cone-fibres.

6. **Outer Nuclear or Granular Layer.**—This consists of granules, which are of two kinds—rod-granules and cone-granules. The **rod-granules** are the more numerous, and are oval enlargements in the course of the rod-fibres, as these pass to the outer plexiform layer. Each rod-fibre has only one rod-granule, and the granules lie at different

levels. Each granule has a nucleus, which has transverse striations, there being at least two clear bands. The external process of each rod-granule is continuous with one of the rods of the bacillary layer, and the internal process passes into the outer plexiform layer, where it comes into relation with the arborizations of the external process of a rod-bipolar.

The **cone-granules** are larger than the rod-granules, but not so numerous, and each contains an oval nucleus. Situated in the outermost part of the outer nuclear layer, they lie close to the membrana limitans externa. The outer end of each granule is continuous with one of the cones of the bacillary layer. The inner end is prolonged into a cone-fibre, which passes into the outermost part of the outer

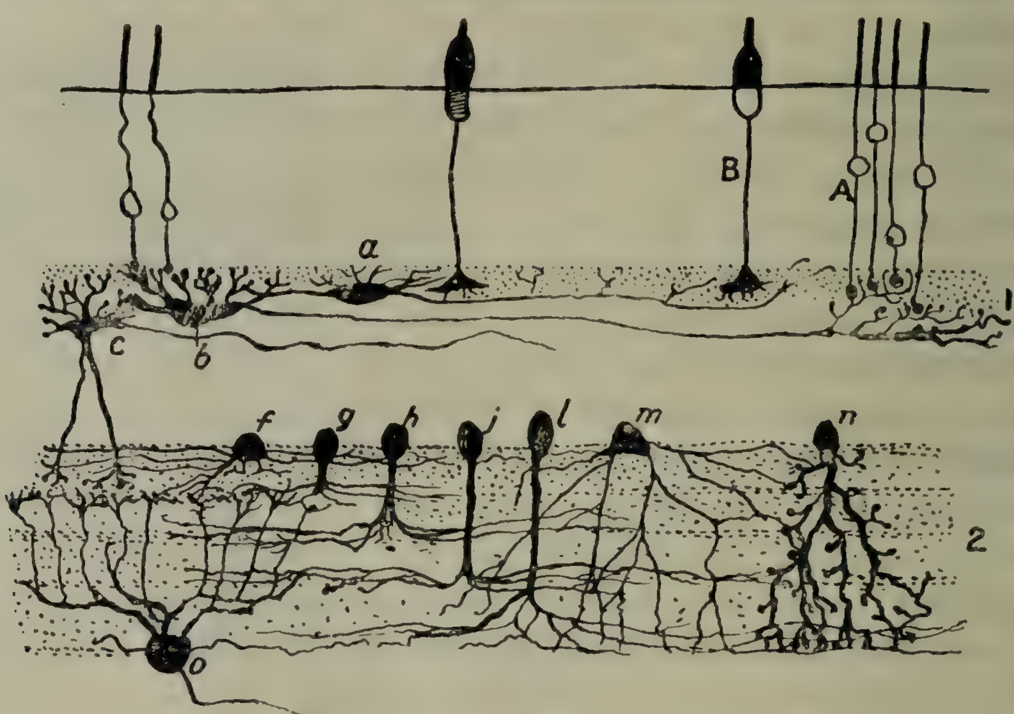


FIG. 1016.—SCHEME OF THE HORIZONTAL CELLS AND SPONGIOBLASTS OF THE RETINA (RAMON Y CAJAL).

A. Rod-fibres
B. Cone-fibres
1. Outer Plexiform Layer
a, b. Horizontal Cells, with arborizations
c. Horizontal Cell, with deep processes
2. Inner Plexiform Layer
f, g, h, j, l. Spongioblasts extending to different depths
m, n. Spongioblasts with diffuse processes
o. Ganglionic Nerve-cell

plexiform layer, where it expands into a foot-plate, from which filaments are given off. These filaments come into relation with the arborizations of the external process of a cone-bipolar cell.

7. **Layer of Rods and Cones** consists of rods and cones, the former being cylindrical, and the latter flask-shaped. The rods are much more numerous, longer, and narrower than the cones, and both are placed perpendicularly.

Each **rod** and **cone** consists of two segments—outer and inner. In the case of the **rods** the two segments are of almost equal length, the inner segment being rather larger than the outer. The outer segment is the only seat of the colouring matter known as *visual purple* or *rhodopsin*. In the case of the flask-shaped **cones,** the *inner* segment of each forms two-thirds of the cone, and is of large size; whilst the

outer forms one-third, is narrow, and represents the tapering part of the flask. The outer segments of both rods and cones have faint transverse striations. The inner segments of both are subdivided. The outer part is composed of delicate fibrils longitudinally arranged, and therefore presents a longitudinally striated appearance. The inner part is faintly granular. The rods and cones are continued at their inner ends through the membrana limitans externa into the rod-fibres and cone-fibres, which belong to the outer nuclear layer. The outer ends of the rods project into the pigmentary layer.

8. **Pigmentary Layer.**—The most external layer of the retina is in close contact with the choroid coat. It consists of a single layer of hexagonal epithelial cells, which contain pigment. The deep surfaces of the cells give off processes which extend into the intervals between the outer ends of the rods and cones.

Fig. 1017.—Section of the Retina as seen under the Microscope (magnified).

Sustentacular Fibres (or Fibres of Müller).—These fibres form the supporting tissue of the retina, and extend from its internal surface to the boundary-line between the outer nuclear layer and the layer of rods and cones. The inner ends of the fibres are expanded, and blend at their edges to present the appearance of a distinct retinal layer, which is called the **membrana limitans interna.** Their outer ends, which are very numerous owing to the breaking up of the fibres, also expand and form the **membrana limitans externa,** which lies between the outer nuclear layer and the layer of rods and cones. (The membrana limitans interna and externa are sometimes considered layers of the retina, under which circumstances the retinal layers would be *ten* in number, instead of eight.) From the membrana limitans externa delicate offsets enter the layer of rods and cones, in the innermost part of which they form *fibre-baskets* in connection with the deep ends of the rods and cones. As the sustentacular fibres pass through the inner nuclear layer each has an oval nucleus, which contains a nucleolus. This nucleus is variously described as being situated on one side of the fibre, or as involving its whole circumference. Throughout their course the sustentacular fibres give off lateral offsets, which increase in number from within outwards.

Structure of the Macula Lutea and Fovea Centralis.—The chief structural characters of the macula lutea and fovea centralis may be stated in the following tabular manner:

Macula Lutea.

1. Cones only.
2. Outer nuclear layer has only cone-fibres disposed obliquely.
3. Ganglionic layer very thick, cells being several layers deep.
4. Stratum opticum not continuously disposed.

Fovea Centralis.

1. Thinnest part of the retina.
2. Pigmentary layer thick.
3. Cones only.
4. Outer nuclear layer has only cone-fibres.
5. Ganglionic layer absent.
6. Stratum opticum absent.

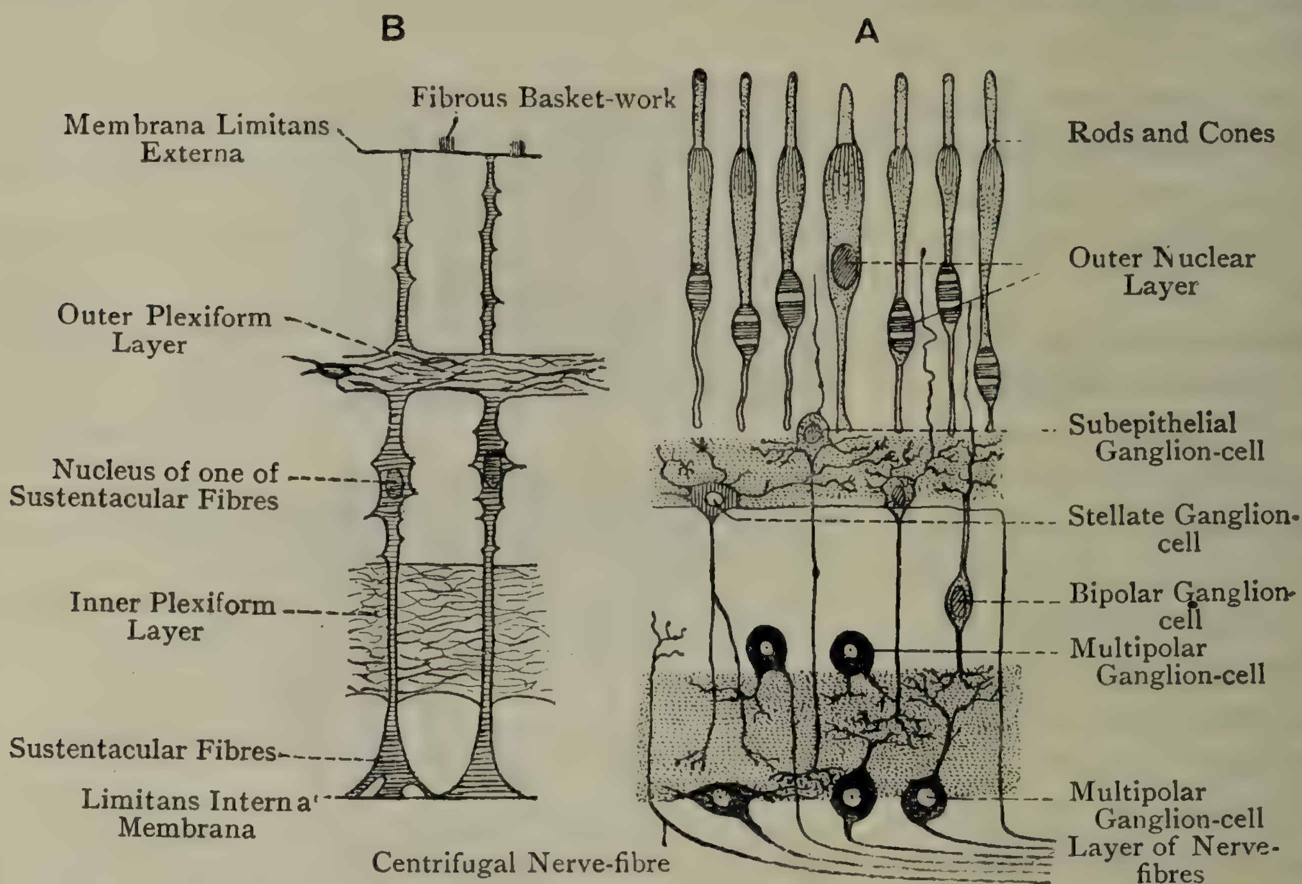


FIG. 1018.—DIAGRAM OF THE ELEMENTS OF THE RETINA (WIEDERSHEIM, AFTER PH. STÖHR).

A, nervous elements; B, supporting elements.

Structure of the Ora Serrata.—At the ora serrata the nervous elements of the retina end, and its pigmentary layer is continued over the deep or posterior surfaces of the ciliary processes. Here is added to its deep or posterior surface a layer of columnar epithelial cells, and the two layers form the pars ciliaris retinæ, which is continued into the pars iridica retinæ (uvea). In the latter the cells of both layers are pigmented.

Blood-supply of the Retina.—The retina is supplied with blood by the **arteria centralis retinæ,** a branch of the ophthalmic artery. Within the orbit the artery pierces the under aspect of the optic nerve a little behind the eyeball, and passes forwards in the centre of the nerve. At the centre of the optic disc it divides into two branches, upper and lower. Each of these breaks up into two branches, nasal or medial,

and temporal or lateral. The temporal branches keep clear of the macula lutea, but give small twigs to it, which, however, do not enter the fovea centralis, this part being non-vascular. As the branches pass inwards and outwards respectively towards the periphery of the retina they ramify freely, and end at last in capillary networks. The arteries do not extend farther outwards than the inner nuclear layer. No anastomoses take place between the branches of the arteria centralis retinæ.

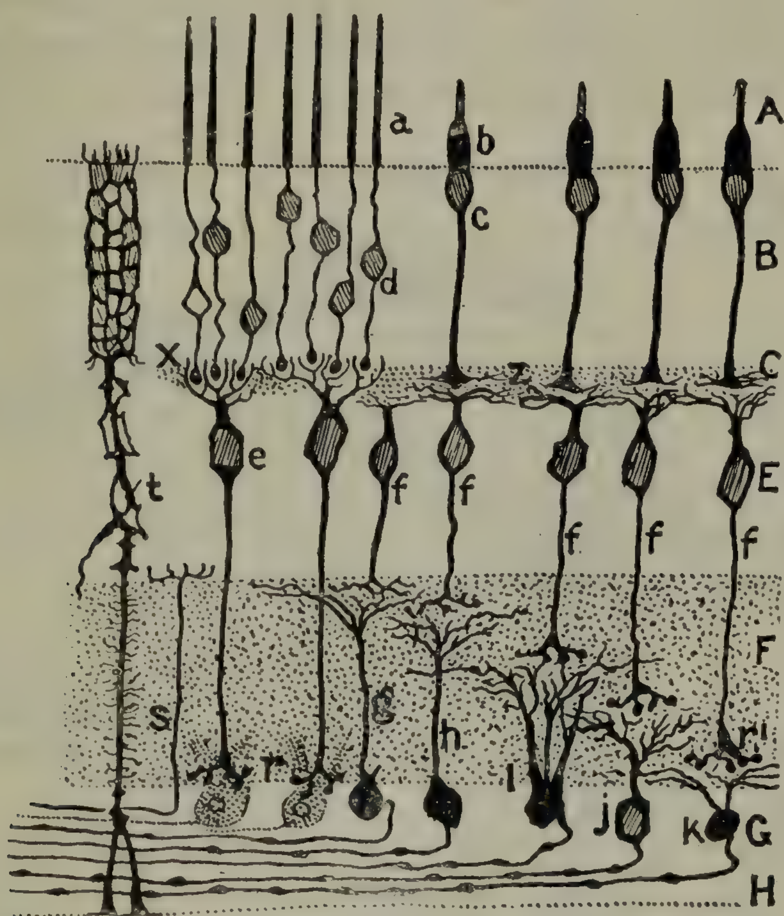


FIG. 1019.—SCHEME OF THE RETINA, SHOWING THE CONNECTION BETWEEN THE LAYER OF RODS AND CONES AND THE GANGLIONIC LAYER (RAMON Y CAJAL).

A. Layer of Rods and Cones
B. Outer Nuclear Layer
C. Outer Plexiform Layer
E. Inner Nuclear Layer
F. Inner Plexiform Layer
G. Ganglionic Layer
H. Layer of Nerve-fibres
M. Sustentacular fibre
a. Rods
b. Cones
c. Granule of Cones
d. Granule of Rods
e. Bipolar Cells of Rods
f. Bipolar Cells of Cones
g, h, i, j, k. Ganglionic Corpuscles ramifying at different levels in Inner Plexiform Layer
r, r′. Deep arborizations of Bipolar Cells
s. Centrifugal Nerve-fibre
t. Nucleus of Sustentacular Fibre
X. Deep ends of Rod-fibres amongst superficial arborizations of Bipolar Cells
Z. Meeting of arborizations of Cones and Bipolar Cells

In the fœtus the arteria centralis retinæ sends a branch to the posterior part of the capsule of the crystalline lens, which reaches it through the ‘ canal of Cloquet ’ in the vitreous body.

The **veins** are ultimately collected into two vessels, upper and lower, which pass through the optic disc, one above and the other below the artery. They then form one vessel which opens into the superior ophthalmic vein. The veins of the retina are destitute of muscular tissue, the wall of each being formed by a single layer of endothelial cells, external to which there is a perivascular lymph-

space, this in turn being limited by another layer of endothelial cells. These lymph-spaces are in communication with those of the optic nerve.

Relation of the Retinal Layers to One Another.—The only two layers which are in direct continuity are the stratum opticum and ganglionic layer, some fibres of the former being the axons of the cells of the latter. As regards most of the strata, the constituent elements of successive layers are brought into communication by means of the interlacements which take place between the arborizations formed by their various processes. These interlacements occur in the inner and outer plexiform layers.

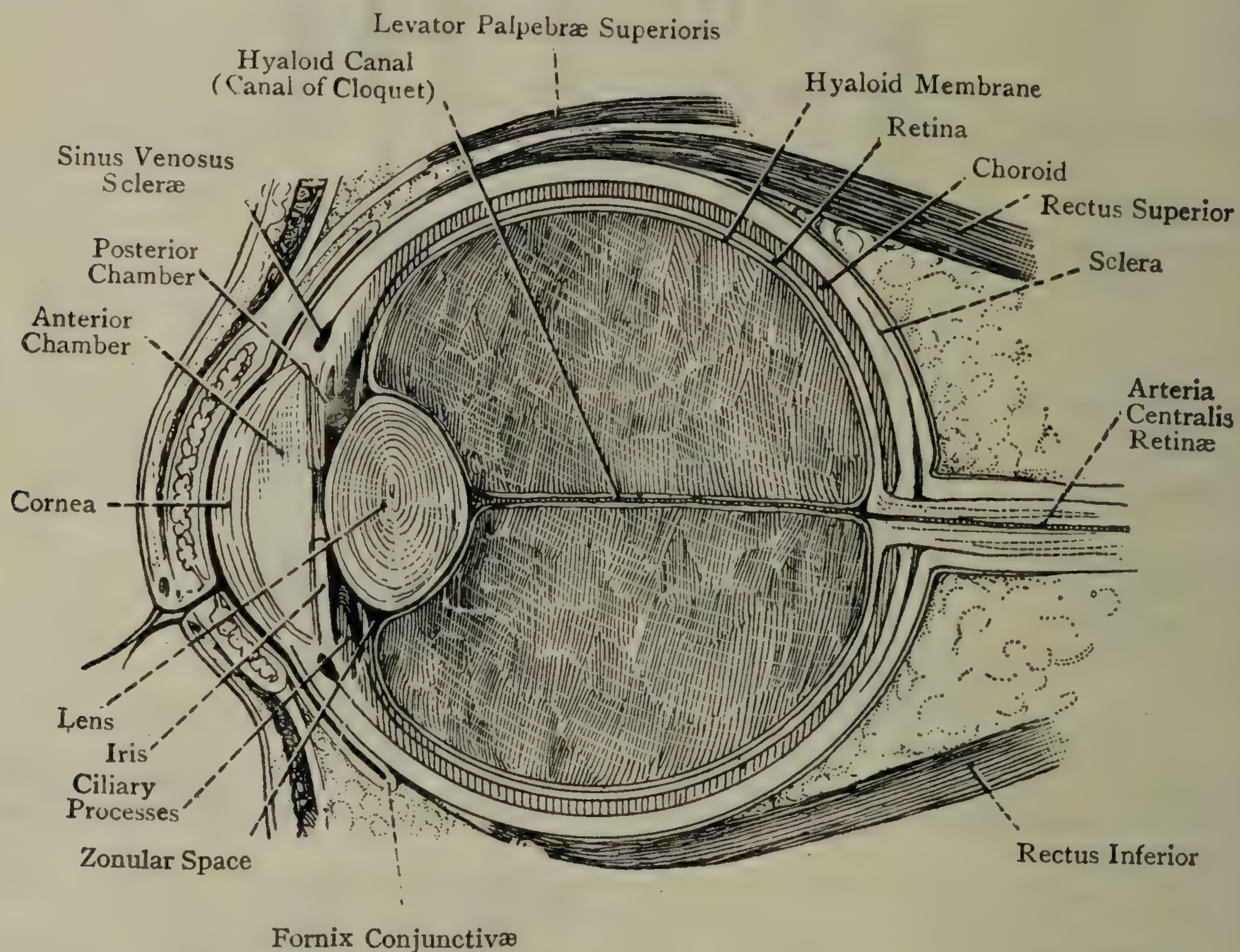


FIG. 1020.—VERTICAL SAGITTAL SECTION OF THE EYE AND ITS APPENDAGES (HIRSCHFELD AND LEVEILLÉ).

In the **inner plexiform layer** there are several strata of interlacements, by means of which the dendrites of the cells of the ganglionic layer are brought into communication with the internal processes of the bipolar cells of the inner nuclear layer. In the **outer plexi orm layer** there is a free intermingling between the external processes of the bipolar cells of the inner nuclear layer and the rod-fibres and cone-fibres.

Nerve-cells of the Retina.—These are arranged in three strata, and communicate with one another through interlacing arborizations. The outermost stratum consists of the rods and cones; the middle stratum is formed by the bipolar cells; and the innermost stratum represents the cells of the ganglionic layer. The axons of the gang-

lionic cells enter the stratum opticum as centripetal fibres, which pass in the optic nerve to the brain. The centrifugal fibres of the stratum opticum ramify in the inner plexiform or inner nuclear layer.

Refracting Media.

Aqueous Humour and Chambers of the Eye.—The aqueous humour occupies the space between the cornea and the front of the crystalline lens, which is divided by the iris into two chambers, anterior and posterior. It is a clear fluid having an alkaline reaction, and is composed of H_2O, holding in solution a very small amount of sodium chloride and traces of albumen.

The **anterior chamber** is bounded anteriorly by the cornea, and posteriorly by the iris and the central portion of the crystalline lens enclosed within its capsule. The anterior chamber communicates with the irido-corneal spaces, through them with the sinus venosus scleræ, and through this canal with the veins of the sclera.

The **posterior chamber,** which is of limited extent, is bounded anteriorly by the iris, and posteriorly by the peripheral part of the crystalline lens and its suspensory ligament, and by the ciliary processes. The anterior and posterior chambers communicate with each other through the pupil; with lymph-spaces in the iris; and through the latter spaces with the perichoroidal lymph-space.

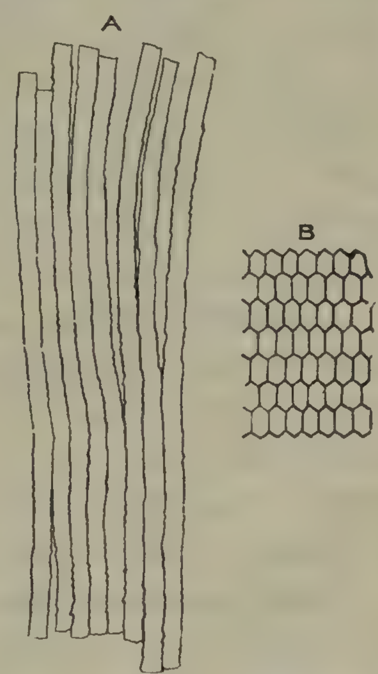


Fig. 1021.—Fibres of the Crystalline Lens (highly magnified) (after Kolliker).

A, fibres of the ox (seen on edge); B, human fibres (seen on end).

Crystalline Lens.—The crystalline lens is situated directly behind the pupil and iris, from which latter it is separated by the posterior chamber. It is a solid, transparent, biconvex disc, the posterior surface being more convex than the anterior, and is enclosed within a homogeneous, transparent envelope, called the **capsule** of the lens. The centre of the anterior surface is called the **anterior pole,** and that of the posterior surface the **posterior pole.** The line connecting these two poles constitutes the **axis** of the lens, and a line surrounding the periphery represents the **equator.** The transverse measurement of the lens is about $\frac{1}{3}$ inch, and its axis measures about $\frac{1}{6}$ inch. The *anterior surface* at its central part faces the pupil. External to this, the pupillary margin of the iris rests upon it, and external to this again is the posterior chamber, with part of the aqueous humour. The *posterior surface* is received into the 'patellar fossa' on the anterior aspect of the vitreous body. The *periphery* is related to the suspensory ligament, the zonular spaces present in this ligament, and the ciliary processes. From the anterior and posterior poles delicate lines radiate

towards the equator. In early life these are three on each surface. Those on the posterior surface form an inverted ⅄; while those on the anterior form an erect Y. These lines represent the free margins of septa within the lens upon which the ends of the lens-fibres terminate.

Structure.—The lens is laminar in structure. The outer laminæ are soft in consistence, but the succeeding ones gradually become firmer, and the central portion, which constitutes the **nucleus,** is very firm and hard. The laminæ are arranged concentrically, and after boiling or immersion in alcohol they may be peeled off, like the coats of an onion. The fibres of which the laminæ are composed terminate upon septa within the lens, of which the radiating lines on the surfaces, already referred to, are the free margins. The concentric laminæ are therefore not continuous all round, but are split up along these lines. The **lens-fibres,** which are disposed in a curved manner, are of small size, and have serrated edges, which fit closely to each other. In transverse section the fibres appear as hexagonal prisms. The fibres are the elongated cells which line the posterior part of the ectodermal vesicle (lens vesicle) from which the lens is developed. In early life each fibre has a nucleus, but after the lens has attained its full development only the outermost fibres are nucleated.

Capsule of the Lens.—This is a transparent, homogeneous, elastic and brittle membrane, which surrounds and encloses the lens. Its anterior wall is thicker and more elastic than the posterior. In the adult the lens and its capsule are non-vascular, but in the fœtus they receive the hyaloid branch of the arteria centralis retinæ, which reaches it through the hyaloid canal in the vitreous body.

Epithelium of the Lens.—The *posterior* surface of the lens is devoid of epithelium, and is in direct contact with the posterior wall of the capsule. The *anterior* surface is covered by a single layer of columnar cells, which intervenes between the anterior surface and the anterior wall of the capsule. Towards the equator these cells become elongated, and pass into short fibres, which become continuous with the superficial lens-fibres.

Crystalline Lens at Different Ages.—The characters of the lens at different ages are as follows:

Fœtal Lens.	**Adult Lens.**	**Lens in Old Age.**
Almost spherical.	Biconvex.	Flattened.
Pinkish colour.	Colourless.	Amber colour.
Semitransparent.	Transparent.	Opaque, more or less.
Soft in consistence.	Firm in consistence.	Very firm in consistence.

Vitreous Body.—This body occupies about four-fifths of the space within the eyeball, and is situated between the crystalline lens and the retina. It is transparent and gelatinous, and is composed of water, holding in solution a small quantity of sodium chloride and albuminous matter. It is surrounded by a transparent, homogeneous envelope, called the **hyaloid membrane.** This membrane is in contact with the retina, except anteriorly, where there is an excavation called the *fossa*

patellaris, into which the posterior surface of the crystalline lens is received.

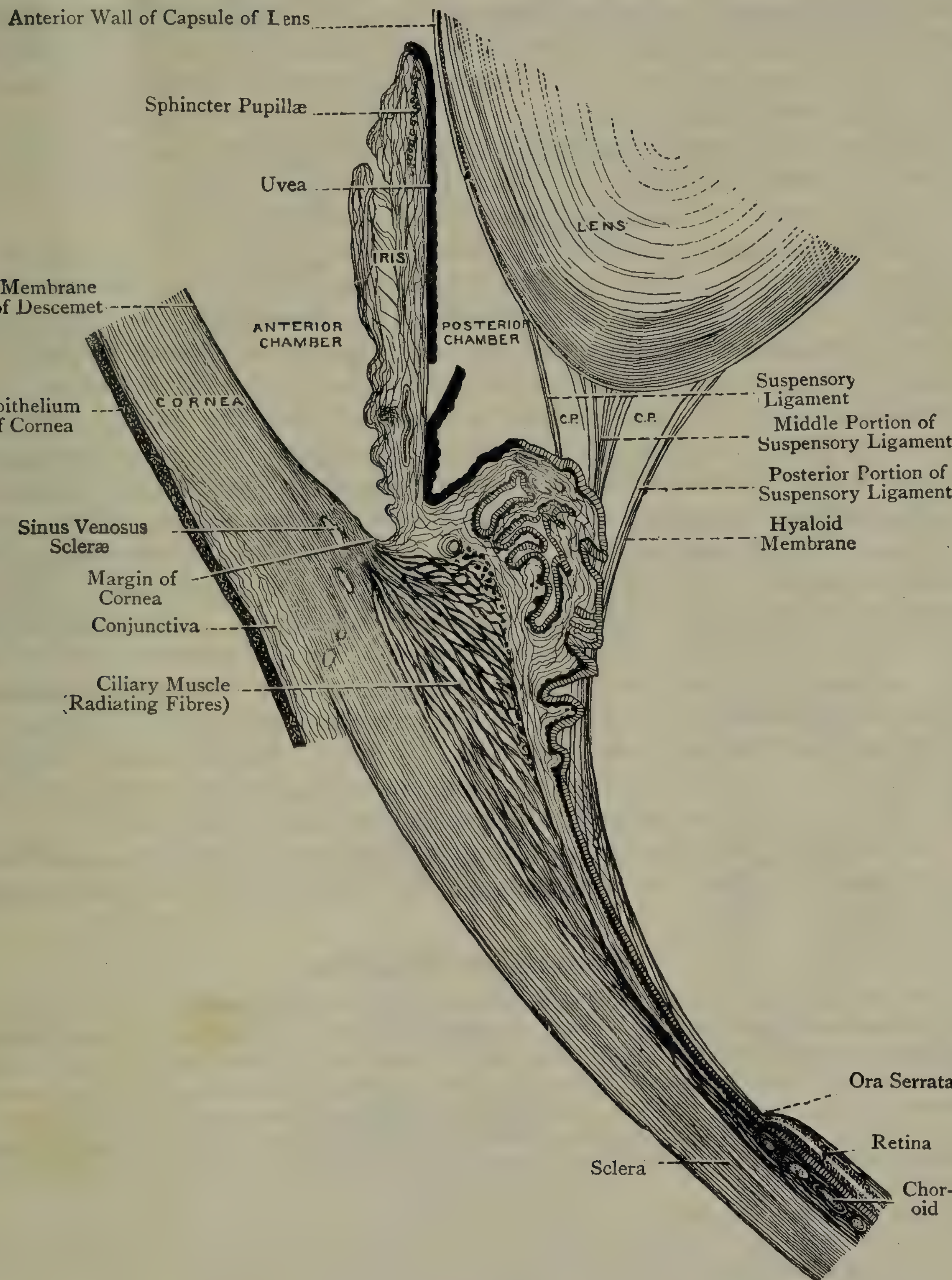


FIG. 1022.—MERIDIONAL SECTION THROUGH THE ANTERIOR PORTION OF THE EYE (MAGNIFIED 16×1) (FUCHS).

C.P., C.P., zonular spaces.

Towards its circumference the vitreous body is laminated, the laminæ being arranged concentrically. Laminæ are also said to radiate

from its antero-posterior axis towards the circumference. Scattered throughout the vitreous body there are some amœboid corpuscles, and it is traversed from behind forwards by a minute passage called the **hyaloid canal** (canal of **Cloquet,** canal of **Stilling).** This extends from the centre of the optic disc to the posterior wall of the capsule of the lens, and posteriorly it communicates with the lymph-spaces of the optic nerve. In the fœtus the canal transmits a branch of the arteria centralis retinæ, called the *hyaloid artery*, which supplies the lens.

No vessels enter the vitreous body, its nutrition being derived from the vessels of the retina and ciliary processes.

Zonula ciliaris, or zonule of Zinn, is the thickened portion of the hyaloid membrane which is situated in front of the ora serrata of the retina. From this point it extends inwards behind the ciliary processes towards the periphery of the crystalline lens. Behind the ciliary processes are radial folds with intervening depressions. The depressions receive the ciliary processes, and the radial folds are separated from the intervals between the ciliary processes by lymph-spaces, which communicate with the posterior chamber of the eye.

Suspensory Ligament of the Lens, and Zonular Spaces.—The ciliary zonule, as it approaches the periphery of the lens, divides into three layers—posterior, middle, and anterior. The *posterior layer* lines the fossa patellaris in front of the hyaloid membrane. The *middle layer* consists of a few scattered fibres which pass to the equator of the lens. The *anterior layer* is the thickest, and forms the **suspensory ligament of the lens,** which is attached to the anterior wall of its capsule not far from the equator (see Fig. 1022). When the radiating fibres of the ciliary muscle contract the suspensory ligament is relaxed, and the convexity of the anterior surface of the lens is increased.

Behind the suspensory ligament of the lens there is a sacculated lymph-space, called the **zonular space,** which surrounds the equator of the lens.

Development of the Eye.

The retina, optic nerve, and crystalline lens are developed from the ectoderm, the retina and optic nerve being derived from the ectoderm of the anterior primary cerebral vesicle, whilst the crystalline lens is developed from the ectoderm of the side of the head. The accessories of the eye—*e.g.*, the sclera, cornea, choroid, ciliary body, and iris—are all developed in mesoderm, but ectoderm, as will be seen, is also employed in some of these. The vitreous body, though developed to a certain extent from the mesoderm, is principally formed from the ectoderm.

The earliest indication of the future eye is in the form of a shallow marginal groove on each side in the widely open cerebral plate of embryos with a few somites. As the region grows these grooves become deepened by the upgrowth of the lateral margins, which ultimately fuse in the middle line, in continuity with the fusion of the edges of the medullary folds further back. In this way the open grooves are converted into recesses or lateral pockets of the closed fore-brain, each pocket being in contact from the beginning with the ectoderm of the surface.

The pocket formed in this way is termed the optic recess, and becomes the **optic vesicle** very soon by its rounded enlargement under the surface ectoderm; such enlargement is mainly at its distal part, its connection with the brain

being slightly constricted, forming a 'neck' for the vesicle. As the development goes on this neck is drawn out into a definite **stalk**, which connects the vesicle with the fore-brain. Stages in these changes can be seen in Fig. 1025. The vesicle is hollow, its cavity being carried into the stalk, and, through this, communicating with that of the fore-brain, which will be the third ventricle. The

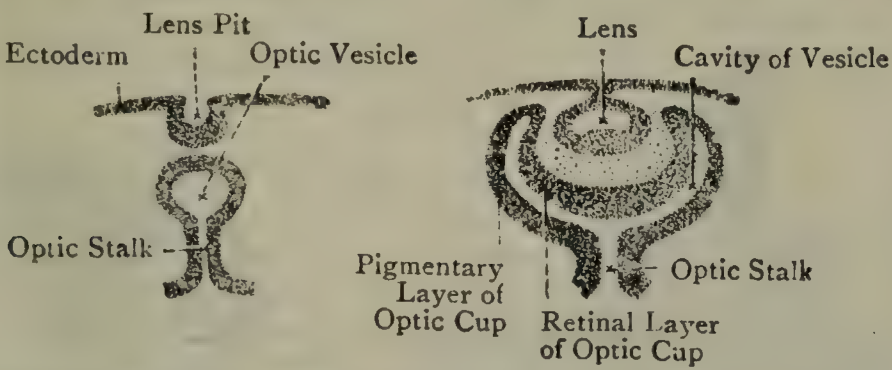


FIG. 1023.—DEVELOPMENT OF CRYSTALLINE LENS AND OPTIC VESICLE (SCHEME).
The lens is lying in the optic cup.

enlargement formed by the optic vesicle lies deep to, and in contact with, the ectoderm of the lateral surface of the head (Fig. 1025).

The ectoderm in relation with the optic vesicle becomes thickened and depressed, this depressed portion constituting the **lens area.** The depressed ectoderm is deepened and converted into a kind of cup, and, the mouth of the fossa becoming constricted, its lips unite. In this manner the lens area becomes transformed into a closed ectodermic sac, called the **lens vesicle,** from which the

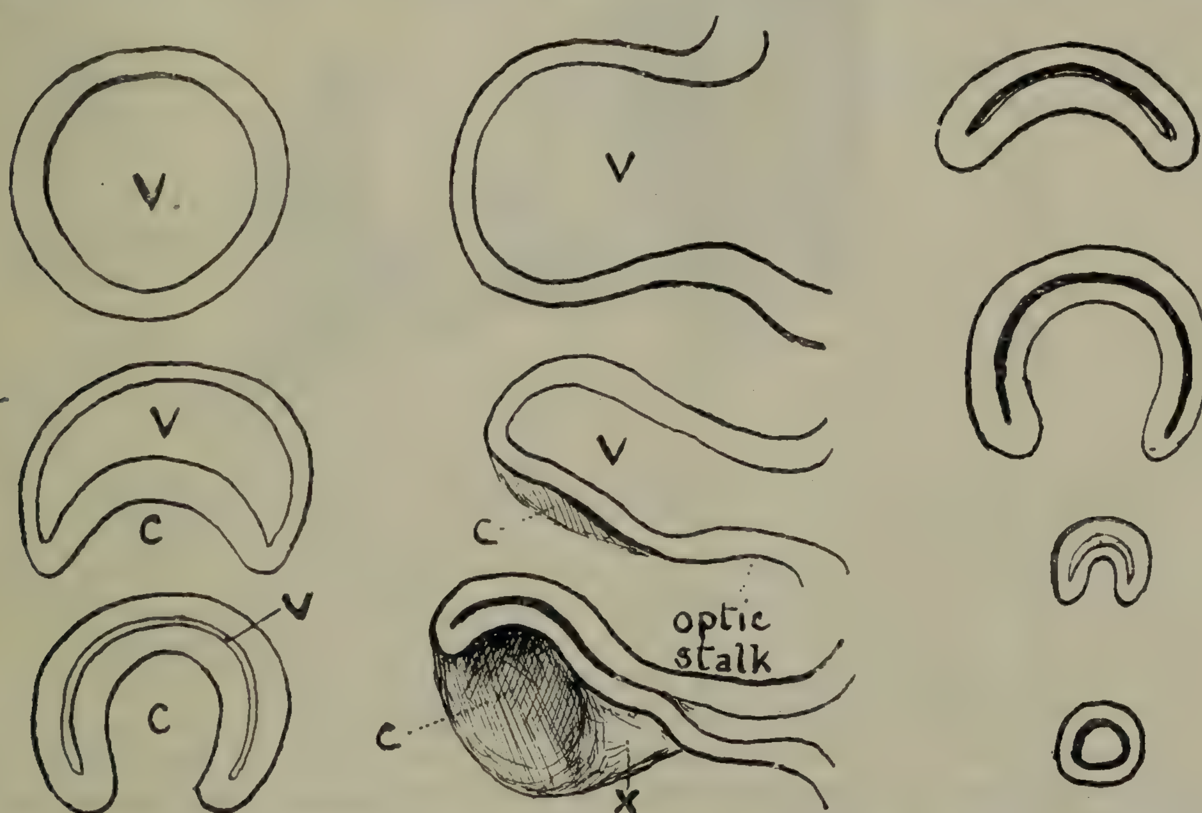


FIG. 1024.—DIAGRAM SHOWING (SEE TEXT) THE CONVERSION OF OPTIC VESICLE INTO OPTIC CUP.

crystalline lens is differentiated. The lens vesicle now becomes completely separated from the surface ectoderm, with which it was originally continuous (Fig. 1023).

The outer wall of the vesicle, facing the rudiment of the lens, is invaginated so as to obliterate the cavity of the vesicle, which is now converted into the *optic cup*. Fig. 1024 gives diagrammatic sections which may help in the comprehension of this change. The middle vertical row of figures here shows sections

along the length of the optic outgrowth; the simple optic vesicle is seen at the top, the commencing invagination of its lower lateral wall is seen next, while the completed invagination is shown in the lowest section. It can be seen that the invagination extends into the optic stalk also. On the left side the invagination is shown by transverse sections of the vesicle, corresponding more or less with the stages of the middle column. Observe that the cavity (V) of the *optic*

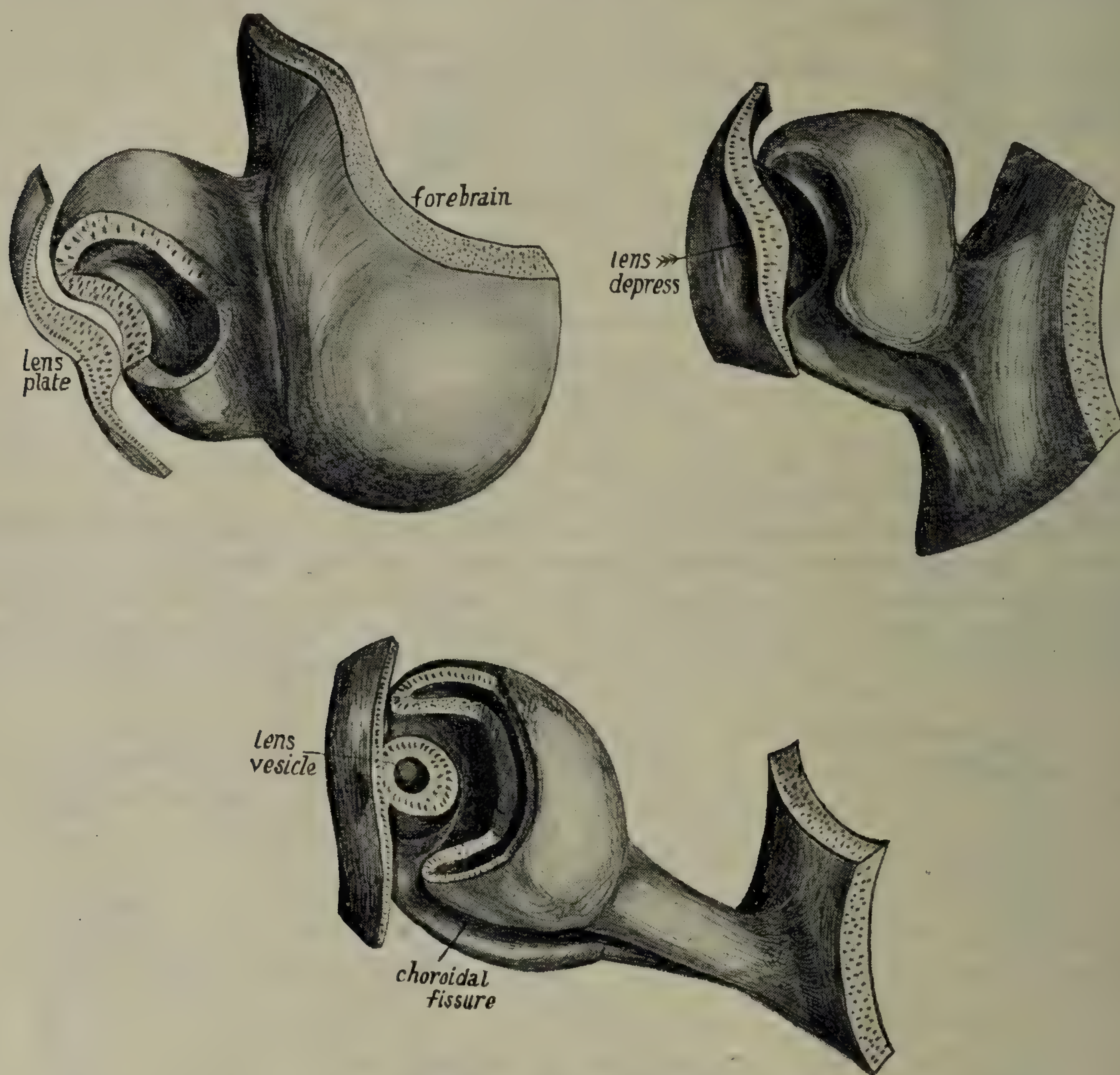


FIG. 1025.—DIFFERENT STAGES IN THE DEVELOPMENT OF THE EYE (FROM RECONSTRUCTION MODELS AT ST. MARY'S HOSPITAL).

A piece of the wall of the optic vesicle has been removed in the first specimen, showing the *cavity of the vesicle*; the lens thickening of the ectoderm is beginning to be depressed. In the second the optic outgrowth is entire, and the lens depression is projecting into the *cavity of the optic cup*. In the third figure removal of part of the wall has opened the cavity of the vesicle, and also the cavity of the cup, in which the lens vesicle is lying, still attached to the ectoderm, its cavity opened by the section. The figures also show the formation of the stalk of the vesicle and the extension into it of the cleft continuous with the cavity of the optic cup.

vesicle is being obliterated, replaced by the cavity (C) of the **optic cup,** which is still open in front and below; the last section in the middle column has gone along this interval between the two sides of the cup. The interval is termed the **choroidal** or **fœtal fissure,** and extends into the stalk. It closes later by the apposition and rapid fusion of its lips, so completing the **optic cup.** The right-hand column of sections is made from the distal end towards the brain; they show the concavity in the vesicle, and in the stalk, lost in the last section.

The **lens vesicle,** when it separates from the surface ectoderm, lies in the opening of the optic cup. Vascular mesoderm extends into the cavity of the cup through the choroidal fissure, behind and below the lens vesicle; when the fissure closes, the mesoderm within the cavity of the cup loses its connection with the outer mesoderm, except at the end of the fissure, where a relatively large vessel persists, and becomes ultimately the *central artery of the retina.* Since the end of the fissure is in the optic stalk, which becomes the optic nerve, this artery passes in the terminal piece of the nerve to enter the eye. The artery, when first formed, is known as the **hyaloid** artery, and is distributed over the posterior surface of the lens.

In cases of non-closure of the choroidal fissure the region of the fissure remains unpigmented, and one of two congenital deficiencies in the eye is met with, each being known by the general term *coloboma.* If the patent fissure affects the ventral wall of the optic cup, then the deficiency in pigment affects the choroid, and the condition is known as *coloboma choroidea.* If the patent fissure affects the lower margin of the optic cup, then the deficiency affects the lower part of the iris, and the condition is known as *coloboma iridis.*

As stated, the wall of the optic cup consists of two layers. The *outer layer,* which is comparatively simple, gives rise to the **pigmentary layer of the retina.** The *inner layer* is, on the other hand, very complicated. After much differentiation it gives rise to **all the other layers of the retina.** The mesodermic tissue, which invests the optic cup, gives rise to the sclera, cornea, choroid, ciliary body (including the ciliary processes and ciliary muscle), and iris. The ciliary processes are covered by layers from the (ectodermal) walls of the cup.

Crystalline Lens.—The lens is of *ectodermic origin.* The surface ectoderm on the lateral aspect of the head opposite the optic vesicle becomes thickened and depressed to form, as stated, the **lens area.** The depressed ectoderm is deepened and converted into a kind of cup. The mouth of the cup becomes constricted, and its lips unite. In this manner the lens area becomes transformed into a closed ectodermic sac, called the **lens vesicle,** from which the crystalline lens is differentiated. The lens vesicle becomes completely separated from the surface ectoderm, with which it was originally continuous. It is now received into the optic cup, which has been formed in connection with the optic vesicle, its position being just within the mouth of the cup, the circumference of the margin projecting slightly in advance of the vesicle.

The anterior and posterior walls of the lens vesicle at this stage consist of several layers of cylindrical cells, and the vesicle contains a small central cavity. The *anterior wall* becomes gradually thin, and is ultimately formed of one layer of flattened cells, these cells constituting the *anterior epithelium* of the adult crystalline lens. The cells of the *posterior wall* become elongated in a forward direction, obliterating the cavity of the vesicle, and coming into contact with the anterior wall. By this process of cell elongation the **lens-fibres** are formed. At the equator of the lens the cells of the anterior and posterior walls merge gradually into one another through the medium of a transitional zone of columnar cells.

At this stage in its development the crystalline lens consists of (1) an anterior epithelial wall, and (2) a posterior wall composed of elongated cells forming the lens-fibres.

As development proceeds, *additional* lens-fibres are formed by the proliferation of cells at the equator of the lens. These fibres are laid down in successive layers, which are arranged concentrically.

Capsule of the Crystalline Lens.—At an early period in its development the lens becomes invested by a mesodermic capsule, freely supplied with blood-vessels derived from the hyaloid artery and anterior ciliary arteries. This capsule is known as the **tunica vasculosa.** It persists throughout the period of active growth of the lens, and then undergoes retrogression to form the **permanent lens capsule.** The portion of the tunica vasculosa which covers the front part of the lens is called the *membrana pupillaris,* but this usually disappears prior to birth. It may, however, be present at birth, giving rise to the condition

known as *atresia pupillæ*. Towards the end of intra-uterine life the tunica vasculosa undergoes retrogression and becomes transformed, as stated, into the **permanent lens capsule,** which is a transparent, homogeneous, elastic membrane.

This mesodermal pupillary membrane is a continuation across the open mouth of the cup of the plane of the choroidal layer. It is, therefore, on the outer surface of the developing iris, of which it forms the mesodermal base, the muscles being derived from the actual ectodermal or retinal layer itself.

Development of the Optic Cup and Optic Stalk.—The optic cup, as stated, is formed by the invagination of the distal or outer wall of the optic vesicle, the invagination also affecting the ventral wall of the optic vesicle and the ventral wall of the part of the optic stalk which is adjacent to the optic vesicle, thereby giving rise to the choroidal fissure. The mouth of the optic cup is directed towards the lateral aspect of the head, and the lens vesicle lies just within the mouth. That the invagination of the optic cup is not caused by the growth of the lens vesicle has been proved by experimental transplantations on amphibian embryos. The margin of the cup projects slightly over the lens vesicle, and the circumference of this margin represents the outline of the **pupil.** The wall of the cup consists of *two layers*—namely, inner and outer, the inner representing the distal or outer wall of the optic vesicle, which has now become invaginated, or folded inwards. The cup is divisible into two regions—namely, (1) the ciliary region, adjoining the margin of the cup; and (2) the fundus. The line of separation between these two regions corresponds to the *ora serrata* of the adult eye.

The **ciliary region** of the optic cup is associated with the ciliary body (including the ciliary processes and ciliary muscle) and the iris, which are developed from the thickened anterior part of the choroid. The *outer layer* of the ciliary portion, as elsewhere, forms the pigmentary layer of the retina. The *inner layer* of the ciliary portion, which is very thin, forms (1) the **pars ciliaris retinæ** on the posterior surfaces of the ciliary processes, and (2) the pigmented **pars iridica retinæ** (*uvea*) on the posterior surface of the iris.

The **fundus** of the optic cup is the proper retinal region. The *outer layer* forms, as in the ciliary region, the **pigmentary layer of the retina.** The *inner* or *retinal layer* becomes differentiated into **all the layers of the retina except the pigmentary layer.** The changes which it undergoes are very complicated. Its thickness is considerably increased, and it subdivides into two layers—outer and inner—from which the various retinal strata (except the outer pigmentary layer) are specialized.

The **optic stalk** is transformed into the **optic nerve.** The stalk is at first hollow, its cavity communicating with that of the optic vesicle on the one hand, and with the third ventricle of the brain on the other. As stated, the choroidal fissure involves the under surface of the optic stalk near the optic vesicle, as well as the under surface of the optic vesicle itself. When the choroidal fissure undergoes closure, the hyaloid artery, which passed through that fissure, becomes enclosed within the optic stalk, and forms the *arteria centralis retinæ* of adult life. By the closure of the choroidal fissure, and the consequent enclosure of the hyaloid artery, the cavity of the distal portion of the optic stalk becomes obliterated. Inasmuch as the ventral or lower wall of this part of the stalk has been previously invaginated, the wall of the stalk is now composed of two layers—outer and inner—the inner being formed by the invaginated ventral or lower wall. The outer layer of the optic stalk is now continuous with the outer layer of the optic cup, whilst the inner layer of the optic stalk is continuous with the inner layer of the optic cup. As regards the proximal part of the optic stalk, its cavity becomes gradually closed. The wall of the optic stalk becomes thickened, its cells proliferate, and they give rise to the neuroglial or sustentacular tissue of the future nerve. The **nerve-fibres** which build up the optic nerve are regarded as having two sources. The majority of them represent the axons of the ganglion cells of the retina, which pass in the optic stalk to the diencephalon and mesencephalon. These are therefore *centripetal fibres*. Other fibres are regarded as being *centrifugal*, these arising in connection with the diencephalon and mesencephalon.

Vitreous Body.—This body is formed within the optic cup, for the most part posterior to the lens vesicle. It is principally developed from the *ectoderm*, but the *mesoderm* also takes part in its formation. The *ectodermic fibres* are derived from those cells which pertain to the **sustentacular fibres** of the retina.

These **ectodermal fibres** form a very delicate reticulum (Fig. 1026) connecting the lens vesicle and the inner layer of the optic cup. Mesodermal ingrowth through the choroidal fissure brings in vessels which ramify to some extent between the ectodermal connecting strands, but for the most part pass forward to the back of the growing lens, over which the vessels spread, with their thin mesodermal surrounding. The main vessel thus reaching the lens is the *hyaloid artery*, and this with its surrounding fine mesoderm occupies at first a large part of the small cavity of the cup, enclosed by ectodermal processes, more or less avascular in the more peripheral parts of the cup. This is the state known as the **primary vitreous,** characterized by ectodermal formations connected in origin with both retina and lens, and associated fairly intimately with vascular mesoderm. The central **hyaloid artery** is distributed over the back of the lens, its terminal branches meeting, at the periphery of this structure, vessels which enter the cup from the outside, turning round its rim.

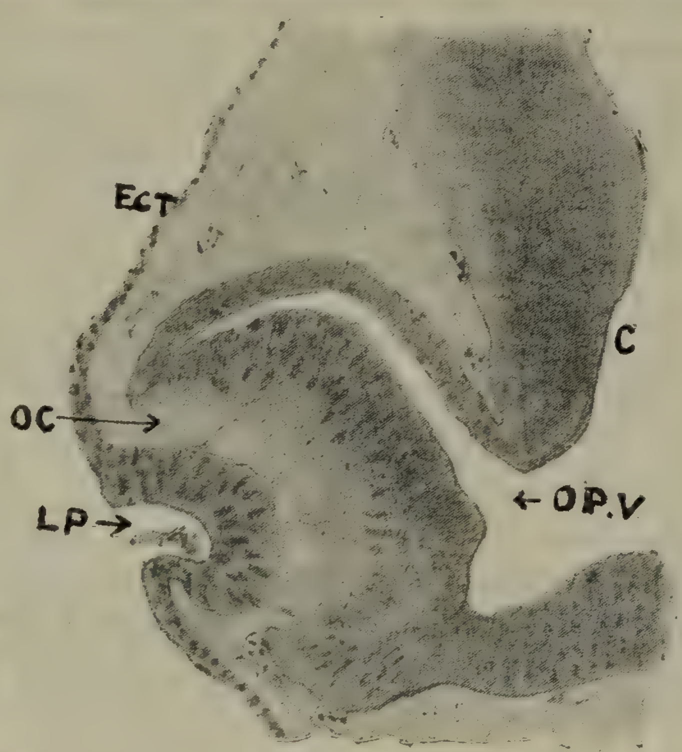


FIG. 1026.—VERTICAL SECTION THROUGH EYE IN 5 MM. EMBRYO.

C, wall of fore-brain ; OP.V., points to cavity of optic vesicle; OC, to cavity of optic cup; L.P., lens pit; ECT., surface ectoderm. Protoplasmic processes connect the lens pit with the inner wall of the cup.

The primary vitreous is gradually succeeded and replaced by the **secondary vitreous.** The time of the beginning of the change is usually considered to be about the fifth to sixth week, when the posterior hyaloid capsule of the lens makes its appearance; after this the slowly increasing ectodermal element can be produced only by the retina. It is this element which, by its growth, occupies the extra space resulting from the increasing size of the eyeball, so that it gradually comes about that the original vascular mesodermo-ectodermal formation (primary vitreous) is surrounded and enclosed by an increasing mass of *ectodermal* **secondary vitreous;** this is largely non-vascular, but does not become completely avascular until the hyaloid artery atrophies. The vessels are contained in a central funnel-shaped ' space ' in this stage, surrounded by the secondary vitreous, which does not compress them in any way; the broad end of the funnel is behind the lens, over which the vessels extend as before, making a vascular capsule for the structure, and joining round the periphery with vessels reaching its anterior surface. The anterior part of this *tunica vasculosa* has been seen already to form the pupillary membrane.

The bloodvessels atrophy and disappear in the latter part of fœtal life, when the interval in which they lay persists as the **hyaloid** (or vitreous) **canal,** or canal of Cloquet, the remaining ectodermal substance, now avascular, being the definite **vitreous.**

About the end of the third month the growth forward of the rim of the optic cup (to form the ectodermal portion of the iris) is accompanied by the appearance of a more fibrillar vitreous formation corresponding with it; this is sometimes referred to as the *tertiary vitreous*, and the fibrils of the **suspensory ligament** of the lens are developed in this formation.

That part of the hyaloid artery which lies in the fissure in the optic stalk remains as the extra-ocular part of the **arteria retinæ centralis.** The actual arteries of the retina are secondary and late branches which extend into that layer from the hyaloid artery as this enters the eyeball; when the lentine part of the vessel atrophies, these retinal branches remain and enlarge.

Derivatives of the Mesodermic Envelope of the Optic Cup.—These are as follows: (1) Sclera, (2) cornea, (3) choroid, (4) ciliary body (including the ciliary processes and ciliary muscle), and (5) iris.

The **mesoderm** which invests the *outer surface* of the optic cup is disposed in *two layers*—outer and inner. The *outer layer* has a fibrous character, and gives rise to the **sclera,** of which the **cornea** is a forward extension. The *inner layer* is vascular, and gives rise to the **choroid,** and mesodermal bases of the **ciliary body** and **iris.** The outer dense fibrous layer of the mesoderm of the outer surface of the optic cup, as stated, gives rise to the sclera. From its anterior margin a thick lamina of mesoderm is prolonged *between the lens vesicle and the surface ectoderm.* This lamina shows two layers—superficial and deep. The *superficial layer* becomes differentiated into the **cornea,** which is thus genetically continuous with the sclera. The *deep layer* becomes the pupillary membrane (see above). Between these two layers there is an interval, which represents the **aqueous chamber.**

The inner vascular layer of the mesoderm of the outer surface of the optic cup, as stated, gives rise to the choroid. The **anterior margin of the choroid,** which adjoins the margin of the optic cup (ciliary region) becomes thickened, and gives rise to the **ciliary body,** in connection with which the **ciliary processes** and **ciliary muscle** are developed. The ciliary processes become covered posteriorly by the *pars ciliaris retinæ,* which is a thin retinal expansion from the ciliary region of the optic cup. The iris is also developed at the anterior margin of the choroid in the form of a ring of mesoderm. In this mesoderm the fibres forming the *dilator pupillæ* and *sphincter pupillæ* muscles are formed by proliferation of the **ectodermal cells of the edge of the optic cup,** which has extended forward in front of the lens, and the back of the iris receives a pigmentary covering (*uvea*) from the *pars iridica retinæ.*

CHAPTER XVII

THE EAR

THE organ of hearing is divided into three parts—the external, middle, and internal ear.

External Ear.

The external ear consists of the auricle (or pinna) and the external auditory meatus. The former has been already described (see p. 1294).

The **external auditory meatus** extends from the bottom of the concha to the membrana tympani, and is about 1 inch in length. It consists of two parts—outer, or cartilaginous, and inner, or osseous. The cartilaginous part, which is also fibrous, is about $\frac{1}{3}$ inch in length, and the osseous part, which lies within the petrous portion of the temporal bone, is about $\frac{2}{3}$ inch long. The widest part of the meatus is its orifice, which is oval, the long measurement being vertical. The narrowest part is situated in its osseous portion, about $\frac{1}{5}$ inch from the tympanic membrane, and it is known as the *isthmus*. There is another constriction of the canal situated near the deep end of the cartilaginous part, and produced by a projection which is placed *antero-inferiorly*. The chief direction of the canal is inwards and slightly forwards. At first it is also inclined upwards, then backwards, and finally downwards.

The *cartilaginous part* is continuous with the cartilage of the auricle, and is attached to the external auditory process of the temporal bone. Its cartilage is folded so as to form a deep groove which is open at its upper and back part, the cartilaginous deficiency being completed by fibrous tissue. In the anterior wall of the cartilaginous part are two clefts (called the *fissures of Santorini*) which are occupied by fibrous tissue. An important and close inferior relation of the cartilaginous meatus is the parotid gland (see Fig. 1027).

The *osseous part* has been described in connection with the temporal bone (p. 194). At its deep end there is a narrow groove, called the *sulcus tympanicus*, which forms about five-sixths of a circle, the deficiency being placed superiorly, at the tympanic notch, where the ring is completed by the squamous part of the temporal bone. The **tympanic membrane** is set obliquely within the tympanic sulcus, being inclined in such a way that its front part is nearer the middle line of the body than its back, and its lower part nearer the middle line than the upper. The floor and anterior wall of the meatus are consequently longer than the roof and posterior wall.

The meatus is lined with skin, which is continuous with that of the auricle. In the osseous part of the canal the skin is very thin, and is provided with vascular papillæ, but is destitute of glands and hairs. It is reflected over the outer surface of the membrana tympani, of which it forms the outer layer. In the cartilaginous part of the canal the skin is thicker, and is provided with hairs, connected with the follicles of which are sebaceous glands. In addition to these there are convoluted tubular glands, similar in structure to sweat-glands, and called the **ceruminous glands,** which secrete the ear-wax.

Blood-supply.—The **arteries** are derived from the posterior auricular of the external carotid, the deep auricular of the first part of the maxil-

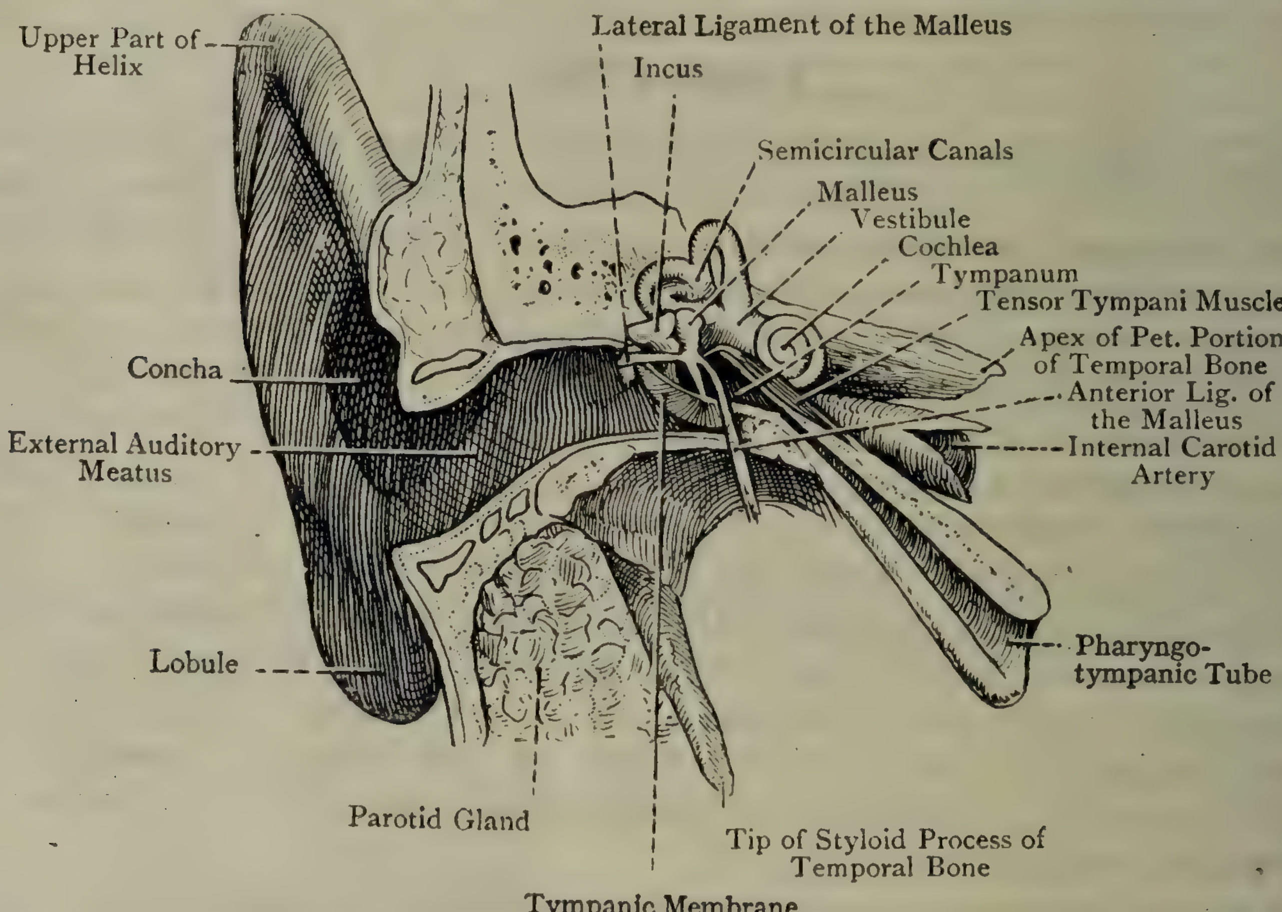


FIG. 1027.—GENERAL VIEW OF THE RIGHT ORGAN OF HEARING (AFTER HIRSCHFELD AND LEVEILLÉ).

The external ear and middle ear are seen in section.

lary, and the anterior auricular branches of the superficial temporal. The **veins** follow the course of the arteries.

Lymphatics.—These pass to the mastoid glands and to the pre-auricular lymphatic glands.

Nerves.—The auriculo-temporal nerve gives two branches to the meatus, upper and lower, which enter it by passing between the cartilaginous and osseous walls. The upper branch supplies the skin covering the upper part of the membrana tympani, while the auricular branch (Arnold's nerve) of the vagus supplies that of the osseous part of the canal in its lower and back part, and also that covering the lower part of the membrana tympani.

Early Condition of the Meatus.—At birth the osseous part of the canal is represented by the *tympanic annulus* and a small portion of

the squamous part of the temporal bone. It is connected by fibrous tissue to the cartilaginous framework of the auricle, and within this fibrous tissue the osseous canal is formed by two outgrowths from the tympanic annulus.

Middle Ear.

The middle ear, or **tympanum,** is an irregular space within the petrous part of the temporal bone, which lies between the membrana tympani externally and the outer osseous wall of the internal ear or labyrinth internally. It is lined with mucous membrane, and it communicates with the naso-pharynx by means of the pharyngo-tympanic tube, through which it receives air. It has three parts: (1) the tympanum proper, or cavum tympani; (2) the attic, or epi-tympanic recess; and (3) the tympanic or mastoid antrum.

The **tympanum proper** (or **cavum tympani**) is situated between the tympanic membrane and the outer wall of the internal ear. Its contents are as follows:

1. A chain of ossicles (malleus, incus, and stapes), with their ligaments.
2. Muscles.
3. Nerves.
4. Bloodvessels.
5. Air.

The vertical and antero-posterior diameters (inclusive of the attic) are fully $\frac{1}{2}$ inch. The transverse measurement is from $\frac{1}{4}$ to $\frac{1}{6}$ inch, except opposite the centre of the membrana tympani, where it is only $\frac{1}{12}$ inch, and the shape of its cavity may, perhaps, be visualized by likening a cast of it to a biconcave disc about the size of a three-penny piece.

The tympanic cavity has six walls—lateral, medial, roof, floor, anterior, and posterior.

The **lateral wall** is formed chiefly by the tympanic membrane, which has the handle of the malleus fixed to it, and slightly by the tympanic annulus, within the circumference of which there is a groove, called the *tympanic sulcus*, in which the membrane is set. The tympanic annulus and sulcus are interrupted superiorly by a notch, called the **tympanic notch.** In front of the tympanic annulus is the open, inner extremity of the **squamo-tympanic fissure,** which lodges the processus gracilis of the malleus, and transmits the tympanic branch of the internal maxillary artery. At the inner end of the fissure is the opening of the *iter chordæ anterius*, by which the chorda tympani nerve leaves the tympanum.

The (medial) **wall** (see Fig. 1028) separates the tympanum from the internal ear or labyrinth. It is very irregular, and is formed by the following parts:

1. The fenestra vestibuli.
2. Projection of the facial canal.
3. The promontory.
4. The fenestra cochleæ.
5. The sinus tympani.

The **fenestra vestibuli** is situated in a depression, called the **fossa ovalis,** at the upper part of the inner wall, and it leads into the cavity of the vestibule. It is irregularly oval, and is elongated from before backwards. It is occupied by the foot-piece of the stapes, and the annular ligament which connects the circumference of the foot-piece to the margin of the opening, the margin being covered by cartilage.

The **projection of the facial canal** lies above the fenestra ovalis. The canal, which contains the facial nerve, is here directed backwards, and has walls of a paper-like thinness.

The **promontory** is seen below the fossa ovalis, between it and the fossa rotunda, and slightly in front of both. It is a rounded promin-

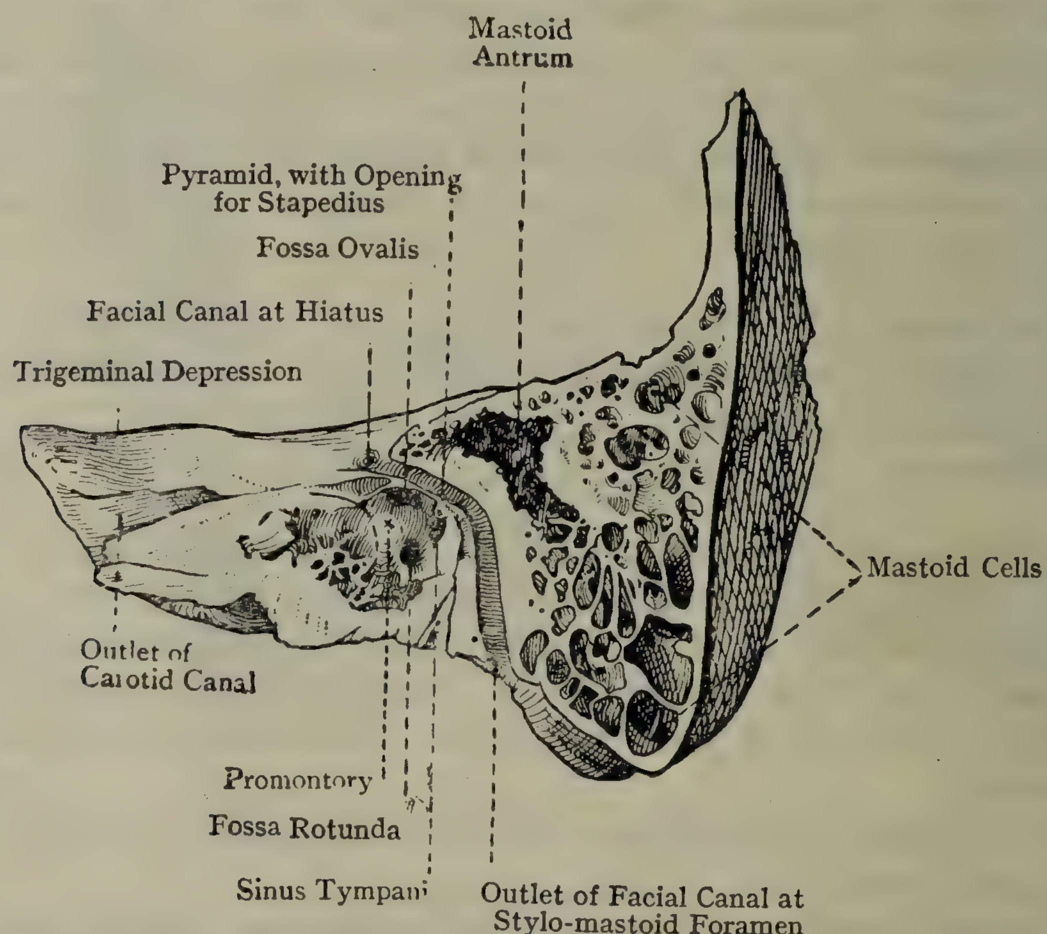


FIG. 1028.—SECTION THROUGH THE PETROUS AND MASTOID PORTIONS OF THE TEMPORAL BONE, SHOWING THE TYMPANUM AND MASTOID CELLS.

ence made by the first turn of the cochlea, and is grooved by the nerves of the tympanic plexus.

The **fenestra cochleæ** is situated in a funnel-shaped depression called the **fossa rotunda,** below and behind the promontory. It leads into the scala tympani of the cochlea, and in the recent state is closed by the secondary membrane of the tympanum.

The **sinus tympani** is a depression behind the promontory, and between the fossa ovalis and fossa rotunda. In close relation to this is the ampulla of the posterior semicircular canal.

The **roof** of the tympanum is a thin plate of bone, called the *tegmen tympani*, which forms part of the anterior surface of the petrous part of the temporal bone.

The **floor,** narrower than the roof, is a thin plate of bone which separates the tympanum from the jugular fossa.

The **anterior wall** is narrow, owing to the descent of the roof, and the inclination towards each other of the outer and inner walls. In it are the openings of two canals, the upper of which lodges the tensor tympani muscle, whilst the lower is the osseous part of the pharyngo-tympanic tube. The two orifices are separated by the margin of the *processus cochleariformis*. The carotid canal lies just in front of the lower part of the anterior wall.

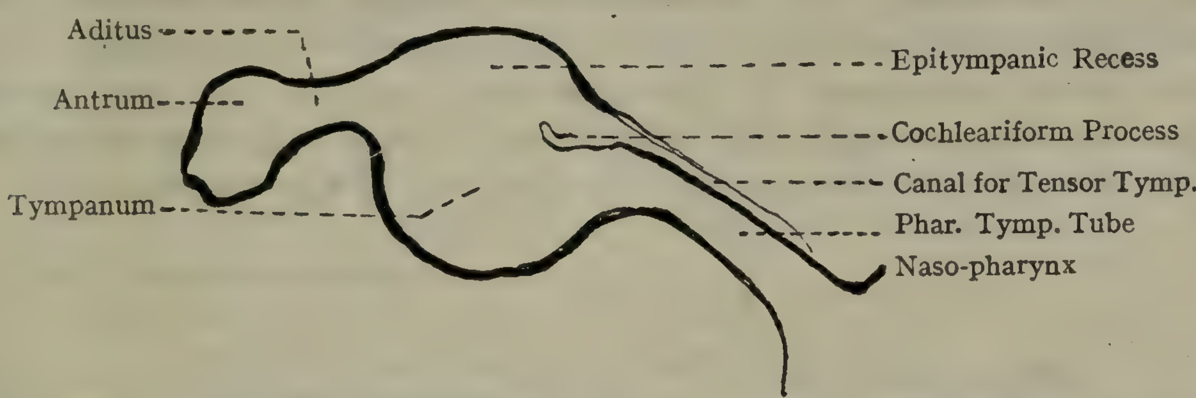


FIG. 1029.—DIAGRAMMATIC OUTLINE OF TYMPANUM AND ASSOCIATED RECESSES.

The **posterior wall** is formed by the anterior or tympanic surface of the petrous part of the temporal bone. From above downwards the following parts are seen: (1) the opening of the mastoid antrum, which communicates with the attic of the tympanum, or epitympanic recess; (2) a depression called the **fossa incudis,** receiving the short process of the incus; (3) a small conical projection, called the **pyramid,** at the summit of which is an opening for the tendon of the stapedius muscle (posteriorly the canal within the pyramid, which contains the

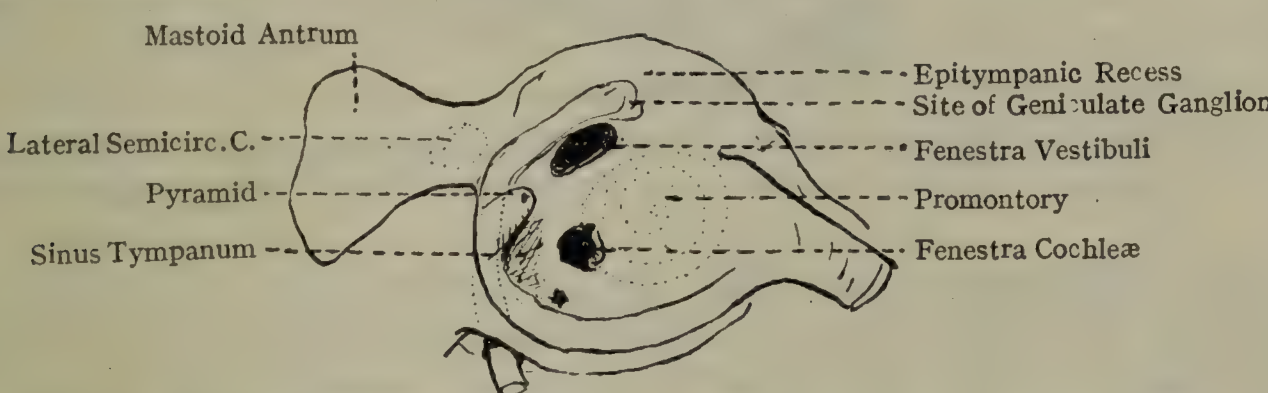


FIG. 1030.—DIAGRAM TO SHOW COURSE AND RELATIONS OF FACIAL CANAL ON THE MEDIAL AND POSTERIOR WALLS OF THE TYMPANUM.

stapedius muscle, passes downwards in the posterior wall of the tympanum, and communicates with the descending part of the canal which contains the facial nerve; this explains how the branch of that nerve to the stapedius reaches the muscle); and (4) the **iter chordæ posterius,** for the chorda tympani nerve.

Tympanic Membrane.—This is the membrane which closes the inner extremity of the external auditory meatus. It is situated on the outer wall of the tympanum, of which it forms the chief part, and it is set for the most part in the sulcus tympanicus, which marks the

inner surface of the tympanic annulus. Superiorly, however, where the ring is wanting, the membrane is attached to the tympanic notch (of Rivinus). This part of it is thinner and looser than the rest, and is called the **membrana flaccida,** or **Shrapnell's membrane.** The attachment of the membrana tympani to the sulcus is by a thickened ring of fibres, called the *annulus fibrosus.* This annulus passes from the extremities of the notch to the short process of the malleus in the form of two bands, the **anterior** and **lateral ligaments** of the malleus, which form the lower boundary of the membrana flaccida. The membrane is set obliquely in the tympanic sulcus, so that its lower part forms an acute angle with the floor of the meatus externus, and its upper part an obtuse angle with the roof of the passage.

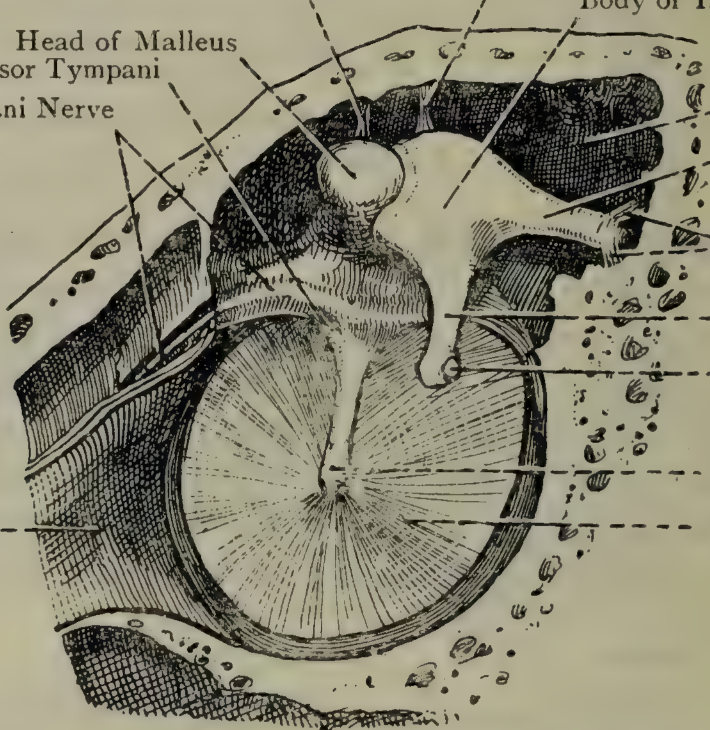


FIG. 1031.—THE RIGHT MEMBRANA TYMPANI, MALLEUS, AND INCUS (INTERNAL, POSTERIOR, AND SUPERIOR VIEW) (SPALTEHOLZ).

The tympanic membrane is somewhat oval. In the vertical direction it measures about 10 mm., and horizontally from 8 to 9 mm. The handle of the malleus lies between the mucous and fibrous layers of the membrane, and descends to a point a little below its centre, where it ends in a small knob, from which the radiating fibres of the membrane proceed. This knob is firmly attached, and, being directed inwards, the membrane is consequently drawn inwards at that point, and its outer surface presents a slight conical depression, the deepest part of which is called the **umbo.**

Structure.—The membrane consists of three layers—external, middle, and internal.

The **external** or **cutaneous layer** is very thin, and is derived from the skin of the external meatus. It contains no glands, is freely provided with bloodvessels and nerves, and is covered by stratified squamous epithelium.

The **middle** or **fibrous layer** forms the proper substance of the membrane, and consists of fibrous tissue. The fibres are radial and circular. The *radial fibres* lie beneath the cutaneous layer, and radiate from the handle of the malleus to the annulus fibrosus. The *circular fibres* are deep to the radial fibres, and are most numerous towards the circumference of the membrane. Both sets of fibres are absent from the membrana flaccida.

The **internal** or **mucous layer** is continuous with the mucous membrane of the tympanum, and is covered by a single layer of squamous epithelium.

The **membrana flaccida, pars flaccida,** or Shrapnell's membrane, has cutaneous and mucous layers only. These are united by connective tissue, which is so loosely arranged that the membrane is flaccid. This part is very liable to perforation.

Cone of Light.—Extending from the knob, in which the handle of the malleus terminates, downwards and inwards to the antero-inferior margin of the membrana tympani there is seen a specially bright reflection, triangular in outline, with the apex towards the umbo. This is called the **cone of light.**

Arterial Supply of the Tympanic Membrane.—(1) Deep auricular branch of the maxillary artery. This vessel, which passes through the anterior wall of the external meatus, supplies the cutaneous layer. It descends from the skin of the roof of the meatus along the course of the handle of the malleus to the umbo, where it divides into branches which radiate towards the circumference of the membrane. (2) The stylo-mastoid branch of the posterior auricular; and (3) the tympanic branch of the maxillary. The former artery enters the tympanum from the facial canal, and the latter through the squamo-tympanic fissure. Branches from them supply the mucous layer, and form an anastomotic ring around the circumference of the membrane. The fibrous layer receives its arterial supply from the vessels of the cutaneous and mucous layers.

The **veins** join the external and internal jugular.

Nerve-supply.—(1) The auriculo-temporal of the mandibular, (2) the auricular branch of the vagus, and (3) branches from the tympanic plexus.

Secondary Membrane of the Tympanum.—This membrane closes the fenestra cochleæ on the inner wall of the tympanum, and separates the tympanic cavity from the scala tympani of the cochlea. It is concave towards the tympanum, and, like the membrana tympani, consists of three layers. The **external layer** is formed by the tympanic mucous membrane; the **middle layer** is fibrous; and the **internal layer** is formed by the lining membrane of the cochlea.

The mastoid antrum and mastoid air-cells are described with the temporal bone on p. 188, while the Eustachian or pharyngo-tympanic tube is dealt with on p. 1378.

Ossicles of the Tympanum.

The tympanum contains three small bones, arranged in the form of a chain which extends from the membrana tympani to the fenestra vestibuli. The bones are the malleus, the incus, and the stapes. The malleus is related to the membrana tympani, the stapes to the fenestra, and the incus occupies an intermediate position between these two.

The **malleus** is so named from its resemblance to a hammer. It is composed of a head, neck, handle, and two processes, long and short. The **head** is the upper, enlarged, rounded end. Posteriorly it has a saddle-shaped facet, directed obliquely downwards and inwards, for articulation with the incus in a synovial joint. The **neck** is the constricted part below the head. The **handle** (*manubrium*) is directed downwards, inwards, and backwards from the neck; it is compressed from before backwards, slightly curved, and ends in a knob. It lies between the fibrous and mucous layers of the membrana tympani, descending to a point a little below the centre of the membrane. It is firmly attached to the fibrous layer by its periosteum. The tensor tympani muscle is inserted into the inner part close to its root. The **long** or **anterior process** (*processus gracilis*), which is slender, springs from the front of the neck, and is directed forwards and downwards to the petro-tympanic fissure, where it is embedded in fibres which form part of the anterior ligament of the malleus, and connect it to the margins of the fissure. The long process is in the adult for the most part replaced by fibrous tissue except close to the neck of the malleus. In early life it is continuous with Meckel's cartilage. The **short** or **lateral process** is situated immediately below the long process. It is directed laterally to the upper part of the membrana tympani, with which it is connected by the annulus fibrosus. It is also connected with the extremities of the notch by the anterior and posterior malleolar ligaments.

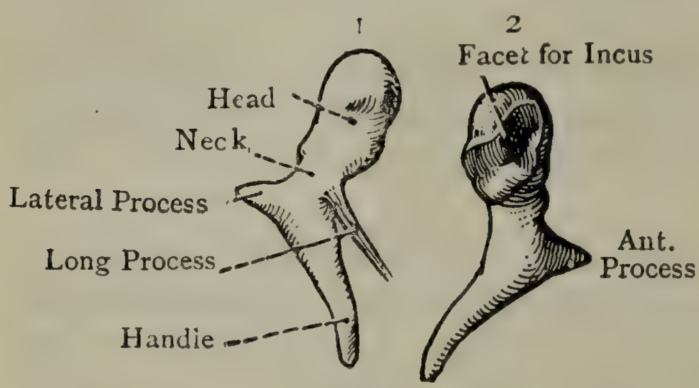


FIG. 1032.—THE MALLEUS.
1, anterior view; 2, posterior view.

The **incus** resembles an anvil. It consists of a body and two processes—short and long. The **body** is thick, somewhat four-sided, and laterally compressed. Anteriorly it presents a saddle-shaped articular surface for the head of the malleus, with which it forms a synovial joint. The **short process** is directed backwards, is tipped with cartilage, and articulates with the fossa incudis on the posterior wall of the tympanum. The **long process** is directed downwards and medially, behind

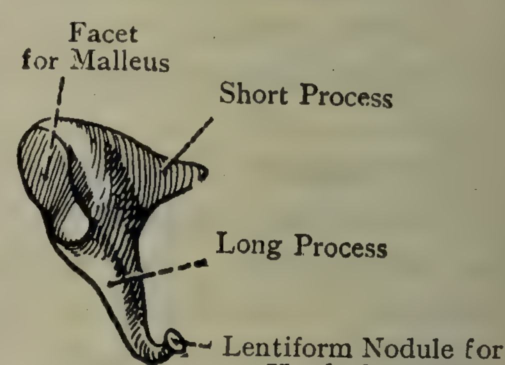


FIG. 1033.—THE INCUS (POSTERO-INTERNAL VIEW).

and parallel to the handle of the malleus. Its lower extremity is bent inwards, and becomes narrowed into a neck, upon which is placed a disc-like knob of bone, called the os orbiculare, which is covered by cartilage for articulation with the head of the stapes. In early life, and up to the sixth month of intra-uterine life, this process forms a separate ossicle.

The **stapes** resembles a stirrup. It has a head, neck, two crura, and a foot-piece or base. The **head** is directed laterally, is concave and covered by cartilage, and articulates with the processus lenticularis of the incus. The **neck** is the constricted part which lies immediately internal to the head. Posteriorly it gives insertion to the stapedius muscle. The **crura** are anterior and posterior respectively, and spring from the neck. They diverge as they pass inwards, and are attached to the foot-piece near its extremities. The *anterior* crus is straighter and shorter than the *posterior*. The **foot-piece** or **base** is somewhat oval, is directed medially, and occupies the fenestra ovalis, which it almost completely fills; its circumference is covered by cartilage, being attached to the margins of the fenestra by annular ligamentous fibres. The arch formed by the crura and foot-piece is occupied by a delicate membrane, which is attached to a slight groove on the inner aspect of the arch.

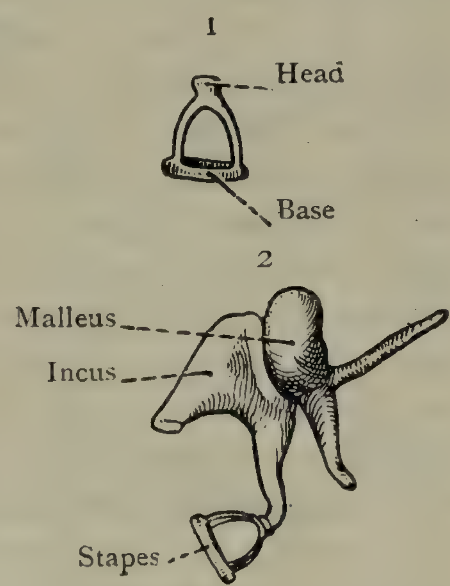


Fig. 1034.—(1) The Stapes, and (2) Tympanic Ossicles in Position.

Development of the Tympanic Ossicles.—The **malleus** and **incus** are usually regarded as being developed from the proximal end of Meckel's cartilage, which forms the cartilaginous bar of the first or mandibular arch. According to some authorities, however, the **incus** is developed from the hyoid bar. The stapes is developed from the dorsal part of the hyoid bar of the second visceral arch.

Ligaments of the Ossicles.—The synovial joints between the malleus and incus and between the incus and stapes are provided with thin capsular ligaments. The ligaments which connect the ossicles to the walls of the tympanic cavity are five in number, three of them belonging to the malleus, one to the incus, and one to the stapes.

The **ligaments of the malleus** are anterior, lateral, posterior, and superior. The **anterior ligament** is arranged as a fibrous band which extends from the root of the long process to the petro-tympanic fissure, through which it passes to be attached to the spine of the sphenoid bone. The **lateral ligament** (or **malleolar fold**) extends from the short process to the anterior extremity of the tympanic notch. The **posterior ligament** extends from the short process to the posterior extremity of the notch. The **superior ligament** extends from the head of the malleus to the roof of the attic or epitympanic recess.

The **ligament of the incus** connects the short process, near its posterior extremity, to the fossa incudis.

The **annular ligament of the stapes** connects the circumference of the foot-piece, which is covered by cartilage, to the margin of the fenestra vestibuli, which is also covered by cartilage.

Muscles of the tympanum are the tensor tympani and the stapedius.

Tensor Tympani—*Origin.*—(1) The cartilaginous part of the pharyngo-tympanic tube; (2) the apex of the petrous part of the temporal bone; and (3) the wall of the osseous canal through which the muscle passes.

Insertion.—The medial aspect of the handle of the malleus close to its root.

Nerve-supply.—A branch from the otic ganglion, and through it from the internal pterygoid branch of the mandibular division of the fifth cranial nerve.

The muscle consists of a fleshy belly, about ½ inch long, and a delicate tendon. In passing backwards to the tympanum it lies in a canal, the entrance to which is situated within the petro-squamous angle of the temporal bone. The canal is placed above the osseous part of the tube, from which it is separated by the *processus cochleariformis.* On entering the tympanum the tendon of the muscle bends sharply over the edge of the processus cochleariformis, and then passes laterally to reach its insertion. The tendon forms very nearly a right angle with the fleshly belly.

Action.—To render tense the membrana tympani by drawing inwards the handle of the malleus, and along with it the membrane.

Stapedius—*Origin.*—The wall of the canal within the pyramid, and of the continuation of this canal in front of the descending part of the facial canal.

The tendon emerges from the canal within the pyramid through a small orifice on the apex.

Insertion.—The posterior aspect of the neck of the stapes.

Nerve-supply.—The facial nerve.

Action.—To draw the head of the stapes backwards. The result is that the front part of the foot-piece of the stapes is tilted away from the vestibule, and its back part is pressed inwards towards the vestibule.

Movements of the Ossicles.—The malleus and incus both act as levers of the first kind, the fulcra of which are represented by an axis passing backwards from the slender process of the malleus. When a sound-wave presses the tympanic membrane inward, the handle of the malleus travels inward with it, and the head of the malleus, or short arm of the lever, moves outward. The upper part, or short arm of the incus lever, must move out too, since it is attached to the head of the malleus, and the long process moves inward, thus pressing the stapes into the fenestra ovalis and compressing the perilymph in the cochlea.

The secondary membrane of the tympanum, stretched across the fenestra rotunda, is bulged outward by the perilymph, thus allowing vibrations to travel through that fluid.

Mucous Membrane of the Tympanum.—The tympanic mucous membrane is continuous anteriorly with that of the naso-pharynx through the pharyngo-tympanic (or Eustachian) tube. Posteriorly it is prolonged into the mastoid antrum, and thence into the mastoid cells. It forms the internal layer of the tympanic membrane, and the external layer of the secondary membrane of the tympanum. It also furnishes sheaths for the tendons of the tensor tympani and stepedius muscles, and for the chorda tympani nerve. Two folds extend downwards from the roof of the attic or epitympanic recess, one in front of and the other behind the superior ligament of the malleus. The former is connected with the head of the malleus, and the latter (sometimes described as the superior ligament of the incus) with the incus.

Attic or Epitympanic Recess and its Pouches.—The part of the tympanic cavity which lies above the level of the upper margin of the tympanic membrane is called the **attic** or **epitympanic recess,** as distinguished from the *atrium* or *tympanum proper.* It contains the head and neck of the malleus, and the body and short process of the incus. These divide it incompletely into two compartments—outer and inner. The **outer attic** is subdivided into two pouches—superior and inferior. The **superior pouch** is partially separated from the **inner attic** by the two mucous folds which have been already referred to as descending from the roof of the attic in front of and behind the superior ligament of the malleus. The **inferior pouch** of the outer attic is known as the *pouch of Prussak.* It is bounded laterally by the membrana flaccida, superiorly by the lateral ligament of the malleus, which partially separates it from the superior pouch, and internally by the neck of the malleus. The pouch communicates posteriorly with the tympanic cavity by an opening which is situated a little above the level of the bottom of the pouch. If fluid, therefore, should accumulate in Prussak's pouch, it may readily lead to perforation of the membrana flaccida.

Two other pouches are present—namely, the **anterior** and **posterior recesses** or **pouches of Tröltsch.** These lie one in front of and the other behind the handle of the malleus, and are produced by the fold of mucous membrane which invests the chorda tympani nerve.

The tympanic mucous membrane is covered for the most part by columnar ciliated epithelium, except over the ossicles and membrana tympani, where the epithelium consists of a single layer of squamous, non-ciliated cells.

The **tympanic** or **mastoid antrum** is supplementary to the tympanum proper, or cavum tympani, behind which it is situated. It communicates by a large irregular opening with the attic, and is lined with mucous membrane, which is continuous with that of the attic and cavum tympani. Opening from the antrum there are the mastoid cells, which are lined with mucous membrane, continuous with that of the antrum.

The average measurements of the antrum are as follows: vertical, about 9 millimetres; antero-posterior, about 11 millimetres; and

transverse, about 8 millimetres. The *roof* is formed by the thin tegmen tympani, which enters into the formation of the middle fossa of the base of the skull, and is consequently related to the **temporal lobe of the cerebrum** and its **meninges.** The **genu** and **descending limb of the sigmoid sinus** lie *behind* the antrum, and a little farther back is the **cerebullum.** The **facial nerve,** as it traverses the descending part of its canal, lies in the *posterior wall* of the cavum tympani, close to the medial wall and in front of the mastoid antrum. This part of the nerve is on a plane anterior to the mastoid process, and is nearly flush with the opening of the antrum. The ampulla of the lateral **semicircular canal** of the internal ear gives rise to a slight eminence on the *medial wall* at its anterior part.

The *lateral wall* corresponds on the surface with the area of the **suprameatal triangle of Macewen,** and is formed by the *postmeatal plate* of the squamous portion of the temporal bone. For a description of this triangle, which is the region selected for *mastoidectomy,* and also for the mastoid cells, see the description of the **temporal bone.**

Summary of Important Structures closely related to the Mastoid Antrum.

1. **Temporal lobe of cerebrum and its meninges (roof).**
2. **Genu and descending limb of sigmoid sinus, and farther back the cerebellum (posterior wall).**
3. **Facial nerve (posterior wall of cavum tympani, close to medial wall and nearly flush with antral opening).**
4. **Lateral semicircular canal (anterior part of medial wall).**

The *upper part* of the antrum communicates, as stated, with the attic of the cavum tympani, but the *lower part* is shut off by bone from the cavity of the cavum tympani.

The **mucous membrane** of the mastoid antrum is continuous with that which lines the mastoid cells. *Anteriorly* it is also continuous with the mucous membrane of the attic and cavum tympani or tympanum proper. The mucous membrane of the cavum tympani is continuous *anteriorly* with that of the pharyngo-tympanic tube, and the mucous membrane of the tube is continuous with that of the naso-pharynx. This extensive and continuous tract of mucous membrane is covered by columnar ciliated epithelium except in the following regions: (1) the promontory; (2) the tympanic ossicles; (3) the tympanic membrane; (4) the mastoid antrum; and (5) the mastoid cells. In these regions the epithelium consists of a single layer of squamous, non-ciliated cells.

It is of considerable importance to note that micro-organisms may pass from the naso-pharynx through the tube into the cavum tympani and attic, and thence into the mastoid antrum and mastoid cells. Purulent affections of these regions may therefore readily be caused in this manner. Such affections may subsequently involve (1) the temporal lobe of the cerebrum and its meninges, (2) the genu and descending limb of the sigmoid sinus, and (3) the internal ear or labyrinth.

Arteries of the Tympanum.—The principal arteries are: (1) the tympanic branch of the maxillary, and (2) the stylo-mastoid branch of the posterior auricular. The **tympanic artery** enters through the petro-tympanic fissure, and supplies the membrana tympani and front part of the tympanum. The **stylo-mastoid artery** enters the facial canal through the stylo-mastoid foramen, and passes from the descending part of the canal into the tympanum. It supplies the back part of the cavity and the mastoid cells, and it forms, with the tympanic artery, a ring round the circumference of the membrana tympani.

In addition to the foregoing two arteries, the following three arteries enter the tympanic cavity: (1) the petrosal branch of the middle meningeal, which enters from the facial canal, into which it passes through the hiatus; (2) the tympanic branch of the ascending pharyngeal, which accompanies the nerve through the tympanic canaliculus; and (3) the tympanic branch of the internal carotid, which enters by a minute foramen on the posterior wall of the ascending part of the carotid canal in company with a sympathetic twig from the carotid plexus.

The **veins** of the tympanum pass to the pterygoid plexus, the superior petrosal sinus, the internal jugular vein, and the pharyngeal plexus.

Nerves of the tympanum are described on pp. 1325 and 1400.

Internal Ear.

The internal ear is the essential part of the organ of hearing, and is known as the **labyrinth** from its remarkable complexity. It consists of two parts—namely, the osseous labyrinth and the membranous labyrinth.

Osseous Labyrinth.

The osseous labyrinth is a cavity situated within the petrous part of the temporal bone, and is divided into three parts—namely, the **vestibule,** the **semicircular canals,** and the **cochlea.** These divisions are lined with a delicate periosteum, between which and the contained membranous labyrinth there is a clear fluid, called the **perilymph.**

Vestibule.—The vestibule is the central division of the osseous labyrinth. The semicircular canals lie behind it, and the cochlea is situated in front of it. In the *lateral wall* is the fenestra vestibuii, which is occupied by the foot-piece of the stapes and its annular ligament. The *medial wall* has anteriorly a depression called the **fovea spherica** or **spherical recess,** which corresponds to the lamina cribrosa at the deep end of the meatus auditorius internus. It is pierced by apertures for the passage of filaments of the auditory nerve to the saccule. Behind and above the fovea spherica there is a ridge, called the **vestibular crest,** which lies obliquely. Posteriorly it bifurcates, and between its two divisions there is a small depression, called the **cochlear recess,** in which are openings for nerve filaments to the canalis cochleæ. Anteriorly it becomes somewhat triangular, and forms a **pyramid,** which is pierced by nerves to the utricle.

The roof of the vestibule, behind and above the crista vestibuli, has an oval depression, called the **elliptical recess,** which encroaches on the inner wall and lodges the **recess of the utricle.** It is pierced by nerves to the ampullæ of the superior and external semicircular canals. Below the fovea elliptica is the opening of the **aqueduct of the vesti-**

bule, which leads to the posterior surface of the petrous part of the temporal bone about ¼ inch external to the orifice of the meatus auditorius internus. It transmits the ductus endolymphaticus and a minute vein.

Anteriorly the vestibule communicates with the scala vestibuli of the cochlea, and posteriorly are the five openings of the semicircular canals.

Semicircular Canals.—The **osseous semicircular canals** are situated behind the vestibule. They are three in number—superior, posterior,

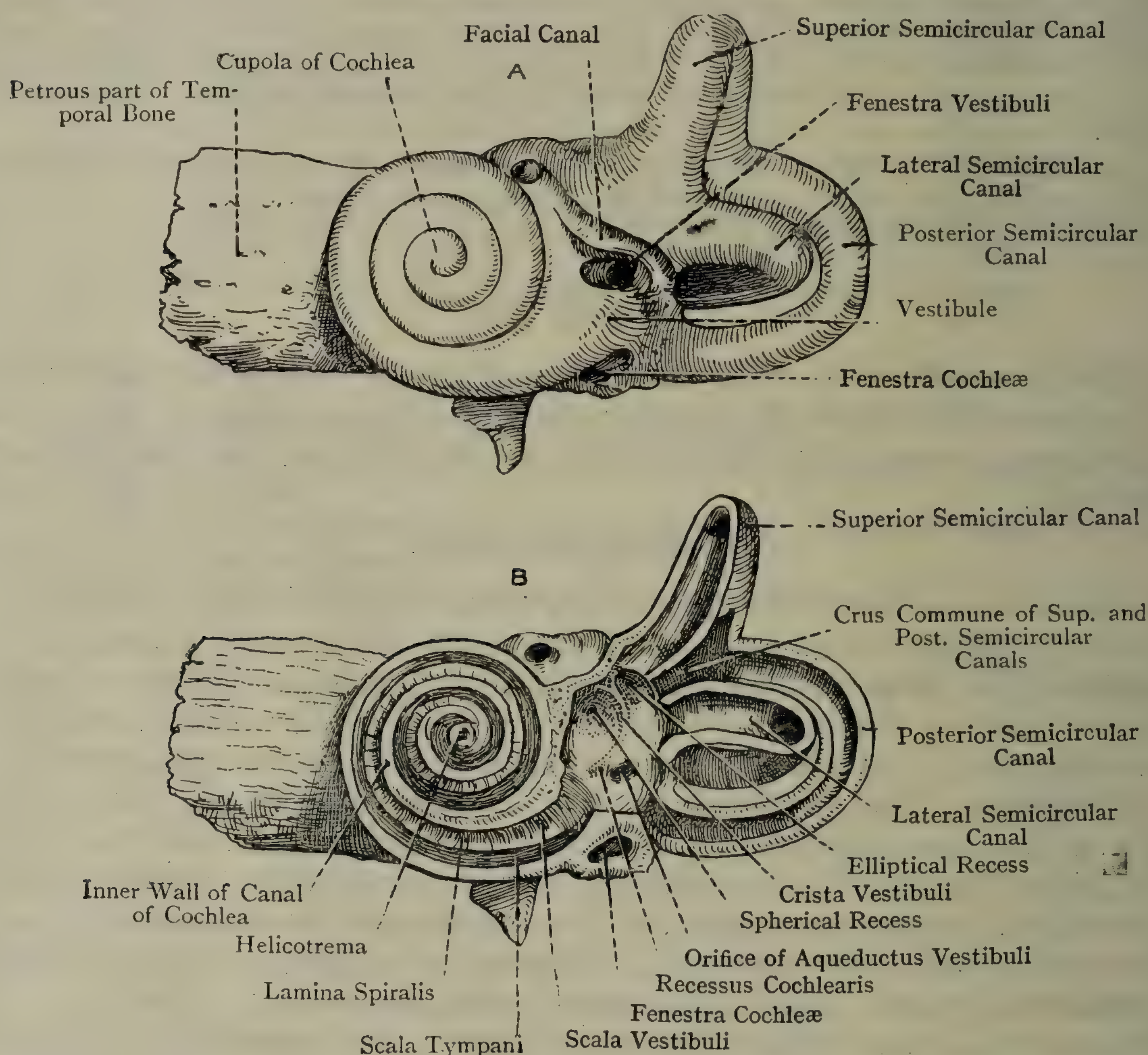


FIG. 1035.—THE OSSEOUS LABYRINTH OF THE LEFT SIDE (LATERAL VIEW). A, entire; B opened (Hirschfeld and Leveillé; B, modified).

and lateral—and they open into the vestibule by five circular apertures, the contiguous ends of the superior and posterior canals having a common orifice. Each canal forms about two-thirds of a circle, and each presents at one end an enlargement, called the **ampulla.** The **superior semicircular canal** occupies a vertical position, and lies transversely as regards the long axis of the petrous part of the temporal bone, giving rise to the *eminentia arcuata* on its superior surface. Its ampullary end (antero-external) opens independently into the upper part of the vestibule above the ampullary orifice of the external canal.

Its non-ampullary end unites with the non-ampullary end of the posterior canal to form the crus commune, and the two open by a common orifice into the vestibule. The **posterior semicircular canal** arches backwards towards the posterior surface of the pars petrosa, with which it is almost parallel, and, like the superior, it occupies a vertical position. Its ampullary end (inferior) opens independently into the lower and back part of the vestibule, and its non-ampullary end, as just stated, joins that of the superior canal. The **lateral semicircular canal** arches outwards, and occupies a horizontal position. Its extremities are independent of those of the other two canals, and they open by separate apertures into the upper and back part of the vestibule. Its ampullary end is in front.

Cochlea.—The osseous cochlea is situated in front of the vestibule. It consists of a tube coiled spirally upon itself, like a snail's shell,

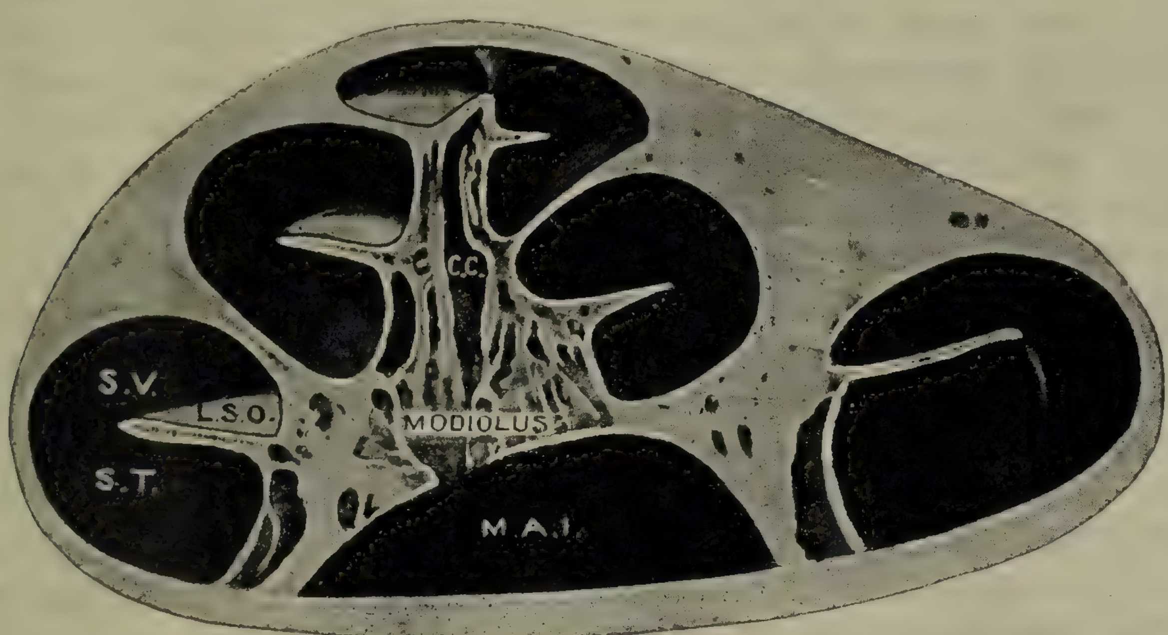


FIG. 1036.—MEDIAN SECTION OF THE LEFT OSSEOUS COCHLEA OF MAN FROM APEX TO BASE (ARNOLD).

S.V. Scala Vestibuli
S.T. Scala Tympani
L.S.O. Lamina Spiralis Ossea
C.C. Central Canal of Modiolus
M.A.I. Internal Auditory Meatus

and is conical. Its base is opposite the lamina cribrosa at the deep end of the meatus auditorius internus; and its apex, known as the **cupola**, is directed outwards and slightly forwards towards the canal which contains the tensor tympani muscle. Its length from base to apex is about $\frac{1}{5}$ inch. It consists of (1) a winding tube, called the **spiral canal of the cochlea**; (2) a central pillar, called the **modiolus**, round which the spiral canal turns; and (3) a thin plate of bone, called the **osseous spiral lamina**, which winds spirally round the modiolus and projects into the spiral canal of the cochlea.

The **spiral canal of the cochlea** (cochlear canal or tube) winds round the modiolus, which forms its inner wall. It describes two and three-quarter turns, and its basal turn or coil gives rise to the *promontory* on the inner wall of the tympanum. At the cupola it ends in a blind extremity. It gradually diminishes in size from base to cupola; its

length is about 32 millimetres; and its diameter is about 2 millimetres at the base, where it is greatest.

The **modiolus** is the central pillar round which the spiral canal of the cochlea turns, and it forms the inner wall of that canal. It commences at the cochlear area of the *lamina cribosa* at the deep end of the internal auditory meatus, and extends almost to the cupola, gradually tapering. It is traversed by minute canals for branches of the cochlear division of the auditory nerve. One of these canals occupies the centre of the modiolus, and is called the **central canal of the modiolus.** This canal begins at the *foramen centrale* of the cochlear area of the lamina cribrosa, and it transmits the nerve-filaments for the apical coil. The other canals, which have no special name, commence at the *tractus spiralis foraminosus* of the cochlear area of the lamina cribrosa, and they transmit the nerve-filaments for the other coils—middle and basal. At successive levels these canals change their direction, and pass outwards to the attached margin of the lamina spiralis, to be presently described. Here they coalesce and form a winding canal, called the **spiral canal of the modiolus,** which lodges the spiral ganglion or ganglion of Corti. From this canal secondary canals for nerve-filaments pass into the lamina spiralis.

The **osseous spiral lamina** is a thin plate of bone, which winds spirally round the modiolus, to which it is attached. It projects from the modiolus into the spiral canal of the cochlea throughout the windings of the latter, and it extends for about half-way towards the outer wall of the cochlear canal. It divides that canal incompletely into two passages or *scalæ*—an upper or scala vestibuli, and a lower or scala tympani, the commencement of which is at the fenestra cochleæ. Close to the cupola the lamina spiralis terminates in a hook-like process, called the *hamulus*. The spiral lamina consists of two plates of bone, between which there are canals for nerve-filaments, these canals being offsets of the spiral canal of the modiolus, which, as has been said, contains the spiral ganglion or ganglion of Corti. They extend to the free margin of the spiral lamina. The free margin of the lamina spiralis is, in the recent state, attached to the outer wall of the spiral canal of the cochlea by means of the basilar membrane or *basilar lamina*, and the scala vestibuli and scala tympani are now completely separated, except in the region of the hamulus, where they communicate through an opening, called the *helicotrema*.

The **lamina cribrosa,** at the deep end of the internal auditory meatus, will be found described in connection with the temporal bone (p. 190).

At the lower end of the scala tympani is the upper opening of the **aqueductus cochleæ,** which passes downwards and medially to the posterior border of the petrous part of the temporal bone. It transmits a small vein to the inferior petrosal sinus, and establishes a communication between the scala tympani and the subarachnoid space.

Membranous Labyrinth.

The membranous labyrinth is situated within the osseous labyrinth, and its constituent parts receive the terminal branches of the auditory nerve. It is separated from the periosteal lining of the osseous labyrinth by the **perilymph,** and it contains the fluid known as the **endolymph.** In the case of the vestibule and the osseous semicircular canals the membranous labyrinth corresponds more or less with them; but in the case of the osseous cochlea it forms part of the septum between the scala tympani and scala vestibuli, and contains a passage called the membranous canal of the cochlea (ductus cochleæ).

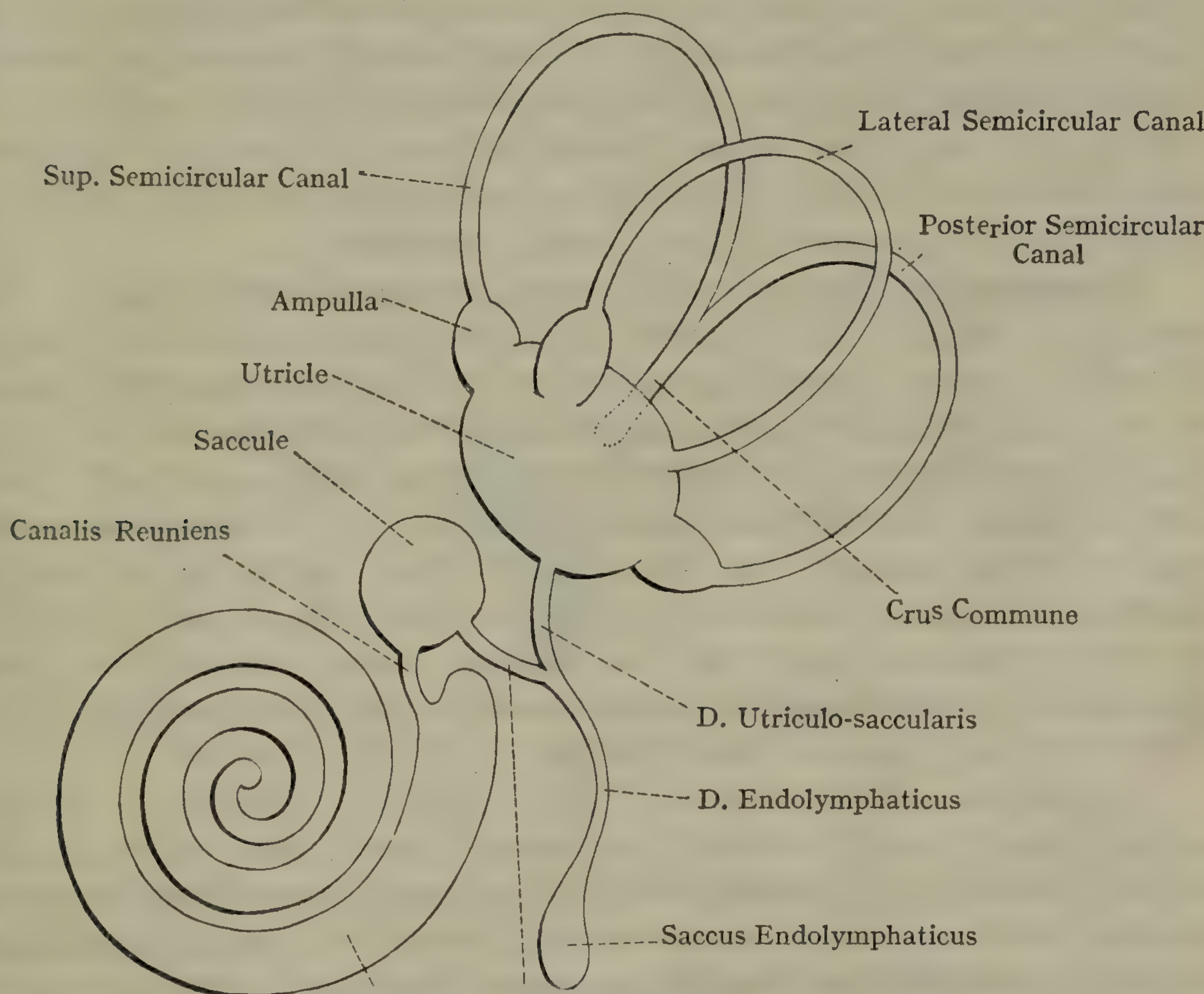


Fig. 1037.—Diagram of Membranous Labyrinth.

Vestibular Part of the Membranous Labyrinth.—The vestibule contains two membranous sacs—namely, the utricle and the saccule—which are in close contact, but do not communicate with each other directly. These sacs contain endolymph.

The **utricle** is the larger of the two sacs, and into it the membranous semicircular ducts open. It occupies the upper and back part of the vestibule, a portion of it, known as the **recessus utriculi,** lying in the fovea elliptica. Near the crista vestibuli the wall of this recess receives fibres of the auditory nerve and is thickened, this part of it being called the **macula utriculi.** From the anterior and medial part of the utricle a minute canal, called the **ductus utriculi** (*ductus utriculo-saccularis*), passes to join the ductus sacculi, and so form the ductus endolymphaticus (see Fig. 1037).

The **saccule,** which is somewhat oval, lies in front of the utricle, and occupies the fovea spherica, where it is near the opening leading into the scala vestibuli of the cochlea. Through the openings of the fovea spherica it receives filaments of the auditory nerve, and this portion of the saccule, being thickened, is known as the *macula sacculi.* Inferiorly the saccule is connected with a small canal, called the **ductus reuniens,** which opens into the canal of the cochlea, or ductus cochlearis, not far from its closed vestibular end. From the posterior part of the saccule a minute canal, called the **ductus sacculi,** passes off, which is soon joined by the **ductus utriculi,** and so the **ductus endolymphaticus** is formed. This latter duct traverses the aqueductus vestibuli, and, having reached the posterior surface of the petrous part of the temporal bone, it ends in a small blind dilatation, called the *saccus endolymphaticus,* which lies beneath the dura mater. The saccule and utricle are thus indirectly connected by means of the ductus sacculi and ductus utriculi; and the saccule communicates with the ductus cochlearis by means of the ductus reuniens.

Semicircular Ducts.—The membranous semicircular ducts correspond in outline to the osseous semicircular canals, within which they lie; they form about two-thirds of a circle, and each has an **ampulla** at one end, which is situated within the ampulla of the osseous canal. They are elliptical in transverse section, and open into the utricle by five orifices, the non-ampullated ends of the superior and posterior canals being united, so that these two open by a common orifice forming the *crus commune.* The *convex* wall of each canal is attached to the periosteal lining of the osseous canal, whilst the *concave* wall is practically free from the osseous wall, and is bathed by the perilymph. These canals contain endolymph.

Structure.—The walls of the utricle, saccule, and membranous semicircular canals consist of three layers: an outer or fibrous layer, which is vascular; a middle layer, or membrana propria, which is translucent; and an inner or epithelial layer. In each ampulla the middle layer, or **membrana propria,** projects into the cavity of the canal from the peripheral wall, this projecting part being known as the *septum transversum.* It partially divides the interior of the ampulla into two compartments, and its free margin, which is covered by the auditory epithelium, is called the **crista acustica** or **ampullaris.** The **epithelial layer** consists of a single stratum of squamous cells, except in those regions to which the filaments of the auditory nerve are distributed. These regions are as follows: (1) the macula (acustica) utriculi; (2) the macula (acustica) sacculi; and (3) the crista of each ampulla.

The **macula utriculi** is the thickened part of the antero-inferior wall of the recessus utriculi, and is lined with auditory epithelium. The macula is covered by calcareous particles, called *otoconia,* which consist of crystals of calcium carbonate. The **macula sacculi** is the thickened part of the anterior wall of the saccule, and is also lined with auditory epithelium covered by otoconia. The **crista ampullaris,** as

we have seen, is the free margin of the septum transversum in each ampulla, and is covered by auditory epithelium.

The **auditory epithelium** is of the columnar variety, and consists of two kinds of cells, auditory and sustentacular. The **auditory cells** are nucleated, and each is provided at its free extremity with a slender, tapering, hair-like filament, which projects into the cavity. These filaments are sometimes spoken of collectively as *auditory hairs*, and the cells are hence called **hair-cells.** Their deep extremities fall short of the membrana propria. The **sustentacular cells** lie between the hair-cells, and are elongated and nucleated. Their deep extremities are attached to the membrana propria, and their free extremities give rise to a kind of limiting membrane. The auditory nerve-fibres pierce the membrana propria, and, having lost their medullary sheaths, the axons end in arborizations round the deep ends of the auditory or hair cells.

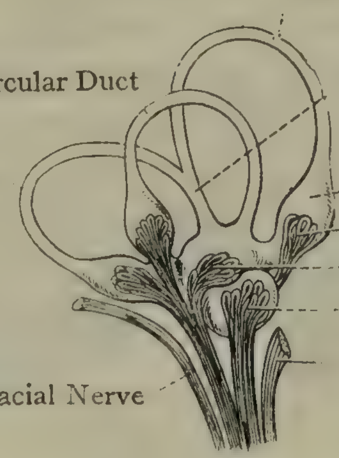


FIG. 1038.—THE MEMBRANOUS SEMICIRCULAR DUCTS, SHOWING THE DISTRIBUTION OF THE BRANCHES OF THE AUDITORY NERVE TO THEIR AMPULLÆ (BRESCHET).

Membranous Cochlea.—The membranous cochlea is situated within the osseous cochlea, and fills the gap which is left by the lamina spiralis. It consists of two membranes, the basilar membrane and the vestibular membrane (membrane of Reissner, Fig. 1040), which enclose between them the *ductus cochlearis*, or scala media. The osseous cochlea in the recent state is therefore divided into three spiral passages—the scala tympani, the scala vestibuli, and the ductus cochlearis. The *scala vestibuli* is continuous with the scala tympani at the cupola through an aperture, called the *helicotrema*; and at the base of the cochlea it opens upon the anterior wall of the vestibule. The *scala tympani* begins at the fenestra cochleæ, and in the recent state is separated from the tympanic cavity by the secondary membrane of the tympanum. The scala media, or *ductus cochlearis*, communicates near its lower end with the saccule by means of the ductus reuniens. The scala vestibuli and scala tympani contain perilymph, which is continuous with the perilymph of the vestibule and osseous semicircular canals. The scala media contains endolymph, which is continuous with that of the saccule.

Basilar Membrane.—The basilar membrane extends from the free margin of the lamina spiralis to the *crista basilaris,* or lower part of the **spiral ligament,** a thickening of the periosteum of that part of the outer wall of the cochlea which forms the outer wall of the scala media, or ductus cochlearis. It separates the ductus cochlearis from the scala tympani, and is divisible into two zones, inner and outer. The inner is called the *zona arcuata,* and supports the spiral organ. The outer is known as the *zona pectinata,* and extends from the foot-plates of the outer rods of this organ to the crista basilaris. The basilar membrane consists of a homogeneous membrana propria, with fibres embedded in it, the fibres being most numerous in the zona pectinata.

Vestibular Membrane, or Membrane of Reissner.—This is a delicate membrane which extends from the upper surface of the lamina spiralis a short distance from its free margin to the outer wall of the cochlea, where it is attached to the periosteum a little above the outer attachment of the basilar membrane. It separates the cochlear duct from the scala vestibuli, and consists of very delicate connective tissue lined on each side with a single layer of squamous epithelium.

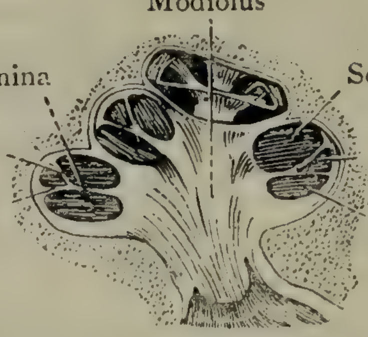


FIG. 1039.—VERTICAL SECTION OF THE COCHLEA OF A FŒTAL CALF, SHOWING THE SCALÆ AND MODIOLUS (KOLLIKER).

The **scala media,** or **ductus cochlearis,** is situated between the basilar membrane and the vestibular membrane. It is triangular in transverse section, and has a roof, an outer wall, and a floor. The **roof** is formed by the vestibular membrane (see Fig. 1040). The **outer wall** is the wall of the cochlea and its periosteum, between the external attachments of the basilar membrane and the vestibular membrane. The periosteum in this region is much thickened, and forms the **spiral ligament of the cochlea,** the lower part of which gives rise to the crista basilaris. The **floor** is formed by the basilar membrane, and a part of the upper surface of the lamina spiralis. It has been seen that the basilar membrane separates the ductus cochlearis from the scala tympani. The ductus ends above in a closed extremity at the cupola, and it has a similar ending at the base of the cochlea. Near its lower blind extremity it receives the ductus reuniens, by which it communicates with the saccule.

It has just been shown that part of the floor of the cochlear duct is formed by some of the lamina spiralis. In the recent state it is of some thickness, which is due to a thickening of its periosteal

covering. This fibrous thickening forms the **limbus laminæ spiralis** (see Fig. 1040).

Its outer margin is crescentic, the deep notch being called the *sulcus laminæ spiralis*. The sulcus has two lips, upper and lower. The upper is called the *labium vestibulare*, the upper surface of which is marked by several interlacing prominences and grooves. At the free margin of this labium the prominences assume the form of tooth-like projections, which are known as the **auditory teeth.** The lower lip of the sulcus is called the *labium tympanicum*. It is continued into the basilar membrane, and is perforated by a great number of apertures for the branches of the cochlear division of the auditory nerve.

Spiral Organ (**of Corti**).—Over the upper surface of the inner part (zona arcuata) of the basilar membrane the epithelium undergoes

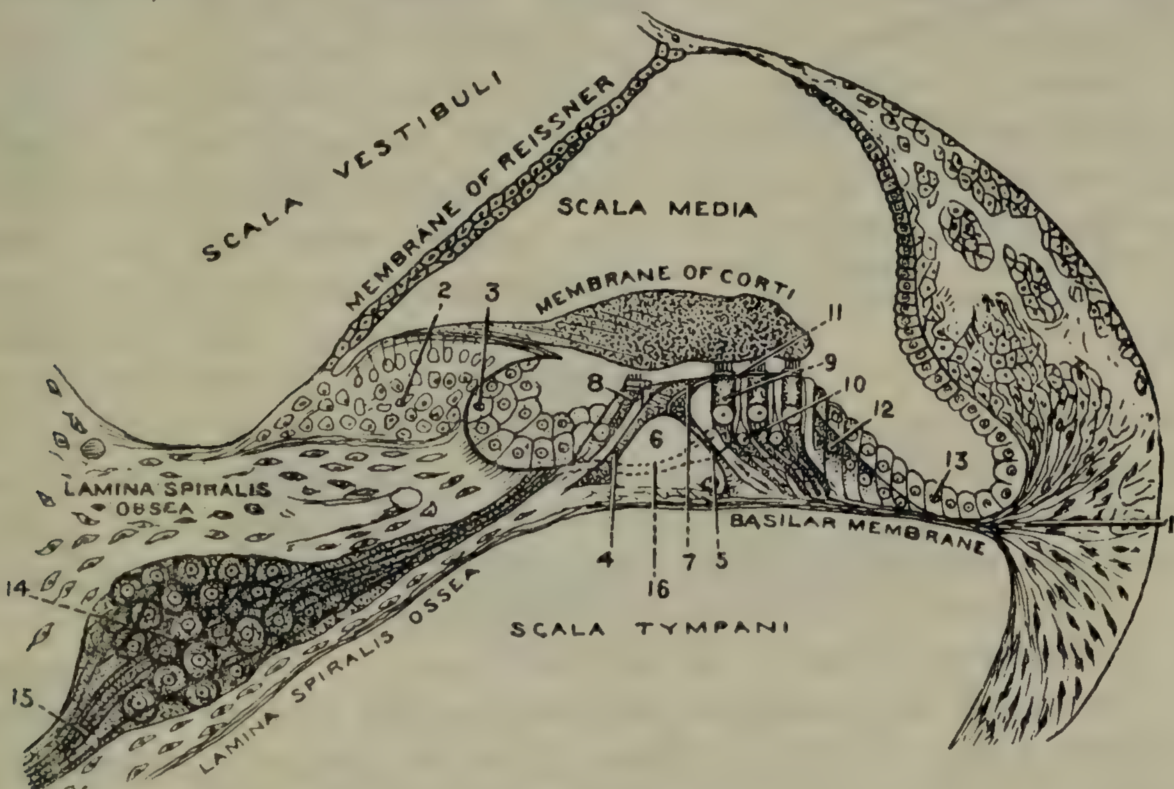


Fig. 1040.—The Organ of Corti (Wiedersheim, after Lavdowsky).

1. Spiral Ligament
2. Limbus
3. Sulcus Spiralis
4. Inner Rod of Corti
5. Outer Rod of Corti
6. Tunnel of Corti
7. Phalangeal Process of Outer Rod
8. Inner Hair-cells
9. Outer Hair-cells
10. Cells of Deiters
11. Lamina Reticularis
12. Cells of Hensen
13. Cells o Claudius
14. Spiral Ganglion
15. Cochlear Nerve
16. Nerve-fibres to Hair-cells

remarkable modification, and gives rise to the **spiral organ** or **organ of Corti.** The constituent parts of this very complicated organ are as follows:

1. The rods of Corti.
2. The auditory or hair cells.
3. The cells of Deiters.
4. The cells of Hensen and of Claudius.
5. The lamina reticularis.
6. The membrana tectoria.

The **rods of Corti** are arranged in two rows, inner and outer (see Fig. 1041). Each rod consists of a foot-plate or base, an intermediate portion, and a head. The **foot-plate,** which is expanded, rests upon the zona arcuata of the basilar membrane, and the foot-plates of the inner rods are separated from those of the outer rods by a slight interval. As the rods rise the **intermediate portions** of the inner and

outer rods incline towards each other, and the **heads** of the two sets of rods come into contact. In this manner a triangular tunnel is enclosed between the two sets of rods and the basilar membrane, which is called the **tunnel of Corti.** This extends along the entire length of the ductus cochlearis.

The **inner rods** are more numerous than the outer, there being from 5,000 to 6,000 of the former and about 4,000 of the latter. They incline upwards and outwards. The **head** of each has a concavity on its outer side, above and below which there is a projecting portion, so that it resembles the upper extremity of the ulna, with its great sigmoid cavity and olecranon and coronoid processes. The concavity on the head of the inner rod receives the round head of the outer rod. Finally, the inner rods are shorter than the outer. The **outer rods** are less numerous and longer than the inner, and they incline upwards and inwards. The **head** of each is divisible into two parts—inner and outer. The *inner part* is round, and is received into the concavity on the outer aspect of the head of the inner rod. The *outer part* is prolonged into a beak-like projection, called the **phalangeal process,** which forms part of the lamina reticularis, to be presently described.

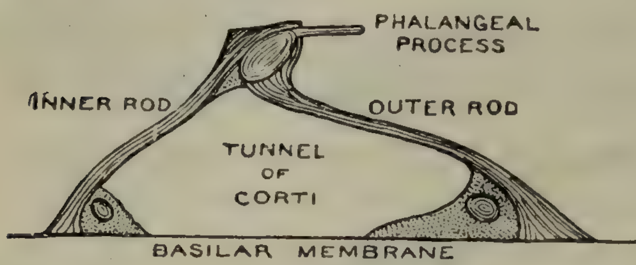


FIG. 1041.—A PAIR OF RODS OF CORTI FROM THE RABBIT'S COCHLEA (SIDE VIEW, HIGHLY MAGNIFIED) (SCHÄFER, IN QUAIN'S 'ANATOMY').

The **auditory** or **hair cells** are arranged in two sets—inner and outer. The **inner hair-cells** lie internal to the row of inner rods, and form a single row. They are from 3,000 to 4,000 in number. Their free extremities, which lie close to the heads of the inner rods, are each provided with a tuft of short, hair-like filaments. The deep, nucleated ends of the cells are related to the terminal arborizations of nerve-fibres. Internal to the row of inner hair-cells there are two or more rows of columnar cells, which are continuous with the columnar epithelium of the sulcus spiralis laminæ. The **outer hair-cells** are disposed in three or four rows external to the outer row of rods. They are much more numerous than the inner hair-cells. Their free extremities, like those of the inner cells, are each provided with a tuft of short, hair-like filaments, and their deep, nucleated ends are related to the terminal arborizations of nerve-fibres.

The **cells of Deiters,** which are sustentacular, are situated between the rows of outer hair-cells. Each cell is nucleated and contains a slender filament, known as the **sustentacular filament** or **phalangeal process.** This filament is attached by its base to the basilar membrane, and is prolonged into the tapering upper end of the cell. It terminates in an expansion, which forms a phalanx of the lamina reticularis, to be presently described.

The **cells of Hensen** are disposed as a continuous layer external to the lamina reticularis.

External to the cells of Hensen there are the cubical or columnar **cells of Claudius**: these are merely an epithelial lining layer.

The **reticular lamina** extends between the heads of the rods of Corti and the cells of Hensen. It consists of **phalanges,** which are arranged in two (or more) rows—inner and outer. The phalanges of the *inner row* are formed by the phalangeal processes of the heads of the outer rods of Corti. The phalanges of the *outer row* (or rows) are formed by the phalangeal processes of the cells of Deiters. Between the phalanges there are openings through which the outer ends of the outer hair-cells, with their crescentic tufts of hair-like filaments, project.

The **membrana tectoria,** or **membrane of Corti,** which is elastic, is the most superficial structure in connection with the spiral organ. It extends from the limbus spiralis near, and external to, the attachment of the vestibular membrane to the region of the outer hair-cells. It covers (1) the limbus laminæ spiralis; (2) the labium vestibulare,

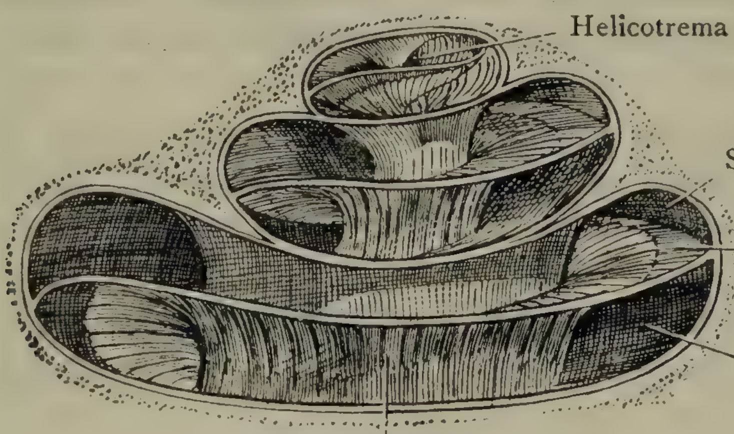


FIG. 1042.—SECTION OF THE COCHLEA, SHOWING THE DISTRIBUTION OF THE COCHLEA BRANCH OF THE AUDITORY NERVE (MAGNIFIED) (HIRSCHFELD AND LEVEILLÉ).

and the auditory teeth; (3) the sulcus laminæ spiralis; (4) the inner hair-cells; (5) the inner and outer rods of Corti; (6) the cells of Deiters; and (7) the lamina reticularis.

Auditory Nerve.—The auditory nerve, within the meatus auditorius internus, breaks up into two divisions—vestibular and cochlear.

The **vestibular nerve,** as it traverses the meatus auditorius internus, has a gangliform enlargement, the **vestibular ganglion,** and divides into three branches. These enter the vestibule through the foramina in the superior vestibular area of the lamina cribrosa at the deep end of the internal meatus. They are distributed to the macula utriculi and to the cristæ acusticæ of the ampullæ of the superior and external semicircular canals.

The **cochlear nerve** in the meatus auditorius internus divides into two branches—one to the macula sacculi, and the other to the crista of the ampulla of the posterior semicircular canal. The filaments of the former, which has a gangliform enlargement, pass through the foramina in the inferior vestibular area of the lamina cribrosa, and the

latter passes through the foramen singulare in the lamina cribrosa. The cochlear nerve, having parted with these two branches, breaks up into filaments which pass through the foramina of the cochlear area of the lamina cribrosa, and so reach the base of the modiolus of the cochlea. They traverse the canals of the modiolus, from which they pass into the canals between the two layers of the lamina spiralis. In doing so they have to cross the **spiral canal** of the modiolus, which is situated close to the attached margin of the lamina spiralis. This canal contains a ganglion, called the **spiral ganglion,** which follows the windings of the canal, and contains bipolar nerve-cells. As the auditory fibres pass from the canals of the modiolus into those of the lamina spiralis the course of each fibre is probably interrupted by a bipolar cell of the spiral ganglion. The nerve-fibres, leaving these bipolar cells, traverse the canals between the two layers of the lamina spiralis. Having lost their medullary sheaths, they pass through the foramina of the labium tympanicum on the outer margin of the limbus spiralis, and enter the basilar membrane, where they end in arborizations which are connected with the inner and outer hair-cells.

Blood-supply of the Labyrinth.—The labyrinth derives its blood from the **internal auditory,** which is a branch of the basilar artery or of the anterior inferior cerebellar. The vessel traverses the meatus auditorius internus, and divides at its deep end into two branches—vestibular and cochlear. The **vestibular artery** supplies the utricle, saccule, and semicircular canals, and the **cochlear artery** supplies the cochlea.

The **veins** of the labyrinth ultimately join to form one vessel, called the **internal auditory vein,** which opens into the inferior petrosal sinus. The aqueductus cochleæ and the aqueductus vestibuli each transmit a vein; that which passes through the former joins the inferior petrosal sinus or the bulb of the internal jugular vein, and that which passes through the latter opens into the superior petrosal sinus.

Development of the Ear.

Internal Ear—Membranous Labyrinth.—The membranous labyrinth is developed from the surface ectoderm in a manner similar to the development of the crystalline lens. Over a circumscribed area, corresponding to the upper end of the first visceral cleft, and upon the side of the hind-brain, the ectoderm becomes thickened and invaginated. A depression is thus formed, which is called the **auditory pit.** This pit becomes deepened, its mouth becomes constricted, and its lips, coming together, unite. The auditory pit then becomes transformed into a closed sac, called the **auditory** or **otic vesicle,** or **otocyst.** The auditory vesicle now becomes isolated from the surface ectoderm, and sinks into the adjacent mesoderm, taking up a position close to the side of the hind-brain.

The auditory vesicle, which is at first almost spherical, soon becomes pyriform, this being due to the formation of a process, called the *recess of the labyrinth* or *vestibule,* which is prolonged from its dorsal wall. As this process lengthens it gives rise to the **ductus endolymphaticus,** which occupies the aqueductus vestibuli of the petrous portion of the temporal bone. The expanded terminal

part of the ductus endolymphaticus is called the *saccus endolymphaticus*, and it lies underneath the dura mater. The ventral aspect of the vesicle gives off a tapering diverticulum, which gives rise to the **ductus cochlearis,** or **scala media,** of the cochlea. This duct describes a bend, within which lies the **cochlear ganglion** of the cochlear division of the auditory nerve. As the duct elongates it continues to bend in a spiral manner, and so the **ductus cochlearis** is formed. The cochlear ganglion elongates, and follows the spiral turns of the duct, from which circumstance the ganglion is known as the **ganglion spirale.**

The three **semicircular ducts** are developed from the upper or cephalic part of the auditory vesicle, this part representing the future utricle. This portion of the vesicle presents two folds—vertical and horizontal. From the vertical fold the **superior** and **posterior semicircular canals** are formed, whilst the horizontal fold gives rise to the **lateral semicircular canal.**

The auditory vesicle now becomes transversely constricted, and is divided into two sacs—large and small. The large sac is called the **utricle,** from which the semicircular ducts have just been developed. The small sac is called the **saccule,** from which the ductus cochlearis has been developed. The portion of this duct which communicates with the saccule becomes constricted, and forms the *canalis reuniens* **of Hensen.**

The constriction which completely divides the auditory vesicle into utricle and saccule also involves the vesicular end of the ductus endolymphaticus, and divides it into two ducts, called the *ductus utriculi* and *ductus sacculi.* This arrangement constitutes the only communication which now exists between the utricle and the saccule.

As stated, the **cochlear ganglion,** or **ganglion spirale,** of the cochlear division of the auditory nerve lies within the spiral turns of the ductus cochlearis. As the osseous cochlea becomes formed, the ganglion spirale comes to occupy the spiral canal of the modiolus. The **vestibular ganglion** of the vestibular division of the auditory nerve lies in the internal auditory meatus after the completion of ossification.

The membranous labyrinth, hitherto considered, is entirely epithelial. Certain of its epithelial cells undergo important specializations to fit them for sensorial purposes. These cells form *six groups* in definite regions. These groups are as follows: (1) The *crista acustica ampullaris,* of which there are *three,* one in the **ampulla** of each of the three epithelial semicircular canals; (4) the *macula (acustica) utriculi*; (5) the *macula (acustica) sacculi*; and (6) the *spiral organ (of Corti)*, specialized from the epithelial ductus cochlearis. The groups connected with the ampullæ of the semicircular canals, the utricle, and the saccule, receive their nerve-fibres from the **vestibular ganglion** of the vestibular division of the auditory nerve. The organ of Corti receives its nerve-fibres from the **cochlear ganglion,** or **ganglion spirale,** of the cochlear division of the auditory nerve.

Osseous Labyrinth.—The membranous labyrinth is surrounded by mesodermic tissue, which becomes disposed in *four layers*. These layers, from within outwards, may be spoken of as (1) the connective-tissue layer, (2) the gelatinous layer, (3) the perichondrial layer, and (4) the cartilaginous layer. The *connective-tissue layer* forms the connective tissue of the various parts of the epithelial labyrinth. The fibrous tissue of the *gelatinous layer* acquires vacuoles, and gives place to the various **perilymphatic spaces,** which contain a fluid called the **perilymph.** In the case of the cochlea, the scala vestibuli and scala tympani alone contain perilymph, the cochlear duct containing endolymph. The **perichondrial layer** forms the lining perichondrium of the periotic cartilaginous capsule, and subsequently becomes the lining periosteum of the osseous labyrinth. The *cartilaginous layer* forms the **periotic cartilaginous capsule,** which undergoes ossification, and gives rise, amongst other parts, to the *osseous labyrinth,* which is of larger size than the membranous labyrinth. The osseous semicircular canals conform in shape to the membranous semicircular ducts, but are of larger size. The osseous vestibule differs from the membranous vestibule in being a single osseous case, whereas its contents are the utricle and the saccule.

Whilst the perilymph lies external to the membranous labyrinth, the interior

of the semicircular ducts, utricle, saccule, and scala media contain endolymph, the latter being in communication with the saccule by means of the canal is reuniens.

The **middle ear** or **tympanum** and **pharyngo-tympanic tube** (see p. 73 *et seq.*) are developed from the *tubo-tympanic recess* of the pharynx. This is the widest part of the early pharynx, opposite the second and third arches, and by the time the embryo has reached the second month of development the recess is definitely indicated; it projects laterally with its contained cavity, compressed dorso-ventrally, widely open into the general pharyngeal cavity. Its *roof* supports the *otic capsule*, while the outer parts of the first two visceral grooves are seen in its floor, with the second arch between them. It is bounded in front by the first arch, and caudally by the third arch. The first lateral pouch, on its lateral edge, is in contact with the persistent upper end of the first *outer* groove; the second pouch, which has lost contact, is at its postero-lateral angle. The recess deepens, and the third arch grows forward, cutting off the outer part of the cavity from the pharynx and narrowing the anterior part, which still remains continuous with the pharynx; the outer and larger part is the early **tympanum,** and the constricted front portion becomes the *tube.*

The otic capsule enlarges and chondrifies, and as it grows depresses the inner part of the tympanum, slightly rotating it, so that its former *roof* now becomes its *inner* wall, applied to the surface of the capsule. Its *floor,* also rotated, now slopes *downwards and* medially, and is in close relation with the **meatal plate,** a cellular ingrowth from the upper end of the first outer groove; this has grown in below the tympanum, and by a later process of hollowing forms the ectodermal lining of the **outer meatus** and **membrane.**

Meckel's cartilage develops in the mesoderm of the first arch, therefore antero-lateral to the recess, in front of the position of the first pouch. It sends an extension over the pouch to invade the second arch area behind this, passing under the floor between the endoderm and the meatal plate; this extension forms the *basis of the tympanic membrane and the manubrium,* and its upper part probably also forms the incus. The hyoid bar (**Reichert's cartilage**), the bar of the second arch, is behind this, immediately in front of the second pouch; an extension from its upper end over the roof gives rise to the stapes. The stapes becomes associated with the cartilaginous capsule, which has enlarged considerably; the enlargement extends postero-laterally, and leads to the fusion of Reichert's bar with the capsule (**tympano-hyal**) and the position of the remnant of the second pouch in the *fossula rotunda* (fenestra cochleæ).

The *chorda tympani* crosses the first pouch; the level of the early tympanum might roughly be taken as extending up to this nerve. The higher level of the adult cavity is attained by a later extension. In the early condition of the tympanum, the malleus, incus, stapes, and chorda tympani nerve lie embedded in the mesodermic tissue which intervenes between the epithelial or mucous roof of the membranous tympanum and its osseous roof. This mesodermic tissue disappears, and the mucous (originally epithelial) lining of the tympanum now comes into direct contact with the malleus, incus, stapes, and chorda tympani nerve, all of which it encloses within folds. Though these structures *apparently lie within* the tympanic cavity, this is not their actual position. They are *really outside the cavity,* inasmuch as they lie *external to* the mucous lining of the cavity. This may be illustrated by stating that the handle or manubrium of the malleus and the chorda tympani nerve do not lie in the tympanic cavity, but are placed between the middle, or fibrous, layer and the internal, or mucous, layer of the membrana tympani.

External Ear.—The external ear consists of (1) the external auditory meatus, including the membrana tympani, and (2) the pinna.

The **external auditory meatus** is developed from the upper part of the first external or ectodermic furrow, which corresponds in position to the first internal visceral cleft.

The **membrana tympani** is developed from the **closing membrane** which separates the first internal visceral cleft from the first external ectodermic furrow.

This **closing membrane** is a *trilaminar* structure. Its inner layer consists of entoderm; its middle layer of mesoderm; and its outer layer of ectoderm. The **membrana tympani,** which is developed from it, is therefore *trilaminar*. The *outer layer* is **ectodermic,** and is continuous with the cuticular lining of the external auditory meatus; the *middle layer* is **mesodermic,** or fibrous; and the *inner layer* is **entodermic,** or mucous, and is continuous with the mucous lining of the tympanic cavity.

The component parts of the **pinna** are developed from six projections, consisting of mesoderm, covered by ectoderm. These appear on the upper ends of the first and second visceral arches, where these bound the upper part of the first external ectodermic furrow, which gives rise to the external auditory meatus. The **helix** is developed from two of these tubercles, and each of the other four gives rise to the **antihelix, tragus, antitragus,** and **lobule.** The mesodermic tissue of the projections becomes differentiated into connective tissue and cartilage, and the ectoderm covers these.

GLOSSARY

Terms still in common use, though now 'discarded,' are included in this list, with a certain number of proper names coming in the same category.

Abdōmen, a word of uncertain derivation, but possibly from *abdo*, I hide or conceal.
Aberrant, wandering from the normal source.
Acervŭlus, a little heap.
Acervulus cerebri, brain-sand.
Acetabulum, a vessel for holding vinegar; a juggler's cup. But used by Pliny to signify hip-socket.
Acĭnus, any juicy berry with stones—*e.g.*, the grape; the kernel in the berry.
Acrocephalous, having a pointed or conical head.
Acromion, the point or summit of the shoulder.
Acusticus, ā, um, pertaining to sound, or to the sense of hearing.
Adamantoblast, enamel germ cell.
Adductor canal, subsartorial canal.
Adenoid, glandular.
Aditus, an approach or access.
Adrenal, near to the kidney.
Advehens, carrying to.
Afferent, carrying to.
Agger, a mound or rampart.
Agminated, disposed in columns.
Ala, a wing.
Ala cinera, vagal triangle.
Albicans, white.
Albuginea, whitish.
Alcock's canal, pudendal canal.
Allantois, sausage-like.
Alveolus, a little trough.
Alveus, a trough.
Amacrine, without a long fibre.
Ambiguus, dark, obscure.
Ameloblast, enamel germ.
Ammōnis, cornu, horn of Ammon, who was represented as having the head of a ram.
Amphiarthrosis, literally, articulation on both sides. Secondary cartilaginous joint (fibro-cartilage).
Ampulla, a flask.
Amygdala, an almond.
Anastomosis, literally, an outlet; the communication of branches of vessels with one another.
Anconēus, pertaining to the elbow.
Ankylosis, bony union between two bones which are normally separate.
Annulus, a little ring.
Ansa, a handle, loop, or brace.
Ansa cervicis, ansa hypoglossi.
Anserinus, pertaining to a goose.
Antecubital, in front of the elbow.
Antibrachium, forearm.
Anticubital fossa, cubital fossa.
Anticus, in front, anterior.
Antinion, opposite to the inion.
Antrum, a cave or cavity.
Antrum of Highmore, maxillary sinus.
Antrum, mastoid, tympanic antrum.
Anus, a ring.
Aorta, literally, the lower end of the trachea; a carrier.
Apertura piriformis, anterior aspect of nose.
Aponeurosis, an expansion from a tendon.
Aponeurosis, lumbar, lumbar fascia.
Aponeurosis, pharyngeal, pharyngo-basilar fascia.
Apophysis (' grow from '), a process or swelling on a bone.
Appendix ventriculi laryngis, saccule.
Aqueductus cerebri, aqueduct of mid-brain.
Aqueductus Fallopii, facial canal.
Arachnoid, like a spider's web.

Arantii, corpus, nodule (in cusps of aortic and pulmonary valves).
Archenteron, primitive intestine.
Arcuatus, curved.
Area acustica, vestibular area.
Areola, a small open place.
Arnold's ganglion, otic ganglion.
Arnold's nerve, tympanic nerve.
Artery, literally, an air vessel; the trachea was known as the arteria aspera; a bloodvessel which carries the blood from the heart.
Arthrodia, from the Greek word meaning 'a joint'; applied to a gliding joint.
Arthrosis, plane joint.
Arytenoid, pitcher-like.
Ascending frontal convolution, precentral convolution.
Ascending parietal convolution, postcentral convolution.
Aspera, rough.
Asterion, a star.
Astragalus, the ankle-bone; a die (pl. dice); talus.
Atlas, a support; refers to Atlas, who carried the earth on his neck.
Atresia, imperforation.
Atrium, the hall in a Roman house.
Attic, epitympanic recess.
Attollens, raising up, elevating.
Attrahens, drawing to or towards.
Auditory, pertaining to the organ, or sense, of hearing.
Auerbach's plexus, myenteric plexus.
Auricle, the external ear.
Auricle (O.T.), atrium (heart).
Auricular appendix (O.T.), auricle.
Azygos, without a pair, single.

Bacillary, pertaining to a small staff or rod.
Balănus, an acorn.
Barba, a beard.
Bartholin's duct (great duct of Rivini), principal sublingual duct.
Basilar, belonging to the base.
Basilic, royal, important.
Basion, base.
Bechterew, nucleus of, superior vestibular nucleus.
Bell, nerve of, nerve to serratus anterior.
Bellini, ducts of, terminal collecting tubules of kidney.
Biceps, having two heads.
Bicornis, two-horned.
Bicuspid (teeth), pre-molar.
Bigelow, Y-shaped ligament of, iliofemoral ligament.
Biventer, having two bellies.
Bowman's capsule, capsule of glomerulus.
Bowman's membrane, anterior elastic lamina of cornea.
Brachium, the arm.
Brachium conjunctivum, superior cerebellar peduncle.
Brachium pontis, middle cerebellar peduncle.
Brachycephalic, short-headed.
Bregma, from a Greek verb meaning 'to moisten.'
Broca, area of, parolfactory area.
Broca, band of, diagonal band.
Bronchiole, a little bronchus.
Bronchus, literally, a draught; the windpipe.
Bryant's triangle, (1) horizontal line from anterior superior spine; (2) vertical line from top of great trochanter; (3) line joining anterior superior spine to top of great trochanter.
Bubonocele, a variety of tumour in the groin.
Buccinator, a trumpeter.
Bulla, a knob; a bubble.
Burdach, fasciculus of, fasciculus cuneatus.
Burns, falciform process of (ligament of Hey), superior cornu of saphenous opening.
Burns' space, suprasternal space.
Bursa, a sac containing fluid.
Bursa omentalis, lesser sac.

Cacūmen, tip, peak, or end.
Cæcum, blind.

Cæruleus, dark blue.
Calamus, a reed-pen.
Calcaneum, the heel.
Calcar, a spur.
Calcination, reduction to a powder (or line) by heat.
Calcis, of the heel.
Calix, a cup or goblet.
Callosal convolution, gyrus cinguli.
Calloso-marginal fissure, sulcus cinguli.
Callosum, hard, thick.
Calvaria (*calva,* the bald scalp), the upper part of the skull.
Canalis reuniens, ductus reuniens.
Cancellated, lattice-formed, reticulated.
Canthus, the angle of the eye.
Capillary, pertaining to the hair; a vessel of hair-like minuteness.
Capitellum, a small head.
Capsular, suprarenal.
Caput gallinaginis, urethral crest.
Caput medusæ, varicose veins radiating from umbilicus in portal obstruction.
Cardia, the opening of the stomach; the heart.
Cardiac, pertaining to the heart (originally to the stomach).
Cardinal, principal or chief.
Carīna, a keel.
Carneæ, pertaining to flesh.
Carŏtid, stupefying; or perhaps from two Greek words meaning ' head ' and ' ear.'
Carpus, the wrist.
Cartilages, alar, lower lateral cartilage.
Cartilages, lateral, upper lateral cartilage (of nose).
Cartilages, Santorini, of, corniculate cartilage.
Cartilages, Wrisberg, of, cuneiform cartilage.
Caruncula, a little piece of flesh.
Caruncula sublingualis, sublingual papilla.
Carunculæ myrtiformes, carunculæ hymenales.
Cauda, a tail.
Caudate, tailed.
Caudate lobe (O.T.), tail of caudate lobe.
Cavernous, full of hollows or cavities.
Centimetre (cm.), $\frac{2}{5}$ of an English inch.
Cephalic, pertaining to the head.
Cerăto, horny.
Ceruminous, pertaining to wax.
Chiasma, two lines placed like an **X**.
Choāna, a funnel.
Choanæ, posterior apertures of nose.
Choledŏchus, bile-receiving.
Chondral, pertaining to cartilage.
Choroid (Chorioid), like skin.
Cinereus, ash-coloured.
Cingulum, a small girdle.
Circumflexus, bent around.
Circumvallate papillæ, vallate papillæ.
Cisterna, a cistern or reservoir.
Clarke, posterior vesicular column of, thoracic (dorsal) nucleus.
Claustrum, a bulwark, barrier, or inclosure.
Clava, a club; gracile tubercle.
Clavicle, from *clavis,* a key, or possibly a hoop-stick.
Cleido-, pertaining to the clavicle.
Clinoid, like the knob of a bedpost.
Clitoris, from a Greek verb meaning ' I shut up ' or ' enclose.'
Clivus, a slope.
Cloāca, a sewer or drain.
Coccyx, a cuckoo.
Cochlea, a snail.
Cochlea, membranous, duct of cochlea.
Cochleariformis, spoon-like.
Cœliac, pertaining to the belly.
Collicŭlus, a little hill.
Colliculus, quadrigeminal body.
Colliculus seminalis, urethral crest.
Colon, the great gut.
Columns, rectal (Morgagni), anal columns.
Comes, a companion.
Comma tract, semilunar tract.

Complexus, literally, folded together; encompassing.
Concatenatæ, chained together.
Concatenate glands, deep cervical (lymph) glands.
Concha, a shell.
Condyle ('knuckle'), a small round prominence covered by cartilage.
Coni vasculosi, lobules of epididymis.
Conjunctiva, connecting.
Conniventes, winking or blinking.
Conoid, cone-like.
Conoid tubercle, coracoid tuberosity.
Conus arteriosus, infundibulum.
Conus elasticus, crico-vocal membrane.
Convolūta, rolled together.
Coracoid, like a crow or raven.
Cord, vocal, false, vestibular folds.
Cord, vocal, true, vocal fold.
Cordiform, heart-shaped.
Cords (gangliated, lumbo-sacral, etc.), trunks.
Cornea, horny.
Corniculum, a little horn.
Cornu ammonis, hippocampus.
Corōnal, literally, pertaining to a crown; transverse.
Coronary, encircling.
Coronoid, like a crooked beak.
Corpora albicantia (brain), corpora mamillaria.
Corpus (of long bone), shaft.
Corpus adiposum buccæ, buccal pad.
Corpus arantii, nodule (aortic and pulmonary valves).
Corpus cavernosum penis, corpus cavernosum.
Corpus cavernosum urethræ, corpus spongiosum.
Corrugator, a wrinkler.
Cortex, the bark or outer covering.
Costal, pertaining to a rib.
Cotyloid, cup-like.
Cowper's gland, bulbo-urethral gland.
Coxa, the hip.
Cranium, the skull.
Crassum, thick, dense, or bulky.
Cremaster, a suspender.
Cribriform, sieve-like.
Cribrosa, perforated with sieve-like pores.
Cricoid, like a ring.
Crista tuberculi majoris, lateral lip of bicipital groove.
Crista tuberculi minoris, medial lip of bicipital groove.
Crucial, pertaining to, or shaped like, a cross.
Crural, pertaining to the leg.
Crural canal, femoral canal.
Crural ring, femoral ring.
Crural septum, femoral septum.
Crus, cerebral peduncle.
Crusta, basis pedunculi.
Cryptorchismus, concealment of the testis.
Cryptozygous, hidden arches.
Cubitum, the elbow.
Cucullaris, pertaining to a cowl or hood.
Culmen, the top or summit.
Cuneate, wedge-shaped.
Cuneiform bone (hand), triquetrum.
Cuneus, a wedge.
Cupola, a dome.
Cymba, a boat or skiff.
Cystic, pertaining to the gall-bladder. The condition of a thin-walled swelling containing fluid or semi-fluid.
Cytoplasm, formative yolk; protoplasm in a cell.

Dacryon, a tear.
Dartos, skinned or flayed.
Deciduous, falling away.
Decussation of lemnisci (fillet), sensory decussation.
Deferens, carrying away.
Deiters, nucleus of, lateral vestibular nucleus.
Dens, odontoid process.
Dens serotinus, wisdom tooth.
Dentate fascia, dentate gyrus.
Descemet's membrane, posterior elastic lamina of cornea.
Detrūsor, from *detrudo,* I drive away.
Deutoplasm, literally, wet plasm; nutritive yolk.

Dia-, through or between.
Diaphragm, a partition.
Diaphysis ('grow between'), the shaft of a bone, or the part which grows between the epiphyses.
Diarthrosis, an 'apart' joint—*i.e.*, a 'free' joint (the articular surfaces being free to play upon each other); synovial joint.
Diencephalon, the 'tween-brain or inter-brain; thalamencephalon.
Digastric, having two bellies.
Diploë, a doubling.
Discus proligerus, cumulus ovaricus.
Diverticulum, from *diverto*, 'I separate,' or 'part,' or 'go a different way.'
Dolichocephalic, long-headed.
Dorsal, pertaining to the back aspect.
Dorsum, the back.
Douglas, pouch of, recto-uterine or recto-vaginal pouch.
Douglas, semilunar fold of, arcuate line.
Duct, nasal, naso-lacrimal duct.
Ductus deferens, vas deferens.
Ductus perilymphaticus, aqueduct of cochlea.
Duodēnum, twelve (probably fingerbreadths).

Ebur, -ŏris, ivory.
Eburnea, pertaining to ivory.
Ectopia, a displacement.
Efferent, carrying out.
Emboliformis, beak-shaped or wedge-shaped.
Emissary, sent out.
Emulgent, milking, straining out.
Enarthrosis, ball-and-socket joint.
Encephalon, the contents of the head or skull.
Endocardium, 'within the heart'; the lining membrane of the cardiac chambers.
Endognathion, literally, inner jaw.
Endosteum, 'within a bone'; the medullary membrane.
Ensiform, sword-like.
Ensiform process, xiphoid process.
Entomion, a notch.
Ependyma, from Greek words meaning 'clothing upon.'
Ephippium, a saddle.
Epi-, upon or over, above.
Epicardium, upon the heart.
Epididymis, upon the testicle.
Epiglottis, cushion of, tubercle of epiglottis.
Epiotic, upon or over the ear.
Epiphysis ('grow upon'); a process of a bone which has a secondary centre of ossification.
Epiploön, from a Greek verb meaning 'to float upon.'
Epipteric, upon a wing.
Epipteric bone, sutural bone at pterion.
Epistropheus, axis.
Epoöphoron, above the egg-bearing organ.
Erythrŏblast, red (cell) germ.
Ethmoid, like a strainer.
Eustachian cushion, tubal elevation.
Eustachian spine (of medial pterygoid plate), processus tubarius.
Eustachian tube, pharyngo-tympanic tube.
Eustachian valve, valve of inferior vena cava.
Exognathion, literally, outer jaw.
Exomphalos, out of the navel.

Facet (French, *facette*, a little face), a small plane surface, usually articular.
Falciform, sickle-like.
Fallopian tube, uterine tube.
Falx, a sickle.
Falx aponeurotica inguinalis, conjoint tendon.
Fascia, a bandage, or a bundle of reeds.
Fascia bulbi, fascial sheath of eyeball.
Fascia, Camper's, superficial layer of superficial fascia of anterior abdominal wall.
Fascia, Colles', deep layer of superficial fascia of perineum.

Fascia, coraco-clavicular, clavi-pectoral fascia.
Fascia infundibular, internal spermatic fascia.
Fascia intercolumnar, external spermatic fascia.
Fascia, Scarpa's, deep layer of superficial fascia of anterior abdominal wall.
Fascia, Sibson's, suprapleural membrane.
Fasciculus, a small bundle.
Fasciola cinerea, splenial gyrus.
Fastigium, a roof.
Fauces, the throat.
Fauces, anterior pillar, glosso-palatine arch.
Fauces, posterior pillar, pharyngo-palatine arch.
Fel, the gall-bladder.
Femur, the thigh.
Fenestra, an opening, a window.
Fenestra ovalis, fenestra vestibuli.
Fenestra rotunda, fenestra cochleæ.
Ferruginea, pertaining to iron-rust.
Fibula, a buckle, clasp, or brace.
Fillet, lemniscus.
Filum, a thread.
Fimbria, a fringe.
Fimbriātum, fringed.
Fissure, a cleft or slit.
Fistula, a pipe or tube.
Flechsig, tract of, posterior spino-cerebellar tract.
Flocculus, a little lock of wool.
Fold, bloodless (Treves), ileo-cæcal fold.
Fold, ileo-colic, vascular fold of cæcum.
Fold, recto-vesical, sacro-genital fold.
Follicle, a small bag or sac.
Fontana, spaces of, spaces of irido-corneal angle.
Fontanelle, a small spring.
Foramen, an aperture or a hole.
Forceps, a claw of a beetle.
Fornicatus, pertaining to an arch.
Fornix, an arch or a vault.
Fossa, a ditch or trench.
Fossa, antecubital, cubital.
Fossa ovalis, saphenous opening.
Fossa, rhomboid, floor of fourth ventricle.
Fossa, spheno-maxillary, pterygo-palatine fossa.
Fourchette, a fork.
Fovea, a small pit.
Foveola, a very small pit.
Frenulum, a small bridle.
Frenum, a bridle.
Frontal, pertaining to the forehead.
Frontal spine (of frontal), nasal spine.
Fundiform, sling-like.
Funicular, pertaining to a cord.
Funiculus, a slender rope, a cord.
Furcalis, pertaining to a two-pronged fork.
Furcula, a small two-pronged fork.
Fusca, dark or dusky.

Galactophorous, milk-carrying.
Galea, a helmet.
Galĕa aponeurotica, epicranial aponeurosis.
Galen, great vein of, great cerebral vein.
Galen, veins of, internal cerebral veins.
Gallinaginis, of a woodcock.
Gallus, a cock.
Ganglion, a swelling or excrescence.
Ganglion, aortico-renal, lower part of cœliac ganglion.
Ganglion, Gasserian, trigeminal ganglion.
Ganglion, jugular (O.T.), superior ganglion of ninth.
Ganglion, jugular (B.N.A.), superior ganglion of tenth.
Ganglion, lenticular, ciliary ganglion.
Ganglion, Meckel's, spheno-palatine ganglion.
Ganglion nodosum (B.N.A.), inferior ganglion of tenth.
Ganglion, ophthalmic, ciliary ganglion.
Ganglion, petrous (O.T. and B.N.A.), inferior ganglion of ninth.
Ganglion, semilunar, trigeminal ganglion.

Ganglion, stellate, first thoracic ganglion.
Ganglion, submaxillary, submandibular ganglion.
Gärtner's duct, duct of epoöphoron.
Gastric, pertaining to the stomach.
Gastrocnemius, the belly of the leg.
Gemellus, paired or double.
Geminus, twin or twofold.
Geniculate, knee-like.
Genio-, pertaining to the chin.
Gennari, stria of, visual stria.
Genu, the knee.
Gerota's capsule, renal fascia.
Giacomini, *banderella* or *frenulum,* tail of dentate gyrus.
Gimbernat's ligament, pectineal part of inguinal ligament.
Ginglymus, a hinge.
Ginglymus, hinge-joint.
Giraldes, organ of, paradidymis.
Glabella, without hair; smooth.
Gladiolus, a small sword.
Gladiolus, body of sternum.
Gland, Bartholin's, greater vestibular gland.
Gland, Cowper's, bulbo-urethral gland.
Glenoid, like a shallow socket.
Glisson's capsule, hepato-biliary capsule.
Globosus, round or spherical.
Globus, a globe or sphere.
Glomerulus, a small ball of thread.
Glosso-, pertaining to the tongue.
Glottis, the mouthpiece of a flute.
Gluteal, pertaining to the buttock.
Gnathic, pertaining to the jaw.
Gnathion, the jaw.
Gomphosis, a bolting together.
Gonion, an angle.
Gracilis, slender.
Grisea, grey.
Gubernaculum, a rudder.
Gula, the gullet.
Gustatory, pertaining to taste.
Guttural, pertaining to the throat.
Gyrus, a circle; a crook.
Habenula, a small thong or rein.
Hæmorrhoidal, associated with hæmorrhoids.
Hallux, the great toe.
Ham, a thing bent or crooked.
Hamular, hook-shaped.
Harmonia, a fitting together.
Hartmann's pouch, sacculation at junction of neck and body of gall-bladder.
Hassall, corpuscles of (thymus), concentric corpuscles.
Haustrum, a machine for drawing water.
Heister's valves, spiral valve.
Helicine, spiral.
Helicotrēma, hole of a spiral.
Helix, a coil or spiral.
Hepar, the liver.
Hepatic, pertaining to the liver.
Hernia, a sprout; a rupture.
Hesselbach's triangle, inguinal triangle.
Hiatus, a gap.
Hiatus Fallopii, hiatus for superficial petrosal nerve.
Highmore, antrum of, maxillary sinus.
Hilum, a little thing; a trifle.
Hippocampus, a seahorse.
Hippocampus major, hippocampus.
Hippocampus minor, calcar avis.
Hircina, pertaining to a goat.
His, bundle of, atrio-ventricular bundle.
Homodynamic, **Homogenesis**, **Homologous** } see Chapter I.
Houston's valves, horizontal folds of rectum.
Huguier, canal of, anterior canaliculus for chorda tympani.
Humerus, the upper part of the arm; the shoulder.
Hunter's canal, subsartorial canal.
Hyaline, glassy.
Hyaloid, like glass.
Hydatid, a watery vesicle.
Hydrocele, a watery tumour.
Hymen, the marriage deity.

Hyoid, like the Greek letter upsilon.
Hypo-, beneath or under.
Hypophysis, 'grow beneath.'
Hypothenar, beneath the palm of the hand.

Ileum, implying twists or coils.
Ilium, literally of the soft parts—*i.e.*, of the flank; os ilium, the bone of the flank.
Ima, lowest.
Impar, dissimilar (in number), unequal.
Incisivus, cutting into.
Incisura jugularis, suprasternal notch.
Incisura scapularis, suprascapular notch.
Incisura semilunaris (ulna), trochlear notch.
Infundibuliform, funnel-shaped.
Infundibulum, a funnel.
Inguinal, pertaining to the groin.
Inion, literally, the occiput.
Innominatum, unnamed.
Insula, an island.
Intercalary, inserted.
Internodium, the space between two knots or joints.
Interparietal bone, membranous part of occipital as a separate bone.
Interpositum, placed between.
Interstitial, belonging to interstices or small parts between the main parts of bodies.
Intertubercular sulcus, bicipital groove.
Intumescentia, enlargement (spinal cord).
Iris, the rainbow.
Ischiatic, pertaining to the hip.
Ischium, the hip.
Isthmus, faucium, oro-pharyngeal isthmus.
Isthmus rhombencephali, upper constricted end of fourth ventricle.
Iter, a passage or road.

Jacobson, cartilage of, sub-vomerine cartilage.
Jacobson, organ of, vomero-nasal organ.
Jacobson's nerve, tympanic nerve.
Jejunum, empty or hungry.
Jugal, yolking.
Jugular, pertaining to the throat.
Jugular notch (B.N.A.), suprasternal notch.
Jugum, a yolk.

Kerckring, ossicle, occasional centre in posterior margin of foramen magnum.
Key and Retzius, foramina of (Luschka), lateral apertures of fourth ventricle.
Kobelt's tubes, epoöphoron.

Labbe, vein of, inferior anastomotic vein (connects superficial middle cerebral with transverse sinus).
Labrum, a basin.
Lacertus fibrosus, bicipital aponeurosis.
Laciniosum, full of folds, indented, jagged.
Lacrimal, pertaining to tears.
Lacteal, pertaining to milk.
Lactiferous, milk-carrying.
Lacuna, a hollow or cavity.
Lacunæ (of sagittal sinus), lacunæ laterales.
Lacunar, pertaining to a hollow or gap.
Lacunar ligament, pectineal part of inguinal ligament.
Lamella, a small plate.
Lamina, a plate.
Lamina cinerea, lamina terminalis.
Lamina cribrosa, medial boundary of internal auditory meatus.
Lamina papyracea, orbital plate of ethmoid.
Lamina quadrigemina, tectum.
Lateral, on the side of. Used in reference to the sagittal plane of the body.
Lateral mass (ethmoid), labyrinth.
Lateral sinus, transverse sinus.
Latissimus, broadest.
Latum, broad.
Lemniscus, a ribbon.

Leptorhine, having small narrow nostrils.
Levator, a lifter or raiser.
Lien, the spleen.
Liēno-, pertaining to the spleen.
Ligament, a band or bandage.
Ligula, a little tongue.
Limbic lobe, gyrus fornicatus.
Limbous, pertaining to a border.
Limbus, a border.
Limbus fossæ ovalis (or limbus ovalis), annulus ovalis.
Limen, a threshold.
Linea, a line.
Lines, oblique (tibia), soleal line.
Lines, oblique internal (jaw), mylohyoid line.
Lines (occiput), nuchal lines.
Lines, popliteal, soleal line.
Lingual, pertaining to the tongue.
Lingula, a little tongue.
Lister's tubercle, dorsal tubercle of radius.
Longissimus, longest.
Longitudinal sinus, sagittal sinus.
Lower, tubercle of, intervenous tubercle (heart).
Lumbar, pertaining to the loin.
Lumbricalis, like an earth-worm.
Lunar, pertaining to the moon.
Lunula, a little moon; a crescent.
Lutēum, of a yellow colour.
Luys' nucleus, subthalamic body.
Lymphatic, from *lympha,* pure or spring water; lymph.
Lyra, a lyre; hippocampal commissure.

McBurney's point (base of appendix), junction of lower and middle thirds of spino-umbilical line.
Macula, a spot.
Magendie, foramen, median aperture of fourth ventricle.
Magnum, os, capitate bone.
Malar, pertaining to the cheek.
Malar bone, zygomatic bone.
Malleolus, a small hammer or mallet.
Malleus, a hammer or mallet.
Mamma, a breast or pap.
Mammilla, a little breast or pap. Properly spelt *mamilla.*
Mandible, the chewing bone—*i.e.,* lower jaw.
Manubrium, a handle or hilt.
Marshall, oblique vein, oblique vein of left atrium.
Massa intermedia, interthalamic connexus.
Massēter, the chewing muscle.
Mastoid, breast- or pap-like (nipple-like).
Maxilla, jaw.
Meatus (pl. **Meatûs**), a passage or canal.
Meckel's cave, cavum trigeminale.
Meckel's diverticulum, diverticulum ilei.
Mediastīnum, standing in the middle; a partition.
Medulla, marrow.
Megacephalic, having a large head.
Megaseme, having a large index.
Meibomian glands, tarsal glands.
Meissner's plexus, plexus of the submucosa.
Membrane, costo-coracoid, clavipectoral fascia.
Meninges, membranes.
Meniscus, a crescent.
Meniscus (knee), semilunar cartilage.
Mental, pertaining to the chin.
Mesaticephalic, having a head with an index of mean value.
Mesencephalon, the mid-brain.
Mesentery, in the middle of, or among, the intestines.
Mesial, nearer to the sagittal plane of the body.
Meso-, in the midst of. In compounds usually implies a structure like a mesentery, a peritoneal attachment fold.
Mesocephalic, pertaining to a head of mean capacity.
Mesogastrium=meso- (*q.v.*) and stomach.
Mesognathion, middle jaw.

Mesometrium=meso- (*q.v.*) and womb.
Mesonephros, mid-kidney.
Mesorhine, pertaining to an intermediate nasal index; a condition intermediate between broad-nosed and narrow-nosed.
Mesosalpinx=meso- (*q.v.*) and tube.
Mesoseme, intermediate index.
Meta-, after or beyond.
Meta-nephros, hind-kidney.
Metencephalon, the after-brain.
Metopic, pertaining to the forehead.
Metopism, persistence of the metopic or frontal suture.
Microcephalic, pertaining to a small head.
Microseme, small index.
Middle commissure, interthalamic connexus.
Millimetre (mm.), slightly less than $\frac{1}{25}$ of an English inch.
Minimæ, least, smallest.
Mitral, resembling an Asiatic head-dress, or mitre.
Modiolus, the nave of a wheel.
Molar, pertaining to a mill, or to grinding.
Monro, foramen, interventricular foramen.
Mons veneris, mons pubis.
Montanum, pertaining to a mountain.
Monticulus, a small mountain.
Morbus, a disease.
Muliebris, pertaining to a woman, feminine.
Müllerian duct, para-mesonephric duct.
Multangulum majus, os, trapezium.
Multifidus, many cleft; divided into many parts.
Musculo-spiral nerve, radial nerve.
Myelencephalon, marrow-brain.
Myeloplaxes, marrow-plates.
Myentericus, pertaining to the muscular tissue of the bowel.
Mylo-, pertaining to a mill.
Myocardium, the muscular tissue of the heart.
Myrtiform, like a myrtle-berry.

Nares, posterior, posterior apertures of nose.
Naris (pl. **nares**), a nostril.
Nasal, pertaining to the nose.
Natal, pertaining to the buttock.
Natis (pl. **nates**), the buttock.
Navicular, pertaining to a boat.
Nephros, a kidney.
Neural, pertaining to a nerve.
Neuroglia, literally ‘nerve glue.’
Nictitans, winking.
Norma, a rule or measure (aspect).
Notochord, string or cord of the back.
Nucha, the nape of the neck.
Nuck, canal, vaginal process.
Nucleus, a kernel.
Nuhn, glands, anterior lingual (sero-mucous) glands.
Nymphæ, nymphs or goddesses of the fountains, woods, trees, etc.; labia minora.

Obelion, a horizontal line (perhaps a little spit).
Obex, a bolt; a barrier.
Obturator, one who closes or stops up.
Occipital, pertaining to the back part of the head.
Odontoblast, a tooth-germ.
Odontoid, tooth-like.
Odoriferæ, carrying odours.
Œsophagus, food-carrier.
Olecranon, head or point of the forearm.
Olfactory, pertaining to smell.
Olfactory trigone, olfactory pyramid.
Olivary, pertaining to an olive.
Omentum, that which is drawn over.
Omentum, gastro-hepatic, lesser omentum.
Omentum, gastro-splenic, gastro-splenic ligament.
Omo-, pertaining to the shoulder.
Omphalo-, pertaining to the navel.
Operculum, a cover or lid.
Ophryon, the eyebrow.
Ophthalmic, pertaining to the eye.
Opisthion, hinder or rear.
Opisthotic, behind the ear.

Optic, pertaining to sight.
Optic thalamus, thalamus.
Ora, a border or margin.
Orthognathous pertaining to a straight (non-projecting) jaw.
Os incæ, interparietal bone.
Os japonicum, bi-partite zygomatic bone.
Os magnum, capitate bone.
Os, oris, a mouth.
Os, ossis, a bone.
Os tincæ, external os of uterus.
Ossicle of Kerckring, occasional centre in posterior margin of foramen magnum.
Osteoblast, bone-germ.
Osteoclast, bone-destroyer.
Osteogenetic, bone-forming.
Ostium, a door, entrance, or exit.
Otic, pertaining to the ear.
Otoconia, ear-dust.
Otoliths, ear-stones.
Ovary, egg-forming organ.
Oxyntic, producing acid.

Pacchionian bodies, arachnoid granulations.
Pacinian corpuscles, lamellated corpuscles.
Palātum, the palate.
Pallium, a covering.
Palmar, pertaining to the palm.
Palpebra, an eyelid.
Pampiniform, tendril-like.
Pancreas, literally, all or completely flesh.
Para-, near, by the side of.
Paradidymis, near the testis.
Parametrium, near the womb.
Parietal, pertaining to a wall.
Paroöphoron, near the egg-bearing organ; medial mesonephric tubules.
Parŏtid, near the ear.
Parovarium, epoöphoron.
Pars intermedia (Wrisberg), sensory root of facial nerve.
Patella, a small dish; a plate.
Pecten, another name for the os pubis; a comb.
Pectinātus, pertaining to a comb.
Pectinēal or **Pectinēus,** associated with the pecten bone or os pubis.
Pectiniform, comb-like.
Pectoralis, pertaining to the breast.
Peduncle of corpus callosum, paraterminal gyrus.
Pelvis, a basin.
Penicillus, a painter's brush or pencil.
Penis, a tail, or pendant process.
Peri-, around, about, or near.
Pericardium, around the heart.
Perineum, from a Greek verb meaning 'I dwell, or am situated, around.'
Perineum, central point of, perineal body.
Periosteum, around bone.
Periotic, around the ear.
Peritoneum, from a Greek word meaning 'stretched around.'
Peroneal or **Peroneus,** 'pertaining to the peronee,' the Greek name for fibula.
Petit's canal, zonular spaces.
Petit's triangle, lumbar triangle.
Petrous, rocky.
Phalanx, a rank of soldiers.
Pharynx, the throat.
Phenozygous, having visible arches.
Philtrum, a love potion.
Phrenic, pertaining to the diaphragm.
Pinēal, belonging to, or like, a pine-nut or pine-cone.
Pinna, a kind of shell-fish; a feather or wing.
Pisiform, like a pea.
Pituitary, pertaining to phlegm or mucus; hypophysis.
Placenta, a flat cake.
Plagiocephalous, pertaining to an oblique or twisted head.
Planta, the sole of the foot.
Plantar, pertaining to the sole of the foot.
Platycnēmism, broadness of leg.
Platyrhine, having a broad nose.
Platysma, a broad sheet.
Pleura, a rib.

Plexus, a twining or network.
Plexus, Auerbach's, myenteric plexus.
Plexus, gulæ, œsophageal plexus.
Plexus, Meissner's, plexus of the submucosa.
Plica, a fold.
Plica hypogastrica, lateral umbilical fold.
Plica urachi, median umbilical fold.
Plicæ palmatæ (uterus), arbor vitæ.
Pneumogastric, pertaining to the breathing organs and stomach.
Pocularis, pertaining to a cup.
Pollex, the thumb.
Pomum Adami, laryngeal prominence.
Pons, a bridge.
Poplitēal or **Poplitēus,** pertaining to the ham.
Porta, a gate.
Portal, pertaining to a gate.
Portio major and **minor,** sensory and motor roots of trigeminal nerve.
Postaxial / **Preaxial** } see Chapter I.
Posterior vesicular column (Clarke), thoracic (or dorsal) nucleus.
Posticus, posterior.
Poupart's ligament, inguinal ligament.
Primary divisions (of spinal nerves), anterior and posterior rami.
Proctodæum, the threshold of the anus.
Prognathous, having a projecting lower jaw.
Proligerus, bearing offspring; germinating.
Pro-nephros, fore-kidney.
Pro-otic, before the ear.
Prosencephalon, the fore-brain.
Prostate, standing before; or, more probably, pertaining to a porch or vestibule.
Psalterium, a psaltery or instrument of the lute kind.
Psalterium (lyra), hippocampal commissure.
Psoas, from a Greek word meaning 'the muscles of the loins,' and secondarily 'the loins themselves.'
Pterion, a wing.
Pterotic, pertaining to a wing.
Pterygoid, wing-like.
Pubes, the hair which appears on the external genital organs at the age of puberty.
Pubic, pertaining to the os pubis.
Pudendal, pertaining to the pudendum.
Pudendum, 'of which one ought to be ashamed.'
Pudic, modest or chaste.
Pulmo, a lung.
Pulmonary, belonging to the lungs.
Pulvinar, a couch or cushion.
Putāmen, trimmings or clippings.
Pyloric vestibule, pyloric antrum.
Pylōrus, literally, a gate-keeper.
Pyriformis, pear-shaped.

Quadrātus, square.
Quadriceps, having four heads.
Quadrigeminus, fourfold, four.

Racemose, pertaining to a cluster of grapes; full of clusters; clustering.
Radius, a staff or rod; the spoke of a wheel.
Ramus, a branch.
Ranine, pertaining to a frog.
Raphē, a seam.
Receptaculum, a receptacle.
Receptaculum chyli, cisterna chyli.
Rectus, straight.
Recurrent, running back.
Refractory, breaking up.
Reil, island of, insula.
Ren, a kidney.
Restiform, like a rope or cord.
Restiform body, inferior cerebellar peduncle.
Rete, a net.
Retina, from *rete,* a net.
Retrahens, drawing back.
Retzius, cave, retro-pubic space.
Revehens, carrying back.
Rhinencephalon, the 'nose' or olfactory brain.
Rhinion, a nose.
Rhombencephalon, the rhomb-brain (hind-brain).

Rhomboid ligament, costo-clavicular ligament.
Riedel's lobe, an elongation of lower margin of right lobe of liver (due to pressure).
Rima, a cleft or chink.
Risorius, laughing.
Rivini, ducts, sublingual ducts.
Rolando, fissure, central sulcus.
Rostrum, a beak.
Rotula, a little wheel.
Rugæ, wrinkles.

Saccus reuniens, sinus venosus (heart).
Sacrum, sacred; derivation and original meaning very doubtful.
Sagittal, pertaining to an arrow; antero-posterior.
Salpinx, a trumpet or tube.
Salvatella, saving, or making well.
Santorini, cartilages, corniculate cartilages.
Santorini, duct, accessory pancreatic duct.
Santorini, fissures, clefts in cartilage of exterior auditory meatus.
Saphēnous, apparent, manifest.
Sartorius, pertaining to a tailor.
Scala, a ladder, flight of steps, or staircase.
Scala media, duct of cochlea.
Scalēnus, of unequal sides.
Scansorius, of, or for, climbing.
Scaphocephalous, having a head like a boat.
Scaphoid, like a boat.
Scapula, a spade; probably from a Greek verb meaning 'I dig.'
Scarpa's triangle, femoral triangle.
Schlemm, canal, sinus venosus scleræ.
Schindylesis, a splitting or cleavage.
Sciatic (identical with **Ischiatic**), pertaining to the hip.
Sclera, hard.
Sclerotic, hard; sclera.
Scrobiculus, a little ditch or trench.
Scrotum, a skin bag or pouch; a hide (probably originally 'scortum').
Sebaceous, pertaining to grease.
Sella, a seat; a saddle.
Semilunar bone, lunate.
Semilunar fold of Douglas, arcuate line.
Seminalis, pertaining to semen.
Septum, a fence or barrier.
Serotĭnus, that comes or happens late.
Serrātus, jagged like a saw.
Sesamoid, like sesame (a kind of grain).
Shrapnell's membrane, flaccid part of membrana tympani.
Sibson's fascia, suprapleural membrane.
Sigmoid, like the Greek letter Σ (sigma).
Sigmoid cavity, greater, trochlear notch.
Sigmoid cavity, lesser, radial notch.
Sigmoid cavity (of radius), ulnar notch.
Sigmoid notch (mandible), mandibular notch.
Sinus, a cavity or hollow.
Sinus, Valsalva, of, sinuses of aorta.
Smegma, a cleanser.
Solar, relating to the sun.
Solar plexus, cœliac plexus.
Soleus, a sole or sandal; a sole-fish.
Sperma, seed or semen.
Spermatic, pertaining to semen.
Spermatoblast, a seminal bud.
Spermatozoa (plural), seminal animals.
Sphenoid, wedge-like.
Spheno-maxillary fossa, pterygo-palatine fossa.
Sphenotic, pertaining to the sphenoid bone and ear-capsule.
Sphincter, binding or closing tight.
Spigelian lobe, caudate lobe.
Splanchnic, pertaining to viscera.
Splenium, a bandage or compress.
Splenius, pertaining to a bandage.
Squamous, scaly.
Stapes, a stirrup.
Stellātum, starry.
Stensen's duct, parotid duct.

Stephanion, a crown or wreath.
Sternebra, a segment of the sternum.
Sternum, the breast or chest.
Stomata, mouths or pores.
Stomatodæum or **Stomodæum,** the threshold of the mouth.
Stria medullaris, stria habenularis.
Striæ acusticæ, auditory striæ.
Striæ medullares, auditory striæ.
Styloid, pen-like.
Subflava, somewhat yellow.
Subiculum, an under layer or support.
Submaxillary, submandibular.
Substantia gelatinosa (Roland), gelatinous matter.
Sudoriferous, sweat-carrying.
Sulcus, a furrow.
Supercilium, an eyebrow.
Supracallosal gyrus, indusium griseum.
Sural, pertaining to the calf of the leg.
Sustentaculum, a prop or support.
Sustentaculum lienis, phrenico-colic ligament.
Suture, a sewing together, a seam.
Sylvius, aqueduct, aqueduct of mid-brain.
Symphysis, growth together.
Syn-, with; together with (union or harmony may be implied).
Synarthrosis, literally, a 'together with' (direct) joint; fibrous joint.
Synchondrosis, bound together with cartilage; cartilaginous joint.
Syndesmosis, bound together with bands or bonds.
Synovia, resemblance to the white of an egg.

Tænia, a band or ribbon.
Talus, a die (pl. dice); the ankle-bone.
Tapētum, a carpet or coverlet.
Tarsus, a broad flat surface; the instep.
Tectorius, pertaining to a cover.
Tegmen, a covering.
Tegmentum, a covering.
Tela, a web.
Telencephalon, the end-brain.
Temporal, pertaining to the temples of the head.
Tendo Achillis, tendo calcaneus.
Tendon, from *tendo,* 'I stretch.'
Tenon's capsule, fascial sheath of eyeball.
Tentorium, a tent.
Tenuis, slender, small.
Teres, rounded.
Testis, a witness.
Thalamencephalon, the bedchamber-brain, or inter-brain.
Thalamus, a bedchamber; a marriage-bed.
Thebesian valve, valve of coronary sinus.
Thebesian veins, venæ cordis minimæ.
Theca, a cover, case, or sheath.
Thenar, the flat of the hand.
Thorax, the breast or chest; a breast-plate.
Thymus, thyme.
Thyroid, like a shield.
Tibia, a pipe or flute; the shin-bone.
Tinca, a small fish, perhaps the tench.
Tonsil, palatine, tonsil.
Tonsil, pharyngeal, naso-pharyngeal tonsil.
Torcular, a wine-press (twisting is implied).
Torcular Herophili, confluens sinuum.
Torus, a protuberance.
Torus tubarius, tubal elevation.
Trabecula, a little beam.
Trachea ('rough'), the wind-pipe.
Trachēlo-, belonging to the neck.
Tragus, a goat.
Trapezium, a table; a four-sided figure, no two sides of which are parallel to one another.
Trefoil, having three leaves.
Treitz, muscle, suspensory muscle of duodenum.
Treves, bloodless fold of, ileo-cæcal fold.
Triangular fascia, reflected part of inguinal ligament.
Triangular fibro-cartilage, articular disc.

Triangular ligament, inferior or superficial layer; perineal membrane.
Triceps, having three heads.
Trigeminus, threefold, triple.
Trigōnocephalus, a triangular head.
Trigonum, a triangle; triangular.
Triquetrum, three-cornered; triangular.
Triticèa, wheaten, or like a grain of wheat.
Trochanter, from a Greek verb meaning 'I roll, turn, or revolve.'
Trochlea, the wheel of a pulley.
Trochlear, pulley-shaped.
Trochlearthrosis, a pulley-joint.
Trochoides, wheel-like.
Trolard, vein of, superior anastomotic vein.
Tuba, a trumpet.
Tubarius, pertaining to a trumpet.
Tube, auditory, pharyngo-tympanic tube.
Tube, Eustachian, pharyngo-tympanic tube.
Tubercle, a small swelling.
Tubercle, articular, articular eminence.
Tubercle, greater multangular, of, crest of trapezium.
Tubercle, Lister's, dorsal tubercle of radius.
Tubercle, Lower, of, intervenous tubercle (heart).
Tubercle, radial, dorsal tubercle of radius.
Tuberosity, an exaggerated tubercle.
Turbinals or **turbinate bones,** conchæ.
Turbinate, whirled or coiled; like a top.
Turbo, a whirl or coil; a top.
Turcica, Turkish.
Tympanum, a drum.

Ulna, the elbow, but more usually the forearm.
Umbilicus, the navel.
Umbo, a boss or knob.
Unciform, hook-like.
Unciform bone, hamate.
Uncinate, furnished with a hook.
Ungual, relating to a nail.
Unguis, a nail.
Unicornis, one-horned.
Urăchus, urine-holder.
Ureter, from a Greek verb meaning 'I pass urine.'
Urethra, the canal by which urine is passed.
Uriniferous, urine-carrying.
Uterus, the womb or matrix.
Uterus masculinus, prostatic utricle.
Utricle, a little womb or matrix.
Uvēa, from *uva,* a bunch of grapes; a cluster.
Uvula, a small bunch of grapes.

Vagina, a scabbard or sheath.
Vagus, strolling about, wandering, vagrant.
Valgus, bow-legged.
Vallecula, a little valley.
Vallecula Sylvii, vallecula cerebri.
Vallum, a rampart.
Valsalva, sinuses, sinuses of aorta.
Valve, bicuspid, left atrio-ventricular valve.
Valve, Eustachian, valve of inferior vena cava.
Valve, ileo-cæcal, ileo-colic valve.
Valve, mitral, left atrio-ventricular valve.
Valve, Thebesian, valve of coronary sinus.
Valve, tricuspid, right atrio-ventricular valve (cusps are anterior inferior medial).
Valve, Vieussens, superior medullary velum.
Varus, bent or turned inwards.
Vas (pl. **vasa**), a vessel.
Velum, a curtain or veil.
Velum interpositum, tela choroidea.
Velum palatinum, soft palate.
Veneris, 'of Venus.'
Ventral, pertaining to the belly.
Ventricle of larynx, sinus of larynx.
Vermiform, like a worm.
Vertebra, primarily means a joint, but more particularly a joint of the spine.

Vertex, the top or crown of the head.
Veru, a dart, javelin, or spear.
Verumontanum, urethral crest.
Vesalii, foramen, emissary sphenoidal foramen.
Vesica, the urinary bladder.
Vesical, pertaining to the urinary bladder.
Vespertilio, a bat.
Vestibular nucleus, principal or dorsal; medial nucleus.
Vestigial, pertaining to a trace.
Vestigium, a trace or vestige.
Vibrissa, a stiff hair of the nostril.
Vicq d'Azyr, bundle of, mamillothalamic tract.
Vidian canal, pterygoid canal.
Vidian nerve, nerve of pterygoid canal.
Vieussens, ansa of, ansa subclavia.
Vieussens, valve, superior medullary velum.
Villus, shaggy hair; a tuft of hair.
Vinculum, a band or bond.
Vitelline, pertaining to the yolk of an egg.
Vitellus, the yolk of an egg.
Vitreous, like glass, glassy.
Vola, the palm of the hand.
Volar, pertaining to the palm; palmar, or anterior.
Vomer, a ploughshare.
Vorticosæ, full of whirlpools, eddying, coiled.
Vulva, a wrapper or covering.

Wharton's duct, submandibular duct.
Willis, circle of, circulus arteriosus.
Winslow, foramen, opening of lesser sac.
Winslow, ligament, oblique posterior ligament of knee.
Wirsung, duct, pancreatic duct.
Wolffian duct, mesonephric duct.
Wood's muscle, abductor metatarsi quinti.
Wormian bones, sutural bones.
Wrisberg, cartilage, cuneiform cartilage.
Wrisberg, ligament, accessory attachment of lateral semilunar cartilage.
Wrisberg, nerve, medial cutaneous nerve of arm.

Xiphoid, like a sword.

Y-shaped ligament of Bigelow, iliofemoral ligament.

Zinn, inferior tendon or ligament (eye), lower part of common tendinous ring.
Zinn, zonule, ciliary zonule.
Zygōma, a yoke.

INDEX

Arteries, nerves, ligaments, joints, muscles, and veins are classified under corresponding headings. Where a number is given in heavy type, the principal reference is indicated.